The Mining Magazine

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EDITORIAL

A TECHNICAL exhibition, which will devote special attention to work which contributes to safety in mining, is to be held in Cologne from June 25 to July 5. Official delegates from the Board of Trade are attending the exhibition and visits will be arranged to important German mining properties.

IN September last extended reference was made in these columns to a proposed new series of sieves suggested by the British Engineering Standards Association. The complete specification for these test sieves has now been issued (B.S.S. No. 410–1931) and may be obtained from the office of the association.

THE jubilee celebrations of the Society of Chemical Industry will be held in London during the week commencing July 13. The proceedings will comprise a wide programme of scientific discussions, social functions, and visits to industrial centres and will be inaugurated by a reception by the Lord Mayor at the Guildhall.

LAST month there appeared in the MAGAZINE an article by Mr. H. G. Smith on the selection of a mine fan. Unfortunately, an error was made in the four fan characteristic curves which were used as illustrations, owing to the omission of a decimal point. The abcissae values, given in the figures as 50, 100, 150, and 200, should obviously have been ·50, 1·00, 1·50, and 2·00.

IN the course of a letter to *Nature* of April 18, in which he gives the results of an examination of an ancient Egyptian axe-head, Sir Harold Carpenter was able to shed some light on the methods of metal working which were employed in its manufacture. Analysis showed that the axe-head contained 96·9 per cent. of copper, 1·5 per cent. of arsenic, 0·7 per cent. of iron, 0·2 per cent. of tin, and small quantities of nickel, sulphur, and oxygen, and the experiments carried out led to the conclusion that the axe-head had been cast to shape, worked to some extent—probably by hammering—and annealed at about 700° C. As the weapon was at least 3,500 years old the investigation clearly shows a certain degree of permanence for work hardness in alloys of this type.

THIS year the gold medal of the Institution has been awarded to Dr. Charles Camsell, Deputy Minister of Mines and Industries of the Dominion of Canada, " in recognition of his untiring zeal and great ability in promoting the development of the natural resources of the Dominion and in furthering the general interests of the mineral industry." The Consolidated Gold Fields of South Africa gold medal goes to Mr. C. W. B. Jeppe for his work on deep mine ventilation and the same company's premium to Mr. E. G. Lawford for his paper entitled " Notes on Some Stoping Problems in Mexico." The William Frecheville Students' prize is awarded to Mr. W. H. Wilson for his paper on " Bottom-Slicing applied to Mining a large Irregular Replacement Deposit in Limestone."

The Institution Dinner

After a lapse of one year, occasioned by the absence of so many members in South Africa in connexion with the Empire Congress, the dinner of the Institution of Mining and Metallurgy was held again last month at the Hotel Victoria. The function, as usual, was well attended, not far short of two hundred being present, the company including, in addition to members and their friends, many representatives of similar bodies. The chair was taken by Mr. J. G. Lawn, the president, and he was supported by the president-elect, Mr. W. Pellew-Harvey.

The toast of the evening—that of " The Institution "—was proposed by Sir Auckland Geddes, who spoke of the great advances which have been made in metallurgical science and referred to the tendency to increased mechanization of mining enterprises. In this connexion he pertinently reminded members of their responsibility for the creation of unemployment and of extra leisure for those who continued to be engaged, incidentally touching on what is undoubtedly one of the major problems of our time—the utilization of the leisure created by the process commonly known as " rationalization." While praising the work of the Institution in the direction of raising the

standard of their own work, he looked forward to increased co-operation with other technical bodies, referring in particular to the proposed new building of the Association of Scientific and Technical Institutions, and assured members that many people not directly connected with the profession but indirectly interested in its prosperity had every desire to help on the scheme. In responding for the Institution the President said that the past year had been difficult, but notwithstanding this an excellent series of papers had been discussed at the monthly meetings. With regard to the new housing scheme, he felt that, though progress might be slow, it would ultimately be accomplished and that their new home would be a fitting one for the Institution. An interesting coincidence mentioned by Mr. Lawn was that the initials of the new body, A. S. T. I., mean "home" in modern Greek. Referring to the question of unemployment in the ranks of the profession, the President pointed out that the present time was logically that in which preliminary development work should be undertaken, in preparation for the increased demand for metals that was bound to arise in the future, although at the same time he fully recognized the scarcity of funds for this purpose. As regards the changes in practice required to meet the altered position of the industry as the richer and more accessible ores became worked out, he said that the situation could only be met by the application of scientific principles and the continued improvement in mechanical and electrical engineering.

To Mr. Pellew-Harvey fell the pleasant task of proposing the toast of "Our Guests," many of whom he mentioned, at the same time welcoming all. Sir Halford Mackinder, who was the first to respond, after referring to the connexions between mining and agriculture, spoke of the suggestions for an economic survey of the mineral resources of the Empire, which the Institution justly considers to be of the utmost importance, and made the gratifying announcement that at the Imperial Conference held last autumn instructions had been given to the Imperial Economic Committee to implement this. Sir Halford stated that a committee had already been appointed to consider the distribution and availability of the minerals and metals of the Empire and that Sir William Larke had accepted the position of chairman. The functions of this committee will be to survey the information available, to note the gaps in our knowledge, and to draw up plans for work in various parts of the Empire, leaving the various governments and institutions to fill in the details, all the old and the new information being finally assembled by the committee. He emphasized the purely commercial intentions of this new body and repudiated the idea that there was any intention on its part of competing with geological survey work, its real aim being to consider the availability of metals and of the metallurgical resources for handling them and to decide how far surpluses in one part of the Empire might meet deficiencies in another. Sir David Milne-Watson also responded for the guests and in speaking of the building scheme of the Association of Scientific and Technical Institutions, of which he is acting as chairman, reminded members of the present state of industry and said that the best way to get outside corporations interested was to show such bodies how much the individual societies were prepared to do.

That a survey of Imperial mineral resources is under way will be welcome news to those interested in obtaining the greatest possible measure of unity among the peoples of the Empire and details of the progress of its work will be eagerly awaited. As regards the new association building, it is hard to avoid the feeling that, laudable though the scheme may be, the present time is, in view of the wide unemployment in the profession, hardly likely to bring that active support from the individual members of the various institutions and societies which would otherwise doubtless be forthcoming, and it is possible that the full development of the scheme may have to await the incidence of the better times to which all are looking forward.

Rand Mining Methods

The high repute in which Rand mining practice is held by the profession is such that it is with something of a shock that one learns that not only is improvement possible in the technique there employed, but that it is constantly sought by those engaged in the industry. Anything, therefore, which succeeds in drawing attention to the valuable results which are being obtained from research work on the Witwatersrand goldfield deserves the closest attention and the paper by Mr. C. B. Brodigan on "Rand Mining Practice," which was presented at the April meeting of the Institution, comes within this category. The paper took

the form of a critical review of the descriptions of Rand methods presented at the Third (Triennial) Empire Mining and Metallurgical Congress, held in South Africa last year. Presented as it was, as an effort to give a comprehensive picture of this enormous industry in the form of a descriptive sequence of operations, the careful work of the author in knitting the mass of data into a compact whole bore ample evidence of his familiarity with the progress that has been made and with the conditions that have made it possible.

Turning to the paper itself, the author groups the congress papers under six heads : (1) Shaft sinking, (2) power and compressed air supply, (3) preparation of drill steel, (4) stoping, development, and transport of ore, (5) mine drainage and pumping, and (6) labour. Under the first head four papers by Messrs. J. C. Roxburgh, W. G. C. Nixon, A. J. Walton, and B. G. O. Orpen are examined. The reviewer first considers the essential factors which have influenced shaft design on the Rand, pointing out the manner in which the early inclines have been superseded by deep-level vertical shafts, the earlier ones being five-compartment, followed by seven-compartment, and later, when ventilation problems became acute, by circular and " square " shafts in which the ratio of the area to the perimeter has been adjusted to give better ventilation constants. Mr. Brodigan evidently considers that the " square " or modified rectangular shaft has decided advantages over the circular shaft and, in particular, stresses the higher cost of hoisting equipment in the latter type and the consequent higher expenditure necessary for ore-handling and general surface equipment. Power and compressed air supply are covered by one paper, that of Mr. Bernard Price, the general manager and chief engineer of the Victoria Falls Power Company, which supplies most of the Rand mines with electric power and some of them with compressed air, although there are companies, such as the Randfontein Estates, which have their own power supply. Nevertheless, it seems possible to agree with Mr. Price, that the policy which has been adopted generally by the mining industry in the Rand, of purchasing power from a separate company, has been justified by the results. The reviewer's third group, covering the preparation of drill steel, consists of two papers by Messrs. E. C. J. Meyer and G. R. Heywood. The work of these authors, prepared under the auspices of the Central Mining group, bears witness to the freedom with which the results of research are being circulated on the Rand. Mr. Heywood's paper, dealing with steel selection and the preparation of the drill steel, or jumpers, describes among other things the evolution of the round and hexagonal shank bit and the investigations which have led to the practice of using one jumper per hole. Using bits of improved design, it has been possible to drill up to five holes with one bit. Proceeding to the section dealing with stoping and development, Mr. Brodigan briefly reviews the effect of the Rand strike of 1922, one of the most important results of which was the resumption of control of affairs by the mine managements, which permitted of the introduction of devices such as the hole director and the " no-cost " contract system. Continuing, the reviewer examines papers by Messrs. C. S. McLean and B. D. Bushell, covering development methods, a co-operative paper on stoping operations, and Mr. C. L. Butlin's paper on ore-handling. The importance of the water question is next emphasized by Mr. Brodigan, who points out that not only must water be pumped to the surface, but that, in addition to its use in the metallurgical plant, it has to be supplied at a constant pressure to working places, where it is used for dust-laying purposes. Perhaps the most interesting feature of this section, however, is the development of high-lift pumping installations, such as those on the Randfontein Estates, which are covered in a paper by Mr. W. G. C. Nixon. The care with which water settling has had to be studied in the endeavour to supply only clean water to the centrifugal pumps bears evidence of the manner in which such research problems have been approached. Finally, in examining the native labour question, the author testifies to the way in which the men are trained and treated. A well-attended meeting listened to the authors' presentation of his paper and the discussion, initiated by Mr. T. Pryor, was continued by Messrs. Morgans and Palmer, and concluded by the President.

In the course of a review in the MAGAZINE for April, 1930, of the subjects covered by papers presented at the Empire Congress attention was drawn to several now examined by Mr. Brodigan and the value of many of them has been widely recognized. The picture created by the author's competent

handling of his subject is, however, so impressive that those responsible for the individual papers dealt with by Mr. Brodigan owe him a debt of gratitude, in which others will doubtless share.

Platinum Group Metals

The metals of the platinum group possess a number of properties which render them unique and although, by reason of their rarity in the earth's crust and their consequent high price, there has been active search for cheaper substitutes none have been found that are completely satisfactory and that will replace them for certain purposes. Prior to the war the world's supply of platinum, as is well-known, came chiefly from the alluvial deposits of the Urals and Colombia, but early in the last decade it was discovered *in situ* in South Africa and that country in 1928 produced as much as 23,660 oz. of the metal. It has been known for some time, however, that the production of Canada was likely to be increased enormously, as the result of the development of the platinum-metal by-product industry connected with the Sudbury nickel-copper deposits, and the opening of the new extensions to the precious metals refinery of the Mond Nickel Company, at Acton, near London, emphasized this. The opening ceremony was performed on April 23 by Lord Weir and at the luncheon following many distinguished people were present, including the Secretary of State for the Dominions, the Rt. Hon. J. H. Thomas, and the Canadian High Commissioner, the Hon. G. Howard Ferguson.

The original refinery at Acton was built in 1924 and was designed to handle concentrates obtained from the carbonyl process for the extraction of nickel, which had been established at Clydach, in South Wales. Later, crude platinum concentrates from South Africa were treated at Acton, and still later, since the fusion of the interests of the International Nickel and Mond Nickel companies, concentrates from the electrolytic refinery at Port Colborne, Ontario, have also been dealt with. The opening up of the Frood mine has greatly added to the resources of the International Nickel Company with respect to precious metals and the increased capacity of the refinery is the result. The original refinery and the subsequent additions, embodying the latest results of research and experience in the refining of precious metals, have been planned by the technical staff of the Mond Nickel Company, and, although designed to handle the carbonyl concentrates, which average 4 per cent. of platinum metals, the original plant has proved quite flexible and deals efficiently with much richer material, the Port Colborne concentrates running up to 50 per cent. of metals of the platinum group. The equipment of the refinery is on a smaller scale than that of the average metallurgical works, the methods of the laboratory being here employed on a production basis. The Clydach concentrate, containing a relatively large proportion of silver and lead, receives an initial smelt, in which lead is used as a precious metals collector. After cupellation, the silver-rich alloy is parted with sulphuric acid and a subsequent treatment with aqua regia dissolves most of the platinum, palladium, and gold. The platinum is then precipitated as ammonium platinochloride, which is ignited to produce a platinum sponge, and palladium is precipitated as palladosammine chloride, which is similarly treated to yield a palladium sponge. The silver and gold recovered are purified electrolytically. The final insolubles and reduction residues are remelted to concentrate the rhodium, ruthenium, and iridium (known as the " by-metals "), which are present in the original concentrate only to the extent of 0·4 per cent., and the alloy containing them is returned for a wet process treatment and refinement in a special department. For the Port Colborne concentrates the original lead melt and sulphuric acid treatment are unnecessary and they enter the process at the aqua regia stage.

It is interesting to reflect that the new precious metals refinery is the embodiment of a by-product industry, the pyrrhotite ores at Sudbury being, of course, originally worked for their nickel content. The demand for nickel, however, has become so large that when working at full capacity, the output of platinum metals will amount to 300,000 oz. per annum. It has been estimated that the present world consumption of these metals is less than 400,000 oz. yearly, so that the Empire's position in the platinum metals industry has become one of supreme importance. The Canadian ores are expected to yield the precious metals in the following proportions: Platinum and palladium, about 40 per cent. each; rhodium, ruthenium, and iridium, 7 per cent., and gold, 13 per cent.

REVIEW OF MINING

Introduction.—The general trend of affairs altered little as the result of the introduction of the Budget, for which, perhaps, the best that can be said is that it might have been worse. Meanwhile, metal prices continue to sag and lead producers have been forced to agree to a measure of output control, the agreed figure of reduction being fixed at 15%.

Transvaal.—The output of gold on the Rand for April was 840,259 oz. and in outside districts 42,078 oz., making a total of 882,337 oz., as compared with 910,998 oz. in March. The number of natives employed in the gold mines at the end of the month totalled 206,770, as compared with 207,239 at the end of March.

The reports for 1930 of the Anglo American Corporation group—namely, Brakpan, Springs, West Springs, and Daggafontein—were issued last month. The ore reserves at Brakpan showed an increase from 2,531,410 to 2,543,420 tons, but the grade and width were slightly lower at 7·8 dwt. and 53·74 in. The tonnage crushed was a record at 1,040,200 and the gold recovered totalled 391,852 oz., the total revenue being £1,664,371. The working profit was £552,045 and dividends paid during the year absorbed £446,250, equal to 43¾%. Springs Mines reserves also showed an increase, being 3,311,370 tons against 3,250,238 tons, the grade rising from 9·3 to 9·34 dwt., but the stoping width was lower at 49·36 in. The ore crushed totalled 836,700 tons and the gold recovered amounted to 408,250 oz. The total revenue was £1,734,484 and the working profit £791,664. Dividends paid during the year took £562,500, equal to 37½%. The all-sliming process has now been introduced at the mill. At the West Springs the reserves were slightly higher at 2,756,150 tons, the grade falling from 6·34 dwt. to 6 dwt. and the stoping width from 57·26 to 54·37 in. The tonnage crushed was 815,800 and the gold recovered totalled 218,054 oz. The total revenue was £925,509 and the profit £213,633, £179,300 being distributed as dividends, equal to 10%. Development of the Daggafontein property was rapidly advanced during the year and it has now been found possible to calculate the ore reserves, which are estimated at 1,233,802 tons, averaging 8·37 dwt. over a stoping width of 43·93 in. A reduction plant capable of treating 50,000 tons per month is to be erected at No. 2 shaft and will embody an all-slimes process of milling. It is hoped to commence milling early in 1932.

During 1930 the unwatering of the mine on Witpoort Gold Areas was continued and on re-examination it was found necessary to complete the development of certain blocks which had been included in the ore reserves. The new estimate of reserves at the end of the year was 364,000 tons, averaging 6·1 dwt. over a stoping width of 40 in. Development was concentrated mainly on the work outlined above, on new development west of the old workings, and on testing the intact area lying between the old mine and the Apex and Brakpan properties.

According to a statement recently issued an arrangement has been concluded between the African and European Investment Company and the Union Government for the exploitation of the farm Grootvlei, on the Far East Rand, in conjunction with the Union Corporation and the Anglo American Corporation, the Government having granted the company a lease of 2,500 additional claims on the farm. The total mining area of Grootvlei Proprietary Mines will thus be increased to 3,687 claims and preliminary development of the property will be carried out by means of drives from the East Geduld mine.

With the object of prospecting the farm Vlakfontein No. 21 in the Heidelberg district and the ultimate intention of forming a new company for its exploitation, it has been announced that an agreement has been reached between the Lydenburg Gold Farms Company, Ltd., and the Union Corporation, whereby the latter undertakes to spend £25,000 on the prospecting of the property. Previous testing of the farm by bore-holes was inconclusive, but the delineation of the pay shoots in the Daggafontein mine has directed attention once more to Vlakfontein.

Towards the end of last month a rock-burst occurred in the west incline shaft of the Witwatersrand Deep and the caving of approximately 600 ft. of the shaft is expected to hold up mining operations for several weeks.

The reduction in the capital of the Village Deep has now been sanctioned by the Johannesburg High Court. As announced in the March issue of the MAGAZINE, the reduction will be effected by lowering the nominal value of 1,000,113 shares from

14s. to 9s. 6d. each by returning 4s. 6d. per share.

A circular to the shareholders of Rooiberg Minerals states that owing to the present price of tin it has been decided to suspend immediately mining and milling operations. The new alluvial plant will be kept running in order to meet the cost of keeping the mining and milling plant in good condition.

During 1930 the General Mining and Finance Corporation made a profit of £62,676, as compared with £112,224 for the previous year. With the amount brought in £123,826 was available, but in order to cover depreciation in the market value of securities it was necessary to bring in £100,000 from reserve, the balance carried forward being reduced to £19,037.

The profit of the Anglo-French Exploration Co. for 1930 was £22,928. Adding the amount of £63,207 brought in, the available total was £86,135, of which £69,632 has been written off against depreciation, leaving a balance of £16,503 to be carried forward.

Southern Rhodesia.—The output of gold from Southern Rhodesia during March was 42,278 oz., as compared with 42,818 oz. for the previous month and 45,511 oz. for March, 1930. Other outputs for March were: Silver, 5,802 oz.; copper, 106 tons; coal, 57,925 tons; chrome ore, 8,595 tons; asbestos, 1,995 tons; mica, 3 tons.

South-West Africa.—The report of the Consolidated Diamond Mines for 1930 shows a profit of £366,530, to which is added the £150,225 brought in from the previous year. After making various allowances, redemption of debentures, and interest, the balance unappropriated was £348,243, which was carried forward. During the period under review additional crushing and excavating plant was installed at Elizabeth Bay and trenching of the marine terrace deposits north of the Orange River proved an additional payable length of five miles. The estimated diamond content of the 25 miles of terraces in the southern area of the Sperrgebiet was 2,500,000 carats.

Australia.—Low metal prices continue to affect the Broken Hill companies and the Proprietary is passing its half-yearly dividend. The Zinc Corporation has reduced its output, the mine now working three weeks out of four, and the Broken Hill South is also decreasing its production in accordance with the agreement reached between lead producers. On the other hand, a notice from the North Company states that it has recommenced the production of zinc concentrates.

The final report of the liquidators of the Mount Morgan Gold Mining Company has now been issued, covering operations since voluntary liquidation on August 15, 1927, to March 15, 1931, on which date the accounts were finally closed. The statement shows that the total receipts amounted to £1,470,307, while expenditure totalled £276,557, leaving a balance of £1,193,750, which has been distributed to shareholders in amounts totalling 23s. 10½d. per share. Shareholders are now to be asked to resolve that the company be finally dissolved.

Following the announcement made here last month with regard to the Lake View and Star, Ltd., the New Consolidated Gold Fields company has now offered to supply funds for development up to £100,000, being granted a new option on 100,000 shares at 10s. per share until May 30, 1933, the options previously held being cancelled. It is expected that the new plant at the Lake View and Star will be operating on a basis of 20,000 tons per month by October next and on a 30,000 ton basis early in 1932. The cost of further extension to a 40,000 ton capacity is estimated at £30,000, and this will follow.

Trial operations commenced at the Wiluna mine in March and in a circular to shareholders it is announced that during April 18,026 tons were put through, bullion to the value of £19,133 being recovered. The mine equipment is stated to be entirely satisfactory, but adjustments will have to be made in the crushing section and also at the power plant. Data so far collected indicate that a minimum over-all recovery of 80% may be expected from the metallurgical plant. Mr. C. O. Lindberg in a report expresses the view that attention should be directed at an early date to more intensive development of the north section of the property.

Malaya.—It has been proposed by the directors of Kay Yew (Kinta Valley) Tin Mines that the company should be reconstructed by reducing the value of the 5s. shares to 3s. and subdividing the new shares into three 1s. shares. For the provision of further working capital it has been decided to create and issue £12,000 10% debentures, carrying conversion rights.

Shareholders of Rahman Hydraulic Tin have been informed that the aerial ropeway connecting the mine with the Tanah Hitam

mill has now been completed and that it is operating satisfactorily.

Borneo.—It is proposed to reduce the capital of the British-Borneo Petroleum Syndicate to £150,000 by cancelling 4s. on each 10s. share, and when this has been sanctioned by the Court the capital is to be increased to £250,002 by the creation of 333,340 new 6s. shares.

Japan.—A meeting of shareholders of Toyo Tin, Ltd., was held last month, when a scheme was approved whereby a first mortgage is created on the Japanese company's property, in order to secure the repayment of loans to that company. In addition it was agreed that the English company's capital should be reduced to £118,750 in 2s. 6d. shares and then increased to the former figure of £400,000 by the creation of 2,250,000 new shares of 2s. 6d. each.

Canada.—At a meeting of shareholders of Canadian Lorrain, held in Toronto, it was resolved that the company should be voluntarily wound up. It is not expected that it will be possible to make any return to the shareholders.

Colombia.—Shareholders of Colombian Mining and Exploration have been informed that arrangements have been completed between the company and the Colombian government regarding the payment of the capital and interest due to them for the termination of the contract for the exploitation of the Marmato and Supia mines. The payments are to be spread over three years.

Panama.—At the meeting of Panama Corporation held last month the increase of capital was approved, this being followed by an issue of £250,000 8% debentures, which carry conversion rights. Recent reports from the properties show that sluicing is in progress on both the El Mineral and Sabalo River alluvials and that the Remance plant is all but completed. The Remance main shaft has been retimbered and a new shaft is being sunk at the north end of the mine and both are to be carried to the 7th level. The plant for the Mina Blanca property is being designed and is expected to be erected by the middle of next year.

Yugoslavia.—It has been announced by Trepca Mines that the deep adit showed the ore-body to have a width of 223 ft., averaging 13·7% lead and 7·9% zinc, the last 98 ft. cut being high-grade ore, averaging 24% lead and 4·6% zinc.

Portugal.—During 1930 the firm of Mason and Barry, Ltd., which works the San Domingos mine in Portugal, extracted 202,848 tons of ore, as compared with 222,685 tons the previous year, although shipments showed a slight increase at 204,875 tons. The year's working resulted in a loss of £6,957, the balance carried forward being thus reduced to £12,456.

Spain.—To provide capital necessary for the development of reserves, the directors of Tigon Mining and Finance have issued 108,313 shares of the reserve capital at 10s. per share (5s. premium), leaving 41,807 shares still unissued.

National Mining.—The report of the National Mining Corporation for 1930 shows a net loss of £138,024 and there is now a debit balance of £103,090. The loss resulted mainly from the realization of investments, certain sales being effected to meet commitments. The corporation has not undertaken any new business.

Minerals Separation.—During 1930 Minerals Separation made a profit of £54,658, as against £60,016 the previous year. The dividend has been maintained at 25%, equal to 5s. per share, the balance carried forward showing a slight reduction at £28,972. The copper segregation plant erected at the Alaska mine is stated to be working well, and a similar plant with a capacity of 350 tons per day is being erected in the Katanga for the Union Minière.

Murex.—Shareholders of Murex, Ltd., have been informed that negotiations in America have resulted in the formation of the American Murex Corporation, which through the Metal and Thermit Corporation of America will handle Murex products in that country.

Tin.—Towards the middle of last month the bill for the restriction of tin output passed its first reading in the Federal Council of the F.M.S. and some details of its contents are given elsewhere in this issue. The result of the action of the Pahang Consolidated in claiming that it is not subject to the provisions of the bill, or, alternatively, that it should be indemnified by the Pahang State, is awaited with interest.

Diamonds.—The period of restriction agreed upon by those engaged in the diamond industry is due to end on June 30 next. Meanwhile, Antwerp has intimated to the International Diamond Commission that it is in favour of the period being extended.

THE ORE-DEPOSITS OF THE OTAVI MOUNTAINS, SOUTH-WEST AFRICA

By ALEX. W. CLARK, A.R.S.M., B.Sc., A.I.M.M.

In this article the author, after describing the general and economic geology of the country, pays particular attention to the important deposits of vanadium minerals.

INTRODUCTION.—Copper occurs in many different localities throughout the Territory of South-West Africa, but although several deposits had been opened up and worked intermittently in the German times few had been profitably mined. At the present time practically the entire production of copper comes from the Otavi Mountains in the Grootfontein district in the north, from which considerable quantities of lead and vanadium are also exported. The two principal mining concerns of the district are the Otavi Minen- und Eisenbahn-Gesellschaft, which owns and works the Tsumeb Mine, and the South-West Africa Company, Limited, which owns the Abenab Mine and several other smaller vanadium deposits.

The Otavi Mountains lie about 350 miles north-east of Walvis Bay on the plateau which occupies the eastern portion of the country and which is here about 4,500–5,000 ft. above sea level. The principal ranges and peaks—several of which attain altitudes of over 7,000 ft.—lie between Tsumeb, Otavi, and Grootfontein, but a smaller range runs from near Otavi towards the south-west. The Grootfontein district is favoured with the highest rainfall in the Territory, averaging about 20 in. per annum, and the country is covered with grass and bush and presents a pleasing contrast to the sandy coastal desert and the semi-arid region of Namaqualand in the south. Even in the north, however, the rainfall is very uncertain and the future of the country depends more upon stock-raising than on agriculture. Game is plentiful in the district, eland, gemsbok, kudu, hartebeest, and duiker being the commonest species of antelope, while guinea fowl are found in great numbers at certain seasons. Big herds of wild ostrich frequent the open plains and leopard, wild cat, jackal, hyæna, and large numbers of baboons are to be found in the kopjes. During the rainy season from October to April the climate is almost tropical, but the country is healthy and there is little sickness among the European population.

The small mining town of Tsumeb at the terminus of the narrow-gauge railway has a European population of about 600 which, apart from the few Government and other officials, is entirely German. Grootfontein, which is reached by a branch line from Otavi, is pleasantly situated on a low ridge to the east of the mountains. The magistracy of the district, the offices of the South-West Africa Company, and the Northern Labour Organization (native labour) are situated here and the township is also the centre of a large farming community. One of the "sights" of the district is the famous Hoba meteorite—the largest known meteorite in the world—which was found partially buried in surface limestone some 12 miles west of Grootfontein. Its upper surface, which lies almost level with the ground, is roughly rectangular in shape and measures about 10 ft. by 9 ft., while the thickness of the mass is about 4 ft. at one end and 2 ft. at the other, and its weight has been estimated to be about 60 metric tons.

Throughout the district the underlying dolomite rocks have given rise to a typical "karst" topography, characterized by the absence of rivers and streams and by the development of numerous sink-holes and caves, through which the rain water disappears underground. Some of these sink-holes are of enormous size, the Otjikoto Lake, 12 miles W.N.W. of Tsumeb, and the Guinas Lake, 12 miles still further west, being the largest. The former is elliptical in shape and measures about 800 ft. by 650 ft. across and is over 600 ft. deep with sides descending vertically. The water level in the lake varies with the rainfall and although some years ago, during abnormal rains, it rose almost to the surface, it has now fallen to about 50 ft. from the top. Numerous springs are found in the district, but the water which issues from these can account for only a fraction of the rainfall which penetrates the dolomite, and it is probable that large underground supplies exist in this region. The mine pumps in both the Tsumeb mine and Abenab afford a copious supply of water for all purposes.

The copper mines of the Otavi Mountains were known and had been worked by the natives for generations prior to the advent

of the first European explorers. According to Galton,[1] the local Bushmen sold the ore to the Ovambos of Ondonga some 150 miles to the north, who were said to be skilled metallurgists, but some of the ore must have been smelted locally, for traces of old native smelters have frequently been found in the mountains. In order to open up the country and develop its mineral and agricultural resources the German Government granted a concession in 1892 to the South-West Africa Company, Ltd., of London, under which the Company had the sole mineral rights over an area of 22,000 sq. miles in Northern Damaraland, which included the Otavi Mountain area, together with certain freehold land rights. In the same year expeditions were sent out to explore the territories and the copper mines of Gross Otavi and Asis, in the Otavi Valley, and later the Tsumeb mine, 30 miles further north, were investigated. Owing to encouraging results in the early development of these mines the construction of a narrow gauge railway from Swakopmund on the coast to Tsumeb (354 miles) was commenced in 1903. This work was undertaken by the Otavi Minen- und Eisenbahn Gesellschaft of Berlin, which was formed to acquire from the South-West Africa Company *inter alia* the mineral rights over an area of 1,000 sq. miles within the company's concession, including the mines of Tsumeb, Gross Otavi, Asis, and Guchab. The line to Tsumeb was completed in 1906 and two years later a branch line from Otavi to Grootfontein (59½ miles) built by the South-West Africa Company itself, was opened.

During this period the country was in a continual state of unrest and the Herero War (1904–1906), and other native risings, almost stopped operations in the company's concession, but with the completion of the railway to Tsumeb, the development of this portion of the Territory was facilitated and shortly afterwards the first shipments of ore from the mines were despatched. From 1907 to 1914 there were exported from the district: 233,820 tons of ore, averaging 16% Cu, 25% Pb, and 9·34 oz. Ag. per ton; 12,135 tons copper matte; and 9,785 tons metallic lead.

After the occupation of South-West Africa by the Union troops in 1915, Walvis Bay was connected with Swakopmund by rail, and the first 100 miles of the Otavi Railway were replaced by 3 ft. 6 in. standard Cape gauge and connected with Windhoek and the Cape. North of Usakos, unfortunately, the 2 ft. gauge still remains.

Although most of the smaller mines of the Otavi Valley have now been worked out, the increased tonnage from Tsumeb has more than made up for this and a steady increase in production and export of copper and lead from the district has been recorded during the last ten years. Prior to the war a little vanadium ore had been obtained from Tsumeb, where it was first discovered, and from one or two other localities, and a few hundred tons of concentrates were exported to the United States during the war period. Since then a number of vanadium occurrences have been discovered, the principal being the Abenab mine previously mentioned.

Geology.—The rocks of the Otavi Dolomite Series in which the ore deposits occur are of Lower Palæozoic or Pre-Cambrian age and have been correlated with the Nama and Transvaal systems. They consist of massive and bedded dolomites, limestones and lime-shales, conglomerates, arkoses and grits, and lie unconformably on the rocks of the Primary Formation which outcrop in the area south of the mountains. The following may be taken to represent an average section:—

Otavi Dolomite Series.	*Thickness*
Upper arkose	—
Upper bedded dolomites and limestones	1,800 ft.
Lower ,, ,,	750 ft.
Main massive dolomite	3,000 ft.
Platy limestone and lime-shales	600 ft.
Lower massive dolomite	900 ft.
Nosib conglomerate, arkose, and grits	1,200 ft.

The maximum thickness of these sediments is probably about 10,000 to 13,000 ft., about three-fourths of which is composed of carbonate rocks which range from true dolomites to dolomitic limestones and normal limestones free from magnesia. The massive dolomite is blue-grey to light grey in colour, finely crystalline in texture and its composition is that of a normal dolomite. It forms the main peaks and ridges of the Otavi Mountains, where it has been weathered into great jagged blocks and pinnacles, and is usually well covered with trees and scrub. The platy limestone on the other hand supports only a thin growth of grass and is thus easily recognizable on the hill sides. It is also characterized by its pronounced

[1] Galton, F.: "The Narrative of an Explorer in Tropical South Africa." London. 1853.

bedding and its brownish colour. The upper (bedded) dolomites and limestones, which are found only in the north and west, contain several beds of oölite and numerous thick bands of chert, and form low flat-topped and sparsely timbered kopjes. The upper arkose is composed of a series of felspathic grits and quartzite and was formerly regarded as microgranite. Schneiderhöhn [1] attributes to these a thickness of not less than 1,300 ft.

Large tracts of country in the surrounding plains are covered by recent sediments—chiefly the "Kalahari limestone" or calcareous tufa—and in places by red sand.

The folding of the beds of the Otavi formation has been more intensive on the east side of the mountains, where a great laccolith of granite has been intruded into the anticlinal folds which trend roughly east and west. The entire mountain area appears to have been thrown down in a trough fault, or graben, the southern boundary of which stretches east and west on the south side of the Otavi-Grootfontein railway. Great pressure exerted on this block from the south has caused a series of overthrust faults within the Otavi Dolomite Series, the most extensive movement having taken place along the line of the Otavi Valley overthrust, which runs from near Otavi eastward towards Guchab and formed the great ridge along the north side of the railway. Nageib Peak, the highest point in the district, stands out on this ridge at a height of 7,200 ft. A number of smaller (parallel) overthrusts occur on the eastern side of the mountains between Guchab in the south and Abenab in the north, while the country in the neighbourhood of Tsumeb is also highly disturbed. The folding and faulting of the strata, assisted by subsequent erosion, have formed a series of mountain ranges which trend east and west or north-east—south-west, more or less parallel to the folds, and are separated by wide flat-bottomed valleys.

Of the intrusive rocks of this district the granite in the east is the most important. Outcrops of this intrusive can be seen at Nosib, Farkfontein, Grootfontein, and on either limb of the Awagobib Saddle, exposed by denudation, but in the valleys and in the flat plains it is generally covered by the secondary limestone and sand. The principal rock is a coarse-grained hornblende granite, but gneissic and schistose marginal phases are found. Although the main body of the granite does not outcrop further west than Nosib, its presence is indicated by aplite intrusions at Tsumeb, Tsumeb West, and near Bobos. This is a fine-grained quartz-felspar rock with small quantities of muscovite or sericite, and similar aplites are found at Nosib and Farkfontein and also at Gross Otavi and Asis along the line of the Otavi Valley overthrust.

General View of the Abenab Mine: Open-Cast on the Extreme Left.

Dolerite dykes, often highly epidotized, are commonly found near the granite contacts, and in the Tsumeb mine small veinlets of mica and olivine-kersantite are seen cutting the ore-body.

Ore-Deposits.—The ore-deposits are not confined to any particular horizon of the Dolomite Series, but are usually distributed along east and west zones of fracture or faulting. These mineralized zones are found on either limb of the anticlinal folds on the eastern side of the mountains, close to the

[1] Schneiderhöhn, H.: "Das Otavi Bergland und seine Erzlagerstätten." *Zeitschrift für praktische Geologie.* Sonderheft zum XV Internationalen Geologen-Kongress in Südafrika. Juni 1929.

granite outcrops, also in the Tsumeb-Bobos area in the north and in the neighbourhood of the Otavi Valley overthrust in the south. The distribution of the ore occurrences and their association in some cases with minor granitic intrusions indicate a hydrothermal origin. Mineralizing solutions rising to the roof of the intrusion have been injected into fissures in the anticlines where the ore minerals have been deposited chiefly by replacement of the dolomite. In a few of the more prominent fissures caused by overthrusting, aplite intrusions had previously been injected and these have been sparsely mineralized. The deposition of the primary minerals, however, was not confined to the larger fault fissures, for over large areas there are innumerable smaller fissures, fractures, and joints in the dolomite within which the primary sulphides are found.

The primary minerals are principally pyrite, galena, and zinc blende, the pyrite, which is almost invariably cupriferous, being the chief primary copper mineral. Enargite is occasionally found, and silver and cadmium are frequent associates of the galena and blende respectively. Occasionally these minerals occur together, forming mixed ores—as at Tsumeb—but in other deposits copper ores, with variable quantities of lead, predominate, while in others only lead and zinc are present.

Certain mineralized zones are characterized by copper deposits and others by lead and zinc. In all cases where aplite intrusions occur the ore minerals are predominantly cupriferous. Except in the case of the Tsumeb ore-body, however, the primary minerals themselves do not form economic deposits and it is only where secondary enrichment or alteration has taken place that ores of commercial value are found.

In the case of the copper deposits the primary sulphides have been dissolved by descending surface water, which in this way increases in acidity, with a corresponding increase in the solvent action on the brecciated dolomite through which it percolates. Fractures and joints in the country rock are widened by solution until eventually large openings are formed. These later become the receptacles for the deposition of the secondary sulphides—chiefly chalcocite, although chalcopyrite and bornite are occasionally found—whose mineral content has frequently been derived from small scattered veinlets by prolonged erosion of the country rock. The ore is usually associated with a red residual clay—the insoluble residue of the dolomite—or by a characteristic red "cave limestone" formed by replacement of the dolomite *in situ* by the action of surface water percolating through small fissures. Where the replacement is incomplete a pseudo breccia or solution breccia is formed, composed of fragments of grey dolomite surrounded by the more recent red material. These deposits usually occur either in the form of chimneys or pipes, or as steeply inclined vein-shaped bodies, the former often being as much as 30 ft. to 40 ft. in diameter, while the latter, following fractures in the rock, may be up to 100 ft. to 150 ft. in length and 10 ft. to 15 ft. wide. At the outcrops of these deposits deep pockets of red sand containing lumps of copper sulphide ore partially oxidized are usually found—eluvial residues of the deposit. The oxidized minerals are usually malachite and cuprite, but chrysocolla and the rarer silicates dioptase and planchéite have been found (for example at Guchab). These rich pockets of ore rarely exceed 80 ft. to 100 ft. in depth, below which small veinlets of primary sulphides may occur.

All the copper and copper-lead deposits of the Otavi Valley and also at Bobos were of this type. At Asis and Asis East a considerable amount of underground development work was done and at the former mine some narrow veins of aplite carrying cupriferous pyrites were exposed after passing through the secondary sulphides, but the copper values in these were too low grade to work. These smaller mines have now been worked out, although Guchab was producing until quite recently, and the present production of copper, lead and silver comes entirely from the Tsumeb Mine.

The Tsumeb ore-body [1] is a replacement deposit surrounding an aplite stock intruded into a zone of fracture in the upper dolomite. At surface the deposit had a length of about 550 ft. and a maximum width of 45 ft. and thinned out towards either end. The strike is approximately east and west and the pipe dips steeply to the south. The aplite intrusive, which measured about 150 ft. long at surface, there occupied a position in the centre of the hanging wall of the ore-body, dividing it into two distinct ore

[1] Schneiderhohn, H., *op. cit.* Also Wagner, P. A.: "The Geology and Mineral Industry of S.W. Africa" (1916).

lenses joined by a narrow constricted portion. The size and shape of the body and of the aplite vary from level to level. To a depth of about 160 ft. the deposit was worked open cast; thereafter underground mining methods were adopted and at the present time development has been carried to the 20th level at a depth of approximately 2,000 ft., and ore is being mined from below the 16th level (1,500 ft.).

The mine is famous, not only on account of the high metal content of the ore but also for the amazing variety of minerals found, particularly in the oxidized portion of the deposit.

The main ore-body below the oxidized zone consists of a coarsely crystalline aggregate of chalcocite, galena, tetrahedrite, zinc blende, pyrite and enargite and, in the lower levels, of chalcopyrite and bornite. From the 6th level (500 ft.) to the 16th (1,500 ft.) the ore-body, exclusive of the aplite, which is itself mineralized throughout, is estimated to have a copper-lead-zinc content of 45–50%. That is to say that 65–70% of the ore is composed of the sulphides and sulpho salts of these metals, while the remaining 30–35% is made up of unaltered dolomite and siliceous gangue material.

Although the bulk of the oxidized ore is found above the 6th level, oxidation has nevertheless extended to depths considerably below this, particularly in the vicinity of solution planes on either wall of the ore-body. On the other hand, a considerable proportion of the ore at or near the surface was in the form of sulphide, great masses of chalcocite and galena being found coated with carbonate and other oxidation products, among which the following may be mentioned: cuprite, limonite, malachite, azurite, cerussite, smithsonite, hydrozincite, chrysocolla, dioptase, calamine, brochantite, linarite, anglesite, aurichalcite, olivenite, erinite and mottramite. Chalcocite found near the surface and down to a depth of about 350 ft. is entirely supergene. From about 350 ft. to 600 ft. mixed primary and secondary sulphides occur ("the cementation zone"), but as in the case of oxidation the secondary sulphide enrichment has extended much below this depth in the vicinity of fissures in the footwall of the body, which have allowed the passage of downward percolating solutions.

All the chalcocite of the Tsumeb Mine, however, is not of secondary origin, for

Open-Cast at Abenab Mine: Showing Platy Limestone (footwall) on the Left and Breccia on the Right.

Schneiderhöhn [1] has proved the existence of primary chalcocite with octahedral cleavage in the deeper levels. The zinc blende contains about 2·5% of cadmium, and gallium and germanium are present in small amounts in the rare mineral germanite. The silver is said to occur mainly with the sulphides of copper rather than in the lead, but thin films of native silver have also been found. Some of the blende has been found to be tribo-luminescent.

The following values of the copper, lead and zinc content of the ore above and below the 6th level have been computed from a large number of assay results:—

	Main ore-body.	*Aplite.*
Above the 6th level 0′ to 500′	Cu. 13–14%	6%
	Pb. 23–24%	10–11%
	Zn. 8–9%	3%
Below 6th level	Cu. 7–9%	(as above)
	Pb. 26–28%	
	Zn. 13–15%	

[1] Schneiderhohn, H., *op. cit.*; also Lindgren, W., "Mineral Deposits." (3rd ed. 1928), pp. 945–7.

The dolomite country rock shows much secondary folding, while post-mineral faulting has deformed and dislocated the ore-body in places. Although silicified, the dolomite shows no traces of contact metamorphic minerals.

The complex nature of the Tsumeb ores has given rise to many metallurgical problems, but a discussion of these is beyond the scope of this article. At the present time the richest ore, carrying over 10% copper, is shipped direct to Europe without treatment at the mine, the tonnage of ore of this class exported during the past year amounting to about 29% of the total mined. The rest of the ore is treated in the smelter at the mine and yields a 40–50% copper matte, containing about 20% lead and some silver, and pig lead carrying over 30 oz. of silver per ton. Some cadmium is recovered, but the zinc is dumped with the slags. The following table gives the figures for ore production, and export of ore, matte and pig lead from 1918 to date :—

	Ore	*Export (Short tons)*		
	Produced	*Copper-*	*Copper*	*Pig*
Year.	*(Short tons).*	*Lead Ore.*	*Matte.*	*Lead.*
1918	47,133	7,358	—	—
1919	29,758	6,400	—	—
1920	41,351	30,511	—	—
1921	81,359	42,644	1,414	198
1922	126,943	34,251	4,726	749
1923	128,793	38,521	4,390	407
1924	137,562	43,608	5,784	762
1925	126,112	48,114	6,142	1,532
1926	134,314	41,872	6,657	1,413
1927	161,694	37,638	8,385	3,710
1928	187,508	44,670	11,811	4,580

For the year ended March 31, 1930, the ore production was 184,000 tons, and ore exported 53,000 tons, averaging 12·7% Cu., 27·8% Pb., and 8·97 oz. silver per ton, in addition to 13,356 tons of copper matte, averaging 43·3% Cu., 20·7% Pb., and 23·28 oz. silver per ton, and 2,802 tons of metallic lead, averaging 96·9% Pb. and 37·87 oz. silver per ton. In terms of their metallic content the total exports for the year are equivalent to 12,510 tons copper, 20,209 tons lead, and 892,450 oz. silver.

Vanadium.—Apart from the Tsumeb mine no large bodies of lead or zinc ores have been found in the Otavi Mountains. There is at Berg Aukas (in the extreme east) a small massive deposit of zinc blende with a capping of smithsonite, descloizite and some silicate minerals, while at Abenab West a similar outcrop can be traced along a strike of 1,500 ft. More usually, however, the blende and galena are found in small veinlets in zones of fracture or in patches disseminated throughout the dolomite and none of these occurrences have been worked for lead or zinc. By the oxidation of these sulphides, however, and the formation of vanadates of lead and zinc, numerous deposits of vanadium ores have been formed. The ore minerals are principally :—

Descloizite $(PbZn)_2$ $(OH)VO_4$.

Cuprodescloizite $(PbZnCu)_2$ $(OH)VO_4$.

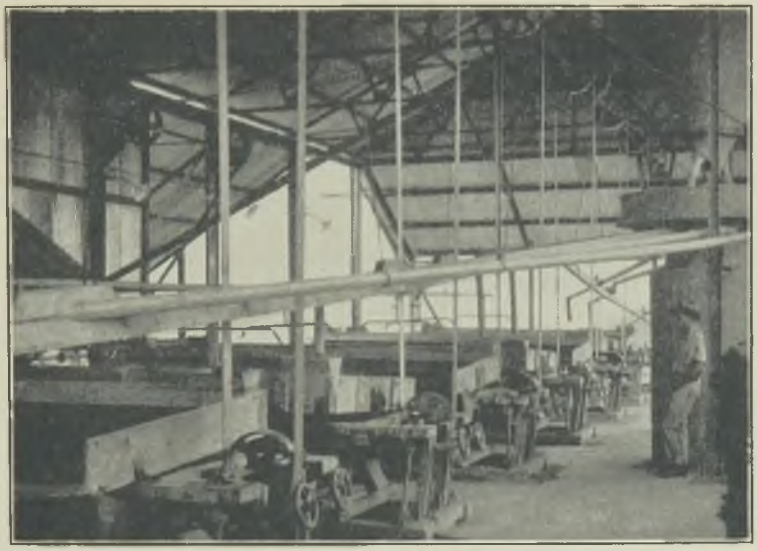
Vanadinite 3 $Pb_3V_2O_8PbCl_2$.

Psittacinite and mottramite—vanadates of lead and copper.

Of these, descloizite is by far the most abundant and most widely distributed, the others occurring in smaller amounts in certain localities. All these minerals are of the vanadate class and all contain lead. No uranium and no radio-active minerals occur with the vanadium. As mentioned previously, descloizite occurs in the oxidized portion of the Berg Aukas zinc deposit, associated with the zinc carbonate, smithsonite, and some beautiful specimens of these minerals were found lining large cavities in the ore-body. Mottramite occurs with the other oxidized minerals in the upper portion of the Tsumeb Mine and also in the small copper-lead deposit at Nosib, from both of which small amounts of vanadium ore have been recovered.

More important economically, however, are the numerous small occurrences of free vanadium ores which have been found at many places throughout the district. At surface the ore is usually found in lumps buried in red sand in pot-holes or in rubble-filled cavities in the dolomite. Some of these "sand-sacks" when worked out show no trace of ore *in situ* in the dolomite below the sand, but others are found to represent the weathered outcrops of ore-bearing pipes or sink-holes containing red cave limestone or dolomite breccia. The ore minerals, descloizite, etc., usually occur filling vugs or interstices in the breccia or encrusting the dolomite fragments or walls of the cavity and are occasionally associated with much secondary calcite. Although traces of galena and blende are frequently observed in the dolomite country rock in the vicinity of these deposits the ore is almost entirely free from sulphides. Of the two largest pipe-deposits—namely, Abenab in the north-east and Uris in the north-west—the former is some 200 ft. by 120 ft. across at surface and so far has been developed to a depth of over 200 ft.—while in the latter deposit

the pipe was 50 ft.–60 ft. wide and pinched out at a depth of about 250 ft. At Uris, however, a considerable quantity of vanadium was recovered from the pockets of eluvial ore at surface and it was only when these operations were being abandoned that the existence of the mineralized pipe was discovered. Smaller pipe deposits have been worked at Tsumeb West, Uitsab and Olifantsfontein and several places in the Otavi Valley and in the kopjes to the east of Guchab, while eluvial ore has been recovered from Uris and the adjacent workings at Karavatu and also from Berg Aukas. From the latter deposit some 13,000 tons of sand from the flats below the zinc-vanadium outcrop yielded over 700 tons of concentrates.



Abenab Mine: Overstrom Tables.

The Abenab deposit is the largest so far discovered in this district and is probably the world's principal producer of vanadium. Discovered in 1921, the mine lies between two small kopjes in the extreme north-east of the mountains about 20 miles north of the railway terminus at Grootfontein, with which it is connected by a good motor road. The dolomites here are steeply inclined towards the north and have been faulted, so that the upper dolomite now rests against the platy limestone, both hanging-wall and foot-wall rock being crushed and brecciated. Surface water circulating within this fracture zone has dissolved out a large pipe-shaped cavity, some 200 ft. by 120 ft. at surface, which has gradually become filled with fragments of dolomite, limestone and chert derived from the roof and walls of the cavity and ranging in size from a fraction of an inch to 2 ft.–3 ft. across, the larger blocks being mainly dolomite. The rock fragments are embedded in red cave limestone in which the ore minerals occur together with considerable amounts of calcite. Several smaller solution cavities carrying vanadium minerals have been found in the vicinity of the main pipe and thin films of descloizite have formed along the bedding planes of the platy limestone on the footwall side of the deposit. The zinc occurrence previously mentioned outcrops about 500 ft. south of the mine and can be followed for a distance of about 1,500 ft. towards the west. At its western extremity (Abenab West) the carbonate ore carries appreciable quantities of descloizite. Some patches of galena and blende are found in many places in the dolomite to the north and west of the Abenab mine, but no sulphides have been found in the main ore-body. Granite underlies the flats to the south, though covered over by secondary lime and red sand.

The chief ore mineral at Abenab is descloizite, which occurs in small well-formed orthorhombic crystals in a crystalline aggregate with calcite or in the red filling of the breccia. Below the 4th level, however, (at a depth of about 120 ft.) a considerable quantity of vanadinite is found in clusters of large prismatic crystals up to 3 in.–4 in.

long, usually coated with a film of descloizite, sometimes as much as $\frac{1}{16}$ in. thick.

The mine was opened up by means of an open-cast, and an inclined shaft was sunk in the footwall from which the ore-body was developed by five main and two intermediate levels at intervals of 30 ft., the ground on each level being blocked out in 30 ft. blocks. A main three-compartment vertical shaft was sunk in the dolomite some 150 ft. to the north-east of the open-cast to the 5th level at a depth of 180 ft. Ore and waste from the open-cast, which has now reached a depth of 150 ft., goes through passes to the main drive on the 5th level and is hoisted to surface through the vertical shaft. Recent development includes the deepening of the shaft and the opening up of a new level at a depth of 220 ft. which is about 20 ft. below the present ground water level. The ore, which is crushed and concentrated in a dressing plant consisting of Blake crusher, Krupp mills and Overstrom and James tables, contains slightly over 10% of concentrate averaging 18% to 20% V_2O_5.

The following are typical analyses of concentrates from Abenab and Uris (1926) :—

	Abenab.	*Uris.*
V_2O_5	18·31	18·75
Pb	45·15	45·57
Cu	0·96	9·99
Zn	13·90	4·12
P	0·041	0·036
CaO	3·15	2·26

The average V_2O_5 content of the Abenab concentrates is now over 19%.

Origin of the Vanadium.—The origin of the vanadium in these deposits has never been satisfactorily explained. Stahl [1] is of the opinion that the ores are concentrations of small quantities of vanadium contained in the primary sulphides of lead and zinc and states that samples of " almost pure " galena from Tsumeb showed amounts varying from 0·034% to 0·041% V_2O_5. The galena at Olifantsfontein and the zinc blende of Berg Aukas, however, were found to contain not even a trace of vanadium. Assuming that the vanadium in the galena as found by Stahl is of primary (magmatic) origin—which is doubtful—it is difficult to believe that deposits of any size could be formed by concentration from such minute traces, even taking into consideration the fact that surface erosion has been proceeding for a very long geological period. Stahl suggests that the upper portions of the primary deposits now eroded were much richer in vanadium than the lower parts still remaining. Deposits of hydrothermal origin, however, rarely contain vanadium [1]; in fact, roscoelite, the vanadium mica, is about the only hypogene mineral of vanadium and that is very scarce. It is generally believed, therefore, that the vanadium has been derived from some external source.

The known deposits of vanadium are few and of limited extent and it is regarded as one of the rare metals. It is, however, widely distributed throughout the crust of the earth, both in igneous and sedimentary rocks. The former, according to F. W. Clarke, contain an average of 0·017% vanadium,[2] which thus occurs in greater abundance in these rocks than many of the common metals such as copper, lead and zinc. It is present in greater amounts in the basic rocks, not as any definite mineral, but in pyroxenes, micas, rutile, magnetite, and ilmenite. Following the process of erosion and disintegration of the igneous rocks the vanadium is found in residual bauxites and laterites or is transported to the ocean and there precipitated along with the oxides of iron and aluminium in the red clays and terrigenous muds. The conditions under which precipitation takes place are not fully understood, but it is believed that biochemical reactions play an important part in the deposition of vanadium in these sediments. It is known to occur in sea-water in the bodies of holothurians and other animals which accumulate after death in the mud of the deep oceans.[3] That vanadium enters into vegetable and low animal life is also indicated by its presence, often in considerable amounts, in the ashes of bitumens, asphalts, coals, and petroleum. Vanadiferous sediments so formed constitute a potential source from which more highly concentrated bodies of ore may be derived by leaching, by meteoric waters and reprecipitation at the outcrops of lead-bearing deposits. Subsequent erosion of these outcrops has resulted in the migration of the more soluble vanadates and their concentration in deposits free from other metallic minerals.

[1] Stahl, A.: Unpublished Report; also *Zeitschrift für praktische Geologie.* Okt. 1926.

[1] Lindgren, W.: " Mineral Deposits " (3rd ed.), pp. 460–1.

[2] Clarke, F. W.: " The Data of Geochemistry."

[3] Lindgren, W.: " Mineral Deposits " (3rd ed.), p. 32 and p. 285.

PANAMA

By V. F. STANLEY LOW, M.I.M.M.

In this article the author, having previously described the alluvial prospects in the concessions of the Panama Corporation, pays particular attention to the lode-mining developments.

Since the first of these two articles appeared in the April issue of the MAGAZINE questions have been asked with regard to the lava-covered deposit on the Atlantic coast of the Panama Corporation's concessions. I would therefore add to what has already been written that there is a considerable variation in the thickness of the gravel at El Mineral. In the "Gold Tunnel" there is a maximum thickness of 11 ft. with an average of 5 ft. The aggregate area of the blocks which are now receiving attention amounts to a little over 100 acres. The difficulty in arriving at an accurate estimate of the gold values is well demonstrated in the above tunnel, which, in passing across the old river bed for a distance of 444 ft., has cut through patches of gravel running as high as £10 per cu. yd. in gold values.

At the time of my first visit nearly all the attention was being given to prospecting for payable lode material. It was on my advice that the prospectors were instructed to examine the country for payable alluvial ground because, although I have always considered that the permanent success of the corporation's undertaking will lie in lode mining, I held the opinion that it would be as well to secure the more ready return obtainable from dredging and sluicing operations.

In the earlier days of the campaign our first camp was established at the Remance mine, in the Veraguas concession, and the development of this property was immediately taken in hand. Remance was a partly-worked mine in which the sampling assays, as shown on the vendor's plans, were found to be in accordance with, and even a little lower than, our own. I had the mining engineer's usual objection to resuscitating a partly-worked mine, but the developments which have taken place have shown how unwise such objections can prove. Under the previous owner the mining had been well and systematically carried out, but in the treatment of the ore an unsuitable form of crushing had been adopted and only the sands, after the crushed material had been submitted to amalgamation, had been cyanided. The slimes had been allowed to run to waste. Anyone who has had experience in the treatment of an ore consisting of partly-decomposed andesite and quartz will be aware of the great gold losses which may be expected if the slimes produced during crushing are not submitted to cyanidation.

OLD TREATMENT PLANT: REMANCE MINE.

As soon as the corporation's officers

settled on the property vigorous development work was taken in hand, with the result that from the north end of the No. 5 Level to the south end of the Powder Hill Adit the Remance main lode has been developed, with the exception of about 500 ft. at the end of the No. 4 Adit, for a continuous length of over a mile, by adits and tunnels driven within the ore-body. The blank at the end of No. 4 Adit, which was already over 2,400 ft. long, was left for purely economic reasons. There are six levels in all and in these and in the shafts, winzes, and rises the development carried out aggregates over 18,000 ft.

Powder Hill Workings: Remance Lode.

Sinking below the lowest drainage adit (No. 4) was delayed pending the installation of suitable pumps. As soon as these had been installed the shaft was sunk to the 5th Level, 100 ft. below the No. 4 Adit, and driving along the lode was taken in hand. During the course of these explorations a run of ore was opened up which averaged £17 of gold per ton for a length of 71 ft. over a width of 29 in. As this was so much richer than the ore for which the mill had been designed, a sample hundredweight was sent to London for a laboratory test. There is no gold visible in the material on this part of the mine. Microscopic examination shows that the gold has become blackened. There is a certain amount of iron pyrites present. The sample sent to Messrs. Holloway and Co., and tested by them, contained 178·4 dwt. of gold and 6·87 oz. of silver per ton of 2,000 lb. It also contained base metals in the following proportion:—Lead 0·06%, copper 0·08%, arsenic 0·013%, tellurium 0·001%. The ore was crushed to pass through 150 I.M.M. mesh and submitted to cyanidation for 18 hours, with the result that a recovery of 98·7% of the gold content was obtained, thereby showing that no modification of the plant now just completed would be required for treating this class of material. The consumption of cyanide was from $2\frac{1}{2}$ to $3\frac{1}{2}$ lb., with 6 lb. of lime for alkalinity, per ton. Tests for treatment by simple amalgamation gave a recovery of only 52%.

The main shaft has recently been sunk to the 6th Level, 200 ft. below the lowest drainage adit, and from the cross-cut put in to cut the lode driving north has been commenced. The latest advices received from the field stated that the drive was in 50s. ore, although 500 ft. short of coming under the high values encountered in the 5th Level, 100 ft. above.

The treatment plant, which has been constructed close to the main shaft, is designed to treat, in the first instance, 100 tons of ore per day, but is capable of enlargement to a capacity of 300 tons per day. In design it follows the usual modern all-sliming cyanide practice:—Storage capacity for crude ore, jaw-breaker, Symons

cone crusher, crushed-ore bins, Hardinge mills, Dorr classifiers, agitators, thickeners, Merrill-Crowe precipitating plant, filters, etc. The several laboratory tests which have been made have shown that the ore is easily amenable to cyanidation and that a good recovery can be relied on. There is already a good tonnage of ore lying in the stopes ready for treatment. The first stoping operations are being carried out in the southern, or Powder Hill, end of the lode and samples taken from the broken material show higher values than would have been expected from the systematic sampling which had been done in the adit below.

Santa Fè Village : Veraguas Concession.

Electric power is used throughout the mill and for underground pumping, as well as for compressing air. The power plant is situated close to the river, some 3½ miles in a direct line of the Remance workings. Power is generated by three 6-cylinder Diesel engines of 450 b.h.p. each, running at 300 r.p.m., direct coupled to alternators, each of which has an output of 310 kw. at 0·775 power factor when generating at 3,300 volts and 50 cycles. The current is transformed down to 440 volts at the mine.

The development and ore extraction are at present confined to the main Remance lode, which has an outcrop length of over 9,000 ft. There are, however, eight other veins which outcrop close at hand and these have, so far as examined, an aggregate length of outcrop of over seven miles. These veins and outcrops will have closer examination when the new plant and the necessary stoping operations have settled down to regular routine work.

The Mina Blanca mine at Hatillos is situated at a distance of about six miles, air-line, to the east of Remance. Here an outcrop containing gold, silver, lead, zinc, and copper had been followed for a considerable distance at the time of my first visit. The first 50 ft. of driving returned a gold assay of 39s. per ton over a width of 37 in. In the absence of all mechanical appliances and of pumping machinery, in order to prove this occurrence at the greater depth of 130 ft., the engineer in charge of operations had sufficient pluck to go down hill and start a tunnel 1,000 ft. away in order to come vertically under the rich ore followed above. Such methods of mining would not appeal to the mining engineer under ordinary circumstances, but at a distance of 300 ft. short of the outcrop above ore was encountered which assayed 7 dwt. of gold per ton. This was carried on, more or less varying in value, until the adit came vertically under the rich ore referred to. When this point had been reached the adit was carried on for the first 100 ft. in ore which assayed 112s. gold per ton over a width of 39 in. This increase in strength and value at a depth of 130 ft. is one of

much importance. The shaft is being sunk to an added depth of 100 ft. to further prove the lode and sinking beyond this depth will be continued. There appears to be a great future before this mine.

It has been customary in the corporation's reports to quote gold and other values at Remance and Mina Blanca as being so much per ton over widths of 4 or 5 ft. This has led to the idea that such is the total width of the ore-bodies at these mines. As a matter of fact, the mineralized material which forms the complete ore-body lies between two hard walls of unaltered andesite and extends to widths of 60 ft. and over. In this ore-body there are well-defined segregations of mineral, running more or less parallel with the general strike and sometimes joining those portions in the lode formation, to which the published figures have generally referred. It only needs to be added that in the main ore-body at Mina Blanca, in comparatively recent times, additional rich veins beyond that which is known as the main vein have been opened up and that these veins have shown gold values assaying as high as 16 dwt., and up to 49 dwt., of gold per ton at No. 1 Adit, rising to 28 dwt., and as high as 80 dwt., of gold per ton at No. 2 Adit, over widths varying from 30 in. to 54 in. Up to the present cross-cutting towards the lode at the lowest level has been prevented by the presence of water, but all that trouble will be obviated when the mine has been connected with the power plant which is now operating the machinery at Remance mine.

As the higher gold values in the Mina Blanca ore follow the quartz and as there is considerable difference in the various parts of the mine, much trouble was taken in selecting and mixing samples taken from various places for laboratory treatment, in order that the material experimented upon would be as representative as possible of the expected run-of-the-mine. The most comprehensive tests were those carried out by Messrs. Holloway and Co. on various samples of ore consisting of highly mineralized quartz mixed with andesite. The mineralization consisted of galena, blende, and a little copper pyrites. Minute crystals of iron pyrites were also disseminated in the quartz and andesite. No gold was visible, but when the crushed material was tabled a streak of gold was discernible above the galena. The free gold, determined by amalgamation, varied in the different samples from 20% to 60%. In some of the samples which were exceptionally high in mineralization material which had been taken for gangue containing fine pyrite, together with a small proportion of galena, was found to contain as much as 74 dwt. of gold per ton. Quartz carrying only a little pyrite contained 14·8 dwt. of gold per ton.

The following analysis will show the variation in mineral contents of some of the samples taken from the Mina Blanca main vein :—Lead ore : 38·5% lead, 24·2% zinc, and 3·5 dwt. gold and 2·4 oz. silver per ton. Blende ore : 4% lead, 18% zinc, and 2·9 dwt. gold and 0·9 oz. silver per ton. The following figures refer to two samples which appeared to consist mostly of gangue :— (1) 0·67% lead, 1·8% zinc, and 63 dwt. gold and 1·5 oz. silver per ton, and (2) 0·4% lead, 0·87% zinc, and 74·3 dwt. gold and 1·5 oz. silver per ton. After a good many trials a mixture was made from the various samples with an assay value per ton of 8·39% lead, 11·76% zinc, 0·27% copper, 5·98% iron, 9·43% sulphur, 10·5 dwt. gold, and 1 oz. silver. In further attempts to make a mixture the gold content could not be got below 20 dwt. per ton.

Direct differential flotation of the mixed ore gave an extraction of 55% to 60% of the gold in a lead concentrate and cyanidation of the flotation tail gave 25% to 35% of the gold in the original ore. From this it would seem that an extraction of 90% and over can be expected. As to whether flotation should precede cyanidation or vice-versa, this will be determined by the pilot plant of 100 tons per day, which is to be erected in such a manner that either step in treatment may be made to precede the other.

Amalgamation gave an extraction of 30% of the gold in the original mixture and table concentration gave 30% of the gold in a lead concentrate containing 71% lead and 490 dwt. of gold per ton. If table concentration were adopted as part of the treatment it would be necessary to follow it by cyanidation and flotation.

Messrs. Holloway reported, at the conclusion of their very careful laboratory tests, that the recoveries of 88% to 90% of the gold, 85% of the lead, and 83% of the zinc obtained thereby would probably be exceeded in practice.

The pilot plant contemplated will consist of :—Jaw-breaker, Symons cone crusher, Hardinge mill, Dorr classifier to 120 mesh, counter-current cyanidation, agitation,

thickening, Merrill-Crowe precipitation and filtering, and flotation in Minerals Separation plant, followed by filtering. It is probable that the Mina Blanca mill will be connected with the Remance new power plant, which is distant only about seven miles in a direct line. If so the power plant will be enlarged to supply the extra output required.

At Hatillos I visited the latest discovery of ore, which outcrops some 3,000 yd. north of the Mina Blanca lode. At the time of my inspection only the first part of the outcrop had been discovered. A sample which I took from the surface assayed 23 dwt. of gold per ton and before I left Panama on my return to England the outcrop had been traced for over 1,500 ft. with the following result: At 128 ft, from the discovery point the ore averaged 14 dwt. of gold per ton, at 400 ft. the assay was 15 dwt. of gold, at 1,200 ft. it was 5 dwt., and at 1,500 ft. the assay was 7 dwt. of gold per ton of ore. This discovery is of great importance, as it has so greatly enlarged the known mineral-bearing area in the Hatillos district.

On my last visit, when I was travelling overland from the Atlantic coast and El Mineral, I turned off at Santa Fé. My mule ride was over a rough precipitous road through the high mountain ranges which, in the earlier stages, opened up some beautifully grand scenery. We rode for nine and a half hours, without stopping for food, and eventually reached Cañazas none the worse for the long ride. The journey was one on which I was glad that my mount was a mule and not a horse. For a timorous person the ride would have been in many places a nerve-racking experience, as the tracks were often so narrow and rough, and left so little margin along the edge of the precipitous ground, that a rider given to thinking would frequently figure that there was only a small misstep on the part of his mule between himself and perdition. A great deal of the country passed through, as well as a great part of that immediately outside Cañazas, is almost identical in appearance with that found at Remance. In fact, the similarity in certain places is so great that but little imagination would be required to delude one's self with the idea that one had been unknowingly transplanted into the Remance area and was in reality sitting on the Remance outcrop. This refers to the part of the Cañazas area which carries gold as a primary metal. In the area in which gold appears as a secondary metal to silver and copper the surface has an entirely different appearance, being smoother, more grassy, and, generally speaking, having more of the outlook of a grazing than of a mineral-bearing country. I am told that this country is very similar to that in some of the copper-bearing areas of Rhodesia.

ON THE TRACK TO THE ATLANTIC COAST.

I had always had high expectations of

seeing a wide mineral-bearing belt in the Cañazas concession and my recent visit more than confirmed my expectations. The ore-bearing indications are so widely distributed over such a large area that preliminary investigations have up to the present carried our men to many places far distant from each other, but these preliminary investigations have indicated where further work should be concentrated. So far at least eight different groups of prospects and outcrops in the area contiguous to the village of Cañazas have received attention.

Close to the village of Cañazas are the outcrops of Molienda, Santa Rosa, and San Juan. A considerable amount of open-cast work had been done on this line of outcrops by the Spaniards and an examination of these shows that the well-defined lode displayed at Molienda and Santa Rosa has split up into stringers at San Juan, which appears to be the south-western termination of this run of lode. In the shaft sunk on the Molienda portion of the lode, distant about one and a half mile from the village of Cañazas, samples taken for me at a depth of 47 ft. showed values of 20 dwt. and 21·6 dwt. of gold per ton over a width of 5 ft. The Molienda outcrop can be easily traced for 1,400 ft. and the Santa Rosa hill is about 1,200 yd. long. The Viriguas and Pandura group is seven hours' mule ride north-west of Cañazas village. In this group should also be included Pintada, which is yet another hour's ride ahead. The twin peaks of Viriguas form a prominent landmark in the district and in one of them is a fissure carrying about 18 in. of quartz, kaolin, and pyrite. The Pandura ridge, which connects with these hills, was considerably worked by the Spaniards by means of open-cuts. On the slopes below these open-cuts the natives of the district "speck" for gold after any heavy rainfall. They say they have found gold up to 5 grains in weight on the surface slopes of this hill.

Pintada is on the eastern slope of Pandura hill. It was here that bornite containing 973 oz. of silver and 47% of copper per ton was discovered. A sample ton sent to London contained 790 oz. of silver per ton and 16% of copper.

Cañazas Village: Chiriqui Concession.

At Cerro Plata, north-east of Pintada and about 25 miles from Cañazas, an outcrop discovered in the creek bed has been traced for 2,000 ft. to the north and for a similar distance to the south. Adits have been driven on this ore-body. The nature of the ore can be seen from the following assays:—7·2 dwt. of gold and 21·1 oz. of silver per ton, 0·13% of copper, 5·6% of lead, and 8·7% of zinc. Assays as high as 19·2 dwt. of gold with 28·5 oz. of silver and 39·2 dwt. of gold with 10·4 oz. of silver per ton have been obtained in the adit.

At La Hueca, two and a half hours by mule from Cañazas village, a large body of copper-bearing rock can be traced for about three miles with a width of about half a mile. A sample taken over the bottom of a pit

sunk to a depth of 6 ft. in this formation returned a value of 1·4 dwt. gold and 7·1 oz. silver per ton and 56·0% copper.

At various distances west and south-west of Cañazas lie other groups of mines—Blandito, Las Animas, San Bartolo, and Lajitos—but space does not allow of a description of these.

An interesting occurrence of gold is that at Guaca, in the hills about four miles south of Cañazas village. Here a syndicate of three private individuals is working a mine on the pillar-and-stall system and treating the ore by grinding in a small Hardinge mill, classifying, and amalgamating. The machinery is driven by a Pelton wheel. The ore-body lies almost flat, the payable portion being about 48 in. thick. The richest portion consists of a hard band of quartz, from 6 to 12 in. thick, which forms the floor, and this, together with the immediately overlying andesite, has been profitably extracted and treated. The area from which the extraction has taken place now amounts to about 500 ft. long by about 300 ft. wide.

One of the most interesting outcrops which I inspected was on the most recently acquired of the corporation's concessions —the Rodriguez. Prior to my visit a sample, taken from the lode on the main highway from Panama City to Santiago, assayed 17 dwt. gold per ton. Higher up the hill I followed the outcrop, where samples had shown a value of 4·8 dwt. of gold per ton over a width of 12 ft., and still higher up, probably about 1,000 ft. from the road, where the outcrop had assayed 8·8 dwt. over a width of 8 ft. Our prospector stated that he had traced this outcrop for a length of three miles and that its width varied from 4 ft. to 20 ft. This outcrop was found crossing the main road at what will be about 30 miles from Panama when the shortened route, which is now under construction, has been completed. It is only three miles distant in a direct line from the seaport of Capira. It is therefore very readily accessible by either road or sea. The country is hilly and contains much timber suitable for building or mining. The rock is of a free milling nature and there is abundant water for all purposes. Altogether the outlook is extremely encouraging.

Starting from the La Mina outcrop just described, and travelling towards Santiago, the Rodriguez concession is eventually left and, after travelling by a circuitous main highway and a few miles of side road, Mina Blanca, at Hatillos, in the Veraguas concession, is reached. I should judge the air-line distance from La Mina to Mina Blanca to be about 70 miles. About six miles distant in a direct line from Mina Blanca is the Remance mine. Again, ten miles further west is the Molienda mine and 20 miles north-west of Molienda is the Cerra Plata prospect. It will be thus seen that there is a series of auriferous lodes

A Flooded Camp in Darien.

outcropping over a width of at least 100 miles. These are only some of the lodes which the Panama Corporation has had time to examine or to develop to date. Many others are known to exist, as well as some on which a certain amount of prospecting has already been done, and there yet remains much virgin country to be explored.

This concludes a summary description of the concessions and the operations of the Panama Corporation. When it is remembered that the concessions cover an aggregate area of 7,150 square miles it can be well understood that a detailed description of the many places to which attention has been devoted would take up much space and would lose interest to any but those actively engaged in opening up, prospecting, and developing these large tracts of country in which the results already obtained lead me to anticipate a great future for mining in this part of the world.

GEOPHYSICAL TESTS IN THE RHINE VALLEY

By R. P. REICHENBACH, D.Eng. Berlin, and H. BERTRAM BATEMAN, A.R.S.M., A.I.M.M.

In this article the authors describe the investigation of certain structural conditions by three methods of geophysical exploration

One of the essentials for geophysical work is, naturally, a thorough study of the geological conditions obtaining, upon which eventually depends the choice of the geophysical method to be applied. It will be taken for granted on this occasion that the principles of the methods themselves are known to the reader, the purpose of the present article being to demonstrate, by quoting examples of surveys, how it is now possible to elucidate structural conditions by means of applied geophysics. Without going into details of the geological conditions, the results of some geophysical investigations carried out in the Rhine Valley by the "Elbof" Geophysical Company of Kassel and London will be shown. Up to the present these results have not been made public.

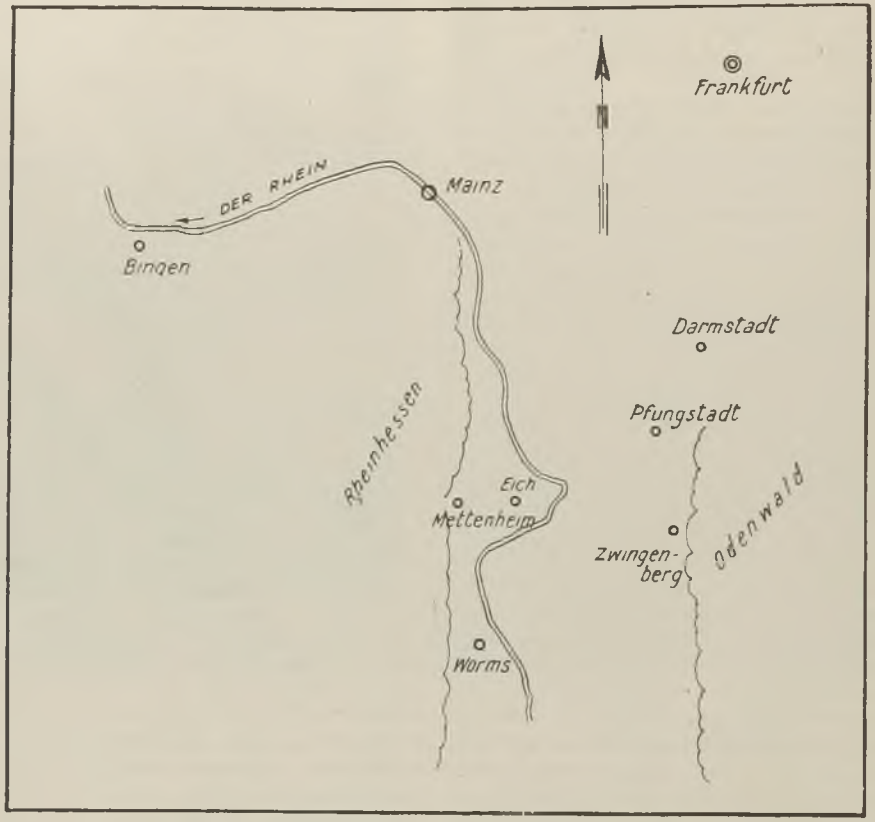


FIG. 1.—SKETCH MAP OF UPPER RHINE VALLEY.

In the Upper Rhine Valley, South of Darmstadt, gravimetric measurements were carried out for the purpose of locating the position of step-faults on the east and west banks of the valley underground, and of obtaining a general idea of the extent to which the bedrock had sunk. A profile about 20 km. long was measured, having intervals of 300–500 m. between the torsion-balance stations. This profile runs from the foot of the Odenwald at Zwingenberg and terminates at Mettenheim on the left side of the Rhine Valley (Fig. 1). Density tests made on Odenwald granite and on sedimentary rocks from the Rhine Valley showed sufficient density differences to guarantee a satisfactory solution of the problem—always provided that the bedrock below the Rhine Valley was likewise of granite.

The direction of the gravimetric profile

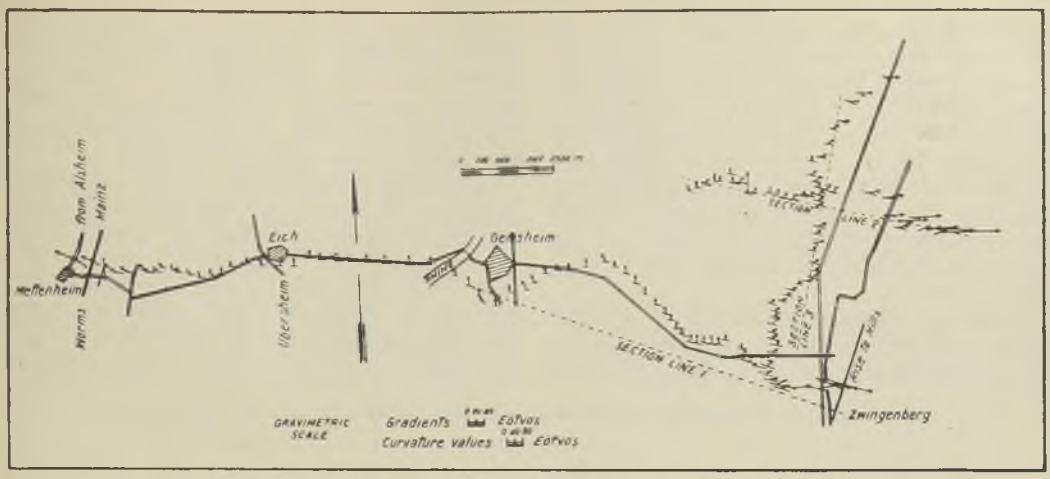


FIG. 2.—GRAVIMETRIC MEASUREMENTS IN THE RHINE VALLEY.

and the distribution of the torsion-balance stations can be seen from Figure 2. Local conditions having to be considered, it was not possible to adhere throughout to the straight profile-line at first contemplated; which fact, however, did not materially affect the results. Topographical influences have been eliminated from the results shown.

On looking at the diagram as a whole (Fig. 2), the length and persistent easterly direction of the gradients in the east is very noticeable; the gradients have a direction at right angles to the valley. Further to the west the direction of the gradients changes as they very soon show almost the same northerly tendency, and strike in the direction of the valley itself. It is not until the extreme west, on the left bank of the Rhine, that longer gradients again appear, which, however, have a distinctly westerly direction. The size of the gradients changes simultaneously with their gradual change from an easterly direction—northwards, and eventually—westwards. The highest values are found in the east. Both the great depth to which the bedrock has sunk and the steep slope of the sides of the valley make their influence equally felt. In the west, on the contrary, the gradient values are not at all so high. The way in which they swing round to the west and the proportion of their increase in length show that here the slope of the side of the valley is not so steep and that the bedrock no longer lies at such a great depth as in the east. For the present no account will be taken of the torsion-balance profile running from Zwingenberg northwards which is shown in Figure 2.

The values of curvature show an extraordinary regularity in direction, which indicates that local disturbances caused by density differences near the surface are practically absent. Thus the overburden is highly homogenous and the results of the measurements are those produced solely by underground influences at depth. From

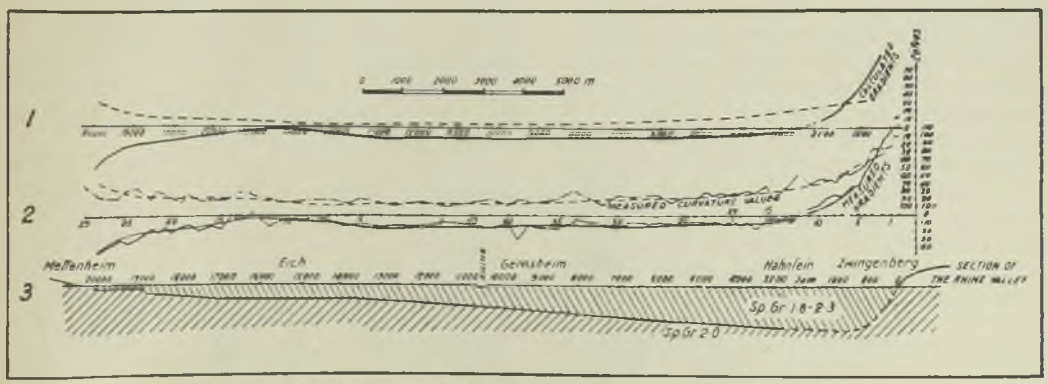


FIG. 3.—GRAVIMETRIC MEASUREMENTS IN THE RHINE VALLEY.

Figure 2 it can be deduced that the gradients may be split into two components, of which one is parallel to the strike of the valley, the other being at right angles to it. In this case the latter will show the valley influences solely, the former showing the extent of the northward rise of the bedrock. The fact that such a rise exists is proved by the general northerly tendency of the gradients, to which attention has already been drawn.

If the gradient components lying at right angles to the valley be arranged into a co-ordinate system—their length as ordinate and the distance between the torsion-balance stations as abscissa—then a curve is obtained which permits of the shape of the sub-surface valley itself being calculated, as far as the density differences are known. The results are shown in Figure 3, the upper curves (1) showing the calculated values for gradients and values of curvature, the lower curves (2) the values resulting from the measurements. It can be seen that the calculated values of the gradients for the geological profile underneath (3) coincide with the measured values to within +1 unit. This is not so in the case of the values of curvature. The difference between the calculated and the measured curve which, however, are similar in shape, amounts to about 25 units; the measured curve lies higher than the calculated one. This, as well as the general northward tendency of the gradients, leads to the conclusion that the bedrock must rise northwards.

To obtain confirmation of this, measurements were made on the profile already mentioned, running south to north from Zwingenberg to Pfungstadt (Figure 2). Here too, the tendency of the gradients is a regular northerly one, although they decrease gradually in size in that direction. At the more northerly torsion-balance stations the influence of the steeply rising banks of the valley makes itself felt again, as can be seen from the switching round of the gradients to the east, which indicates that somewhere in the vicinity of Darmstadt the highest point in the rise of the bedrock has probably been reached.

As may be seen from the sketch of the geological profile (Figure 3), the lowest point to which the bedrock had sunk was recorded on the outskirts of the Odenwald, where it lies at a depth of about 1,200 m. From here it rises gradually and regularly westwards as far as the left bank of the Rhine to approximately the neighbourhood of Eich. From there it runs almost horizontally

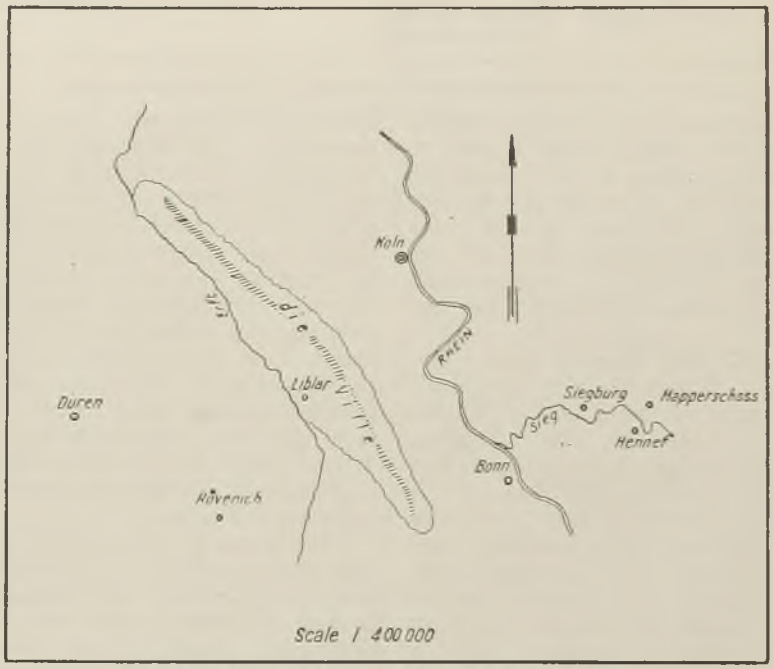


FIG. 4.—SKETCH MAP OF LOWER RHINE VALLEY.

and then rises again very gradually. Apart from some unimportant slips, two large faults appear here.

Thus, the results of the gravimetric survey in this area show that the bedrock rises from south to north and also from east to west. The greatest depth to which it has sunk is on the outskirts of the Odenwald, but, on account of the great depth and the steep rise of the banks of the valley, it is only possible from the gravimetric results to give an approximate estimate of the depth. Furthermore, it could not be determined from these measurements whether the sinking process at the edge of the Odenwald had taken place in the form of steps, but from the general geological facts, this must be assumed to be the case. The faults, located by the torsion-balance measurements, which have originated during the sinking process on the western edge of the Rhine valley, suggest step-formation, but it is probable that a considerable number of minor faults are also present. In view of the fact that the gravimetric survey was only intended to elucidate structural conditions in a general way—not to procure details of peculiarities—the results obtained must be regarded as highly satisfactory.

Seismic measurements carried out in the Lower Rhine basin south-west of Cologne (Figure 4) will serve as a further example of the elucidation of structural conditions. This work was carried out for the Liblar mine, with the object not only of determining the existence and strike of faults, but also to localize the depth of the bedrock underneath the tertiary overburden. We should like here to express our thanks to the directors of the Liblar mine for permitting the publication of the results.

As is already known, two principal systems of faults occur in the Lower Rhine basin, one striking N.W.–S.E., the other approximately N.–S. In this connexion reference should be made to the detailed geological surveys carried out by Mr. Fliegel.[1]

The results of the survey carried out by means of the seismic method are shown in

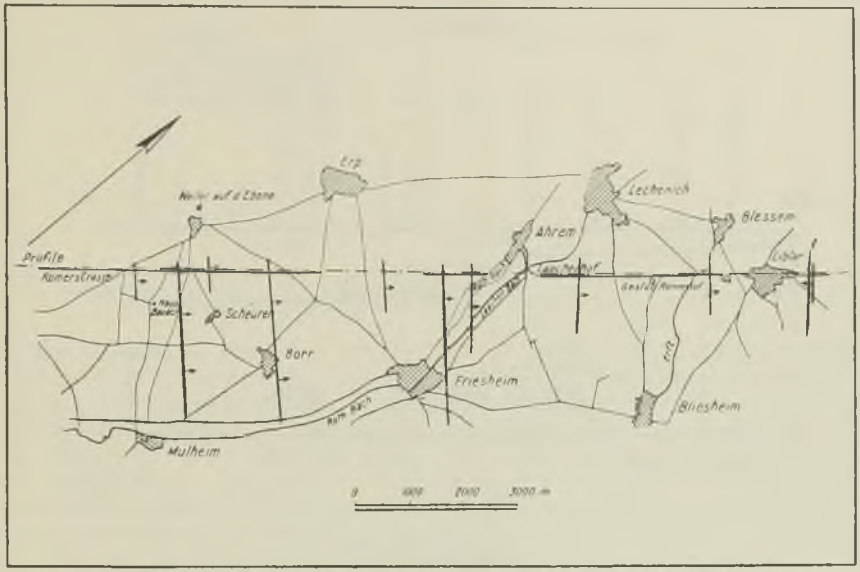


Fig. 5.—Plan of Seismic Measurements in the Lower Rhine Valley.

the accompanying diagrams. First a plan of the position is given (Figure 5), from which it can be seen that the measurements in the southern portion of the Lower Rhine basin were carried out approximately between Rövenich and Liblar. As the results of the measurements shown here refer only to seismic profiles which run in a S.W.–N.E. direction, the only faults which appear are those having a N.W.–S.E. direction of strike. The length of the area surveyed is about 15 km.

The next diagram (Figure 6), shows the seismic results in a diagrammatic section. In the south-west of the profile we are on the ridge of Lommersum. In the north-

[1] G. Fliegel; Der Untergrund der Niederrheinischen Bucht. *Abh. d. Pr. Geol. L.A.* New Series, Vol. 22, Berlin, 1922.

east, the Tertiary deposits increase in thickness in proportion to the step-like sinking of the bedrock. In the neighbourhood of Liblar the thickness is at its greatest at about 900 m. On the edge of the Ville Mountain range the bedrock rises again. It was drilled through as Devonian to a depth of 398 m. under the lower edge of the coal-seam in the open-casts of the Liblar mine; the seismic measurements determined the depth to be 400 m. In the south-west portion of the profile the bedrock was likewise considered to be Devonian, as the strata occurring at this depth show similar seismic peculiarities to conditions in this area. A comparison of the two profiles shown in the diagram makes this quite clear. In addition, the seismic measurements were able at the same time to determine the thickness of the Tertiary deposits, which was particularly important in this case on account of the occurrence of thick brown coal seams at a greater depth than was previously supposed. Unfortunately, it has not been possible to obtain permission to show the position of the brown coal seams in this area in the diagram. In addition, no details can be given about the dip of the bedrock or of the Tertiary, as this was not part of the

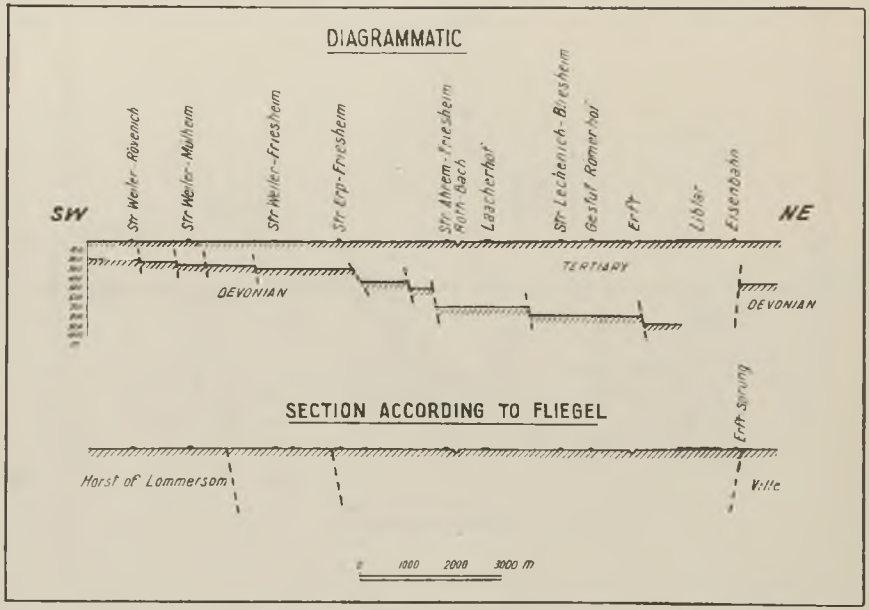


Fig. 6.—Subsurface Structure obtained by Seismic Survey.

those at Liblar. However, the geological age of these strata has not been definitely determined, unless bores have been sunk in the meantime to corresponding depths, but we have not heard that this has been done.

In this diagram a section is shown for comparison, which, according to data found in Fliegel's work, has been constructed in the same profile line as the seismic one, that is, approximately in the direction of the Romerstrasse. It can be seen that the seismic measurements were able to determine a remarkable number of faults of varying throw which dip north-eastwards. As compared with the number of faults determined by the geological investigation, the seismic measurements have considerably widened the knowledge of structural purpose of the survey, although this problem is one which could be dealt with by seismic measurements.

Lastly, brief reference can be made to radio-activity test measurements which were made at Hennef-on-Sieg (Figure 4). As a rule radio-activity measurements are not applied independently, but only as a supplement to other methods. As the radio-active properties of the ground-air are known to increase in fissures and faults, such a structural line can often be easily traced by this method. In some cases, moreover, it is even possible to give details of the dip of faults, etc. For instance, should a fault be located seismically, then radio-activity measurements can follow and determine its strike in a comparatively short space of time. A similar method of

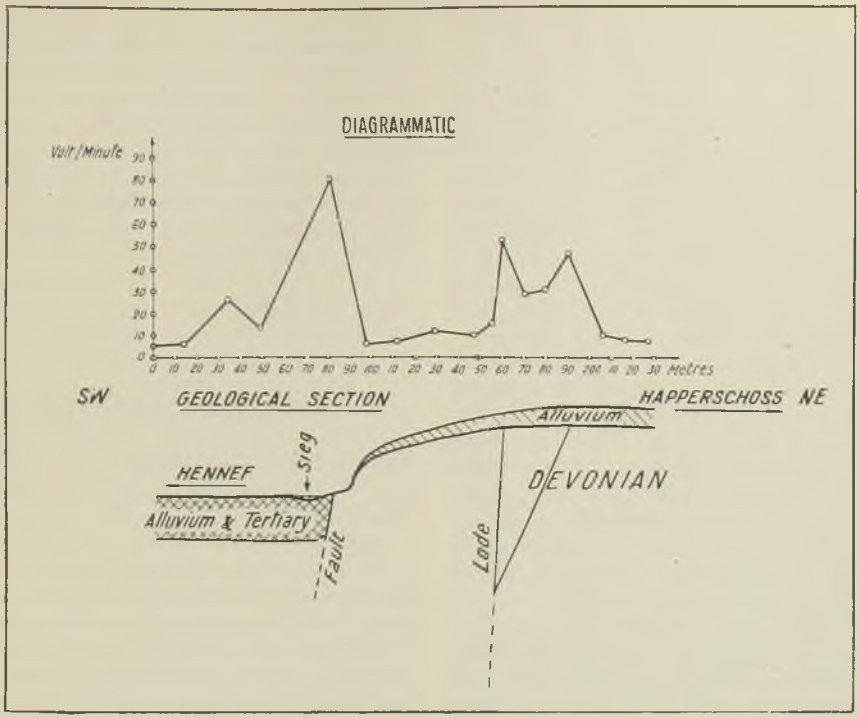


FIG. 7.—RADIO-ACTIVITY MEASUREMENTS OVER FAULT AND LODE.

procedure was adopted at Hennef in so far as geologically known facts were used as foundations for the measurements.

A diagrammatic geological section is shown in Figure 7, the vertical scale being much exaggerated. The fault on the edge of the Kölner Basin is marked thereon and also two lodes whose position and dip are known from actual development work. The result of the radio-activity measurements can be seen from the curve of the measurement values shown in this figure. The reduction of the static electricity occasioned by the conductivity of the ground air being ionized by radio-active substances is measured in volts per minute by an electrometer. The radio-active content of the ground air increases greatly above the fault and decreases immediately afterwards (Figure 7); it is only over the two lodes that it again increases—not, indeed, to such an extent as above the fault on account of the thick alluvium overburden. Similar measurements have proved on various occasions the efficacy of the method for solving this kind of problem.

The results of these different geophysical surveys demonstrate that the practical geophysical methods now available, if expertly applied, can give very valuable data, not only on the geological conditions of an area from the mining point of view, but also from the purely geological standpoint.

LETTER TO THE EDITOR

The Netherlands East Indies Geological Survey

SIR,—The book "Methods in Geological Surveying" contains on p. 119 a statement that practically the whole of the East Indian Archipelago is untouched as far as geological mapping is concerned. This is so unjust to my colleagues of the Netherlands East Indies Geological Survey that I will ask you to grant me some space to describe their organization and work.

As is generally known, the Government of the Netherlands East Indies works certain industries itself. One branch of the Government Industries Department is the Mijnbouw, or Mines Department. A branch of this again is the Opsporingsdienst, or

Research Service, which comprises the Geological and Vulcanological Surveys. The Mijnbouw produces a periodical, the *Jaarboek van het Mijnwezen*, in two parts, one containing geological papers, the other being the "General" part, with a list of staff, a statement of work done, and mineral statistics. The "General" number for 1929—the last to reach me—shows that in that year the Opsporingsdienst had a staff of 28 geologists, one agricultural geologist, two palaeontologists, one petrographer, and one petrological chemist. Nearly all these officers are Dutch and, in accordance with the excellent scheme of education in Holland, can talk and write English, French, and German well, which makes communication simple for those who, like myself, were made to spend much time in early days on classics and learning the Odes of Horace by heart. The geologists of the Survey staff are now housed in a Geologisch Laboratorium, at Bandoeng, in Java. This is a two-storeyed building, with well-equipped laboratories and space for showcases. The cost was about 250,000 guilders. The Director still has an office in the even more palatial building of the Government Industries Department.

The *Jaarboek van het Mijnwezen* was first published in 1871, but work by Dutch geologists has not been confined to its pages and maps. The most famous of all geologists who have worked in the Netherlands East Indies was R. D. M. Verbeek, who laid the foundations of geological study there. He produced geological maps of part of Sumatra (1883), of Banka and Billiton (1897), parts of the Moluccas (1908), and Ambon (1898, in collaboration with Koperberg), but his finest work was the map of Java and Madoera that he and Fennema published in 1896. This is in 26 sheets on the scale 1 : 200,000, the area covered being about the same as England. Another well-known geologist, Molengraaf, mapped parts of Central Borneo and published his results in 1902. Wing Easton published a geological map of part of West Borneo in 1904. The staff of the Netherlands East Indies Geological Survey is now producing, sheet by sheet, a Geological Atlas of the whole of their large territories, revising and amplifying old maps and mapping new ground. The *Jaarboek* for 1929 states that in that year parties were working in Sumatra, Java, West Borneo, East Borneo, and Celebes.

The authors of "Methods in Geological Surveying" very rightly eulogize the work of pioneers in English geological mapping, such as De la Beche, whose map of Cornwall, Devon, and West Somerset no one appreciates more than myself, but when they ignore the work of Verbeek they are guilty of a bad mistake, because Verbeek covered more ground with his geological maps of parts of the East Indies than the total area of England and Wales.

J. B. SCRIVENOR.

Batu Gajah,
March 2.

BOOK REVIEWS

Surveying Calculations. By FREDERICK WINIBERG. Cloth, octavo, 132 pages, illustrated. Price 12s. 6d. London: Mining Publications.

Owing to the development of the great Witwatersrand goldfield and to the establishment of huge mining enterprises in the United States and other parts of the world, the mine surveyor of to-day is called upon to perform with accuracy and speed an amount of expert work which would have been quite beyond the capabilities of the rule-of-thumb practitioner of earlier days. He has become an important technical officer, who in addition to his survey duties has often in his charge mine sampling, ore-reserve estimation, mine statistics and reports, geological records, and so on. Any publication, therefore, which will help in his training and serve as a work of reference afterwards is to be welcomed. "Metalliferous Mine Surveying" by the same author, was one of this helpful kind, and the present book is intended to serve as a companion volume to it. Though mainly confined to calculations arising from the practice of the methods described in the former book, it investigates other problems of interest to surveyors generally.

The first chapter is an introductory explanation of bearings, plotting, and rectangular co-ordinates, essential matters apt to be somewhat mystifying to the beginner. A suggestion may be made here that whole circle bearings or angles of direction are sufficient for the purpose of tabulation. Quadrant bearings are not really necessary beyond use in calculating the co-ordinates. The symbols x and y might also be substituted for the terms departure and latitude.

In Chapter II worked examples are given

of the Weisbach triangle, assumed bearing, Weiss quadrilateral, and three point methods of surface and underground connexion. Failing the simple alignment method with two wires, the first and second of these methods are the best ones to use ; the third and fourth are somewhat cumbersome.

Co-ordinate geometry and its application to the solution of surveying problems take up Chapter III. For rectangular or Cartesian co-ordinates we have to thank that versatile seventeenth-century philosopher, Descartes. For the application of the system to surveying we had to wait until the latter part of the Victorian age. A number of problems can be solved by co-ordinate geometry which otherwise would necessitate laborious trigonometrical computation. For instance, straightening a crooked boundary without alteration of respective areas is easily done with its aid. The equation of a straight line in terms of length and inclination of the perpendicular to the line from the origin can be employed for establishing the centre line of an incline shaft. This was done by the Government Gold Mining Areas (Modderfontein) Consolidated some years ago. A winze sunk 2,300 ft. at an inclination of 18° had to be widened and converted into an incline shaft. The equation of the centre line of the new shaft was determined from the co-ordinates of the survey plugs in the top and bottom of the winze. Intermediate survey stations in the hanging-wall approximately on the centre line were then surveyed in. From the calculated co-ordinates the exact distance of each plug from the centre line was determined, and the timbering and tracks were adjusted to the centre line thus found, and marked on small beacons on the footwall. When the timbering was replaced by a system of concrete sills the same method of surveying proved suitable.

Chapter IV deals usefully with calculations arising from levelling operations, V has a number of worked problems on the strike and dip of lodes and seams, and VI explains the ranging of railway curves.

Students endowed with a vigorous appetite for knowledge will find much sustenance in Chapters VII and VIII, which, with the help of searching mathematics, deal with adjustment of observations and propagation of error.

The book is well produced, and makes a commendable addition to the literature of mine surveying.

ALEX RICHARDSON.

Compressed Air Plant. By ROBERT PEELE. Fifth Edition. Cloth, octavo, 534 pages, illustrated. Price 37s. 6d. London : Chapman & Hall.

A new edition of such a standard work as Peele's " Compressed Air Plant " is always welcome, particularly when, as in the present case, it has been largely rewritten and brought up to date.

The book is divided into two main parts of approximately equal length. The first part (260 pages) deals with the production of compressed air. The theory is passed over in about twenty pages, but plant, the subject matter of the title of the book, is dealt with very fully by illustrations and figures, accompanied by outline specifications, the whole linked together in logical sequence so as " to show the trend and achievements of modern practice." The reader will have nothing but admiration for the clarity with which the author has arranged such a mass of carefully compiled information about plant, and he may also express satisfaction at the equitable treatment of both American and European products. Reciprocating compressors of various makes are dealt with adequately, but the difficulties which have been met with, and overcome, in the construction and running of turbo-compressors are passed over somewhat lightly. A little more detail and criticism of the different methods of testing compressors would also be an advantage.

The second part (274 pages), which deals with the transmission and use of compressed air, naturally covers a much greater diversity of subjects. Separate chapters deal with pipes, engines, moisture, reheating, rock-drills, rock-drill performance, drill-bits and mechanical sharpeners, coal-cutting and quarrying machinery, pumping, haulage, and measurement of consumption. In the chapter on the conveyance of compressed air in pipes two useful nomograms are given and several tables are quoted, but the wide divergence between the different coefficients used by different writers is not discussed or explained. In the chapter on compressed air engines a full description of the Hele-Shaw-Beecham air motor is given, the " Turbinair " and certain other recent designs of air motor being also dealt with.

Many types of rock drill are illustrated and described. The descriptions are clear and the figures excellent, but such details as indicators for rock drills and silencers are overlooked. Silencers are an item of

compressed air plant which are of special interest to city dwellers, but not to contractors. Rock-drill performance and records are dealt with in seventeen pages. This seems rather little after the large amount which has been published on these subjects. Perhaps they are regarded by the author as outside the scope of the present work. The performance of a rock-drill is not efficient or inefficient in the same sense that that of an oil-engine or an electric motor may be. An efficient rock-drill should combine maximum drilling speed, minimum air consumption, good performance over a wide range of air pressure, simplicity, low weight, low first cost, and low maintenance cost, but these are not all obtainable in the same machine. The chapter on drill bits and mechanical sharpeners is a useful addition. Three standard types of sharpener are illustrated and described. A contribution is made to the vexed question of mining terminology by the considered use of the word "bit" to mean "the entire length of the steel, including its shank and cutting edges."

Compressed air meters are discussed and some useful work by the American Compressed Air Society is included in this chapter, this should be an encouragement to our British Compressed Air Society to extend its activities. Some types of shanks are illustrated and discussed, but unwelded shanks (G. R. Heywood) and the use of unshanked steel are hardly mentioned. The final chapter, which is on the measurement of compressed air, is a fitting conclusion to this excellent book.

B. W. Holman.

Géologie et Industrie Minérale du Pays de Liège. By P. Fourmarier and L. Denoël. Paper covers, 238 pages, illustrated. Price 35 francs. Paris and Liège: Librairie Polytechnique Ch. Béranger.

It was only natural that the International Congress of Mining, Metallurgy, and Geology, held at Liège last year, should produce a permanent record of the district in which the Congress was held and the present volume may fairly be said to constitute such a record, which will simultaneously form a permanent memorial of the Centenary of Belgian National Independence. The congress was indeed only one of a number of similar manifestations in honour of this important centenary. Having regard, however, to the important part played by mineral industry in Belgian economics, it may fairly be claimed that mining and metallurgy were bound to receive their meed of recognition on such an important occasion. It may also be remembered that the Exhibition at Liège brought out into very prominent relief the importance to Belgium of these branches of industry. The book before us consists essentially of two parts; in the first part Professor P. Fourmarier, Professor of Geology at the University of Liège, describes briefly but clearly the geology of of the district in question, whilst Professor L. Denoël, Professor of Mining at the same University and Inspector of Mines, contributes the second and larger part of the book in the form of a description of the Liège mineral industry, in which he is particularly concerned in bringing out the progress made in this industry during the last century. Professor Fourmarier commences by a short account of the geology of the district of Liège, but points out that he uses this term in a very broad sense and is not limiting himself to any particular administrative division. He applies that phrase to the coalfield of which Liège forms the centre and, as is only natural, is interested in geological boundaries rather than in more artificial ones. He shows that the town of Liège is particularly well adapted to its purpose, being situated at the boundary between the Northern region where the strata lie comparatively flat and the region of the Ardennes, where, owing to very steep dips, Palaeozoic formations outcrop over a large area. The geographical aspect of the country is thus completely different on the two banks of the Meuse. The left bank, stretching north-westerly, is formed by the Hesbaye Plateau sloping gently to the north to join the flat plain of the Campine. On the south-west, from the right bank of the river, the country rises, forming the well known Ardennes Range up to an altitude of 692 metres. In the same way the underground conditions of Liège are particularly favourable, seeing that the town is built upon Coal Measure strata forming the axial region of the Namur syncline. Following on the general description Professor Fourmarier treats in turn of the development of each of the important formations, commencing by the Cambrian and the Silurian; he then passes to the Devonian and the Carboniferous, to which the main part of his description is naturally devoted. He then treats

briefly the Mesozoic and the Cainozoic strata, and thus gives a succinct but very useful review of the geology of the whole district, terminating his description by a brief review of the economic products of the various formations, amongst which coal seams naturally take first place.

Passing to the second part, contributed by Professor Denoël, by far the largest part is of course taken up by a review of coal mining. Out of a total of 180 pages, 115 pages are devoted to coal mining, only 19 to metalliferous mining, and the remainder to quarries. The author commences by a very interesting account of the history of coal mining in Belgium; he states that definite proof has been discovered that the Romans used coal in this country, but holds that this use was an isolated and purely local example and that clearer evidence of real coal working dates from 1195. He even states that the French word for coal (houille) is derived from the word "hoye," a Liège word meaning a lump. The author takes up in turn each point of interest concerning coal mines; he discusses at length the mode of occurrence of the coals and points out that in the Liège Basin only 3% of the mines are non-fiery, 33% are slightly fiery, and 64% are classed as fiery mines. The author discusses in much detail the accidents in the coal mines, and shows how largely safety explosives have been developed in Belgium. It is interesting to note that in Belgium they are fond of using "encased" cartridges, that is to say cartridges surrounded by a layer, some millimetres in thickness, of a mixture of plaster and of volatile salts such as chlorides and fluorides, and he holds that this casing contributes markedly to the safety of shot firing. The result of the various precautions taken has been remarkably good; firedamp explosions, which were formerly so common and so severe, have become very rare, more particularly in the Liège Basin, although it cannot be said that the risk of firedamp explosions has been entirely overcome.

The author discusses at some length the labour available for coal mining, and points out the marked difference between surface and underground workers. He states that after 1919 there were 29 surface workers for 71 underground workers, and that the coal hewers comprised 13% of the total number engaged and 18% of the underground workers, ranging from 10% to 19% and being highest in the dry coal region. He indicates that the accident death rate in the Liège district is low, being 9·9 per 10,000 workers, underground and surface. He concludes by pointing out that in the area in question the oldest coal mining in the world has reached its zenith and is fighting bravely to maintain its position in spite of the fact that the deposits are within measurable distance of exhaustion. He shows that the principal characteristics of the last quarter of a century are technical progress, improvement in the position of workpeople and increase in the price of coal. He appears to attach the greatest importance to the second of these movements, pointing out that the coal miner has had the advantage of increased wages, of a lower accident risk, of healthier conditions, of more comfort and of greater leisure, and seems to hold that one of the results of this movement has been the fact that conflicts between employers and employed have been rarer and less fierce than they used to be. Many of the demands of the workmen have been acceded to, and above all the two parties have come closer together with the result of a better understanding of their mutual rights and duties. The author sees in this attitude the best augury for the continued prosperity of the Liège coal industry.

H. Louis.

☛ 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

March 18.

Mount Isa Activities.—At the Mount Isa mines, North Queensland, there have been satisfactory runs of various machines in the mill and at the smelter and the local mining warden reports that, provided there are no unforeseen difficulties connected with the lead market, crushing should begin between the middle and the end of April. The main haulage levels are now finished and the Davidson, supply, Lawlor, O'Doherty, and Urquhart (main haulage) shafts are connected. As a result of the driving of the main haulage level from the direction of the Urquhart shaft, the supply shaft and the levels running from it are now dry. The water, which has decreased in volume considerably, now drains towards the Urquhart

shaft, where there are adequate means of pumping it to the surface. The Urquhart shaft is now down 651 ft. and at the end of February there was only 9 ft. of further sinking to be accomplished. The excavations for the loading and operating chambers below the ore-loading pocket are almost finished, while the automatic controls for the ore hoists have been set and tested. In the main haulage level there has lately been introduced a " scraper " for loading mullock into trucks—a novelty in this part of the world that appears, according to the district Inspector of Mines, to be a decided improvement on ordinary methods.

In order to ensure that all portions of the Mount Isa plant shall run in smoothly at the beginning of production, a comparatively small quantity of ore will be treated in the first week, after which the tonnage will be gradually increased to 10,500 tons weekly by the end of six weeks from the date of starting. Both carbonate and sulphide ores from the Black Star, Black Rock and Rio Grande lodes are to be treated, the sulphides chosen during the earlier part of the run being those low in zinc. It is reckoned that from every 3·75 tons of ore crushed there will be produced 1 ton of concentrates. In four weeks after the beginning of crushing, the furnaces in the smelter should be in full swing. The silver-lead bullion then produced will be shipped to England. The limestone needed for the smelter, amounting to 1,200 tons a month, will be procured from leases held by the Mount Isa Company six miles south of Duchess, and will be carried by rail to the mines. About 800 tons of ironstone a month that will be required will also be obtained on the Cloncurry field.

Mount Isa Mines, Ltd., proposes to increase its capital by the issue of 6% second mortgage debentures to the extent of £666,667 (Australian currency), in order to provide funds for completing the treatment plant, and further developing the mine. In this connexion, it may be recalled that Mr. Leslie Urquhart, chairman of the Mining Trust, stated over a year ago that, while the initial capacity of the mill and smelting plant would be about 2,000 tons of ore per day, the extension of the plant to a greater capacity—more commensurate with the size of the mine—would be undertaken as soon as possible. The main shaft and the underground layout have been designed not only to handle the initial mill requirements of 2,000 tons of ore daily, but are capable of dealing with up to 12,000 tons a day when necessary.

Reduction of Coal Rates.—The owners of the principal coal mines in Queensland have at last secured a reduction in the rates paid to the miners in their employ. Under a judgment given by the South Queensland Coal Board, that came into operation a week ago, the contract rates operating in certain specified collieries have been reduced by 10% and shift (or day) rates in the same proportion. The claimants asking for the reduction embrace 27 owners of mines in the principal, or southern, coal-producing district of the State, as well as the Mines Department, owning the Bowen State mine, the Bowen Consolidated Company, and mines in the Central district. It is nine months since the stoppage in the federated mines in the adjoining State of New South Wales came to an end. When that happened the miners concerned accepted a reduction of 12½ % in their rates of pay and through this means, and by the Government and the owners agreeing to reductions on their part, the selling price of coal was reduced by 3s. 3d. a ton. As a result, the price of coal has been greater by that sum in Brisbane than the charge for coal from Newcastle, New South Wales, and the trade here has consequently gone from bad to worse. It has not yet been decided by the Southern Queensland Colliery Proprietors' Council to what extent the selling prices for coal shall be reduced as a result of the new award.

Palmer Goldfield.—An important undertaking in connexion with the old Palmer goldfield, inland from Cooktown in North Queensland, is one initiated by Mr. E. C. Hunter, who last year obtained a concession from the State Government of over 360 acres, which covers several well-known mines that were worked down to water level in the early days of this once-famous field. After having raised £12,000 in Australia, Mr. Hunter went to England to obtain additional capital up to £50,000, which he guaranteed to spend in five years on the Palmer holdings. A week ago, when in Brisbane, he stated that the required capital was being provided by an English company and that work would be commenced on the field about April, at the end of the wet season. On the same field, on the Palmer River, the Palmer River Gold Company has at length been able to make a start with its dredge, after having overcome many difficulties. This company's holdings are at Strathleven, 80 miles from the terminus

of the Cooktown Railway at Laura. A road has been made for this distance over very rough country and the dredging plant safely transported. At the last report from the mine, some unavoidable delay had occurred after a start had been made and not sufficient dredging had been done to give a reliable indication of what will be the result of future operations, but the outlook was said to be promising.

Australian Gold Mining.—Nothing very substantial has yet resulted from the increased activities in the search for and production of gold in Australia, but it is evident from the reports being received from all over the country that the indications of ultimate success in this direction are favourable. The finding of a big nugget in Western Australia acted as a stimulus to prospecting and the early starting in that State of the big Wiluna enterprise, backed by English capital, must increase the gold output appreciably. The Broken Hill Proprietary, owning the Newcastle iron and steel works as well as a mine at Broken Hill, has decided, with the aid of its vast and efficient organization, to interest itself in gold mining in Western Australia. As far as the plans of the company are at present known, it will place its technical resources at the disposal of the State for the development of areas which could be worked on a fairly large scale. In Queensland, in addition to the amount allotted from the unemployment relief fund lately established by special taxation, the State Government has decided to increase the sum usually voted to assist prospectors. Allowances from this vote will now be £2 a week for married and £1 for single men. Mr. Walter E. Cameron, who was some time ago re-employed temporarily on the staff of the Queensland Geological Survey, which he had left some years before to go to Malaya, has just furnished two interesting reports dealing respectively with the Iguana and Golden Gate reefs, on the old Croydon goldfield in North Queensland, which gave very rich results in the early days. In these reports encouraging indications are specified as to the possibility of fresh reefs of equal value being discovered either in the vicinity of or below those mentioned. Mr. Cameron says this ground could be adequately tested by a few diamond drill-holes at a very moderate expense.

Broken Hill Mines.—Owing to the continued fall in the price of lead, the managements of the Broken Hill mines have been forced to seek a further reduction in the costs of production and, under the terms of an agreement made in January last, a conference has been held between representatives of the Mining Managers' Association and the Barrier Industrial Council. Following this conference, the superintendent of the Zinc Corporation gave two months' formal notice to the Industrial Council of suspension of operations. Later the Broken Hill South Company gave a similar notice. Whether these notices are for a complete suspension or a curtailment of the previous scale of operations depends on the future position of world lead prices and the exchange rate. The Broken Hill North Company has not yet given a similar notice and the manager has stated that he hopes the necessity to do so will not arise. The only companies now operating on the Barrier are the three named, all the others having suspended work because of the fall in the prices of lead, silver, and zinc. At the same time the Broken Hill Proprietary, besides helping Western Australia in gold mining, has agreed to take options for six months over the Silver Casket leases, which were taken up a few months ago, covering 30 acres of ground about 12 miles from the Mount Isa mines, North Queensland.

New Gold Finds.—What promises to be an important gold find has been made at a place called Mount Horror, 13 miles north-east of Scottsville, Tasmania. The reef, when examined at a depth of only 14 ft., widened from 2 in. to 9 in. over a distance of 2 chains, and is said to carry splendid values all the way. The prospect is described as one of the most promising reported in the State for many years, and the State Mining Engineer is impressed with its possibilities. Rich gold finds are also reported from Casino, in northern New South Wales, as having been made at Paddy's Flat, 25 miles from Tabulum, near the Queensland border. From small quantities of ore crushed it is estimated that the reef will yield 20 oz. to the ton.

IPOH

April 3.

Tin Restriction.—Restriction, assessment, and quota are words unfamiliar in the tin mining industry until lately, but now one hears them everywhere. Producers are making their returns of output, mines in operation and other data on which the

proposed Assessment will be based and quotas determined. Applicants have to declare their output in each of the years 1929 and 1930 and if special consideration is claimed on grounds other than the average output from mines now producing, reasons must be submitted which may include capital outlay on equipment, development and generally such facts and causes as would have affected their rate of production if restriction had not been contemplated.

A very interesting statement was issued by the Senior Warden of Mines showing the balance of opinion expressed by producers for and against restriction in reply to the questionnaire issued in January. In it he stated that the voting on restriction showed opinion to be divided as follows : For, 68%, representing 1,063,380 pikuls ; against, 12% (183,687 pikuls), and 20% did not vote (310,537 pikuls). The voting was based on the 1929 production which was 1,557,604 pikuls of tin ore. The voting, classified as regards European and Chinese producers, was :—

	European	*Chinese*
	%	%
For . . .	66	73
Against . .	18	2
Did not vote .	16	25

Where any ambiguity existed or where the vote was conditional on provisos such as " in favour of restricting sales and exports only," the votes were recorded as " against."

There have been signs of propaganda and some uninformed criticism, doubt, and apprehension among miners, especially among the smaller Chinese producers. It is not too much to say that for many, if not for most of them, disaster would be certain if the price of tin remained long below $60 per pikul. The better informed have realized that the proposed legislation is for the general good, and the above figures show a clear majority in its favour.

Tin Quota Scheme.—The text of the proposed enactment to be introduced in the Federal Council on April 13 has now been published. It is to be retrospective, coming into effect as on March 1, and to remain in force until terminated by notice in the Government Gazette. Among its chief provisions may be mentioned the following : Decisions made under this enactment are not to be questioned in Courts of Law ; suits are not to be instituted against the Government in respect of anything arising under or resulting from the operation of this enactment ; the Senior Warden, Wardens and Assistant Wardens of Mines are appointed Controller and Deputy Controllers for its purposes ; an Assessment Committee in each State, and a Central Committee for the F.M.S. are to be appointed with duties assigned ; certificates of production will be issued authorizing production, sale and export of a fixed quantity of tin or tin ore within a fixed period, such certificates not to be issued in respect of land which was not mined in the years 1929 and 1930, unless it is proved to the satisfaction of the Assessment Committee that all necessary action had been taken by the producer in the year 1930 to enable mining operations to be begun upon the said land in the year 1931, and until such operations have commenced ; no mine or part of a mine which is not being worked and is not in a condition to be worked will be taken into consideration in the Assessment of production ; a mine or part of a mine which is not being worked may be assessed for production if it is proved to the satisfaction of the proper authority (Assessment Committee) that such a mine or part of a mine is in a condition to be worked ; where mining work has commenced after the beginning of a Quota period the Quota shall be calculated for the remainder of such period only ; with special permission of the Central Committee two or more producers may aggregate the production of their mining lands and obtain in respect thereof a Certificate of Production which shall be valid for production, sale and export of tin and tin ore from all or any of the lands specified in such certificate ; applicants may apply for review of assessment within ten days of notification thereof, and further within ten days of decision by the Assessment Committee may appeal to the Central Committee whose decision shall be final ; sale and export of tin and tin ore are regulated, and heavy penalties are provided for offences against this enactment and rules under it.

Ports and places of export of tin and tin ore by sea and by rail are specified, and are the following : Ports for export by sea : Teluk Anson, Port Swettenham, Port Dickson, Kuantan and Pontian ; Stations for export by rail : Parit Buntar, and Gemas, these being the Customs Stations at the boundaries, north and south respectively, between the F.M.S. and Straits Settlements.

It will be obvious to all concerned that to be effective and successful such regulations must be stringent in application.

Evolution of the Industry.—An address of unusual interest was given under the auspices of the F.M.S. Chamber of Mines by Mr. G. H. Hutton on "Selected Phases in the Evolution of the Tin Mining Industry." The scope of the subject allowed only summary treatment in the time available, but the opportunity was taken to indicate points and lines of investigation of particular importance at the present time. The richness and extent of the tin bearing deposits in Malaya have contributed to the survival of crude and inefficient methods of working and extraction, but the paper was critical of comparatively recent as well as of long customary practices and appliances. Mr. Hutton indicated the following as legitimate conclusions: The mining industry of Malaya might with advantage continue to improve its mining methods; gravel pumping was costly and would gradually become less used as a mining method; gravel pump dredging was suited to certain kinds of operation and offered an opportunity for thoroughly cleaning hard bedrock and efficient washing of the ground; the suction cutter dredge, as developed to date, had not proved itself to be definitely superior as a mining machine to the bucket dredge even in ground overlying hard and uneven bedrock; bucket dredging was an economic mining method, although it is somewhat wasteful in ground with values overlying hard and uneven bedrock; bucket dredging was susceptible of further improvement as a means of recovering and saving tin ore; of many well known improvements to the bucket dredge the use of manganese steel was one of the most important; electrical energy would make possible large plants of various kinds; certain mechanical tools now assisted in excavation; the policy of patenting devices in the tin mining industry should be decried, although new devices might perhaps be registered with the Chamber of Mines.

In the discussion which followed, the seeming antagonism of stabilization and of evolution in industry was commented upon. For comparison with present day costs the earliest gold dredges in New Zealand were mentioned to show that even on the very small scale of those dredges their costs were low—often not more than one penny per cubic yard—or about one-fourth of the all-in costs by recent large dredges in this country. It was mentioned that among methods in early use in Malaya "gravel pump dredging" was tried in several well known localities, where it was unsuccessful as compared with bucket dredges put in later. The answer to this criticism is that methods are successful or otherwise according to their suitability in each case and to the efficiency and economy of operation. The merits of each case require careful investigation, and it is most unsafe to presume similarity. It is not pretended that gravel pumps and jigs on a pontoon with monitors to break the ground can successfully compete with a bucket dredge under conditions for which the latter is suitable, but there is no doubt that the pontoon with pumps and jigs does excellent work economically in the well known case instanced where values are in comparatively shallow ground on a pinnacled and generally uneven bedrock, and there are other similar areas which can probably be best worked in that way. It is well known that monitors are inefficient among limestone pinnacles, but in this, as in other cases, knowledge and experience are profitable to direct and will clearly show the limit beyond which other methods of cleaning up the bottom, familiar to Chinese miners, should be employed to win the remaining values.

TORONTO

April 14.

Porcupine.—Development at the Hollinger Consolidated is progressing favourably and placing as much ore in sight as is being taken out. The ore reserves are estimated at $50,000,000. The management is proceeding vigorously to carry work to possibly 6,500 ft. in depth on the easterly part of the property. It is calculated that the cost of the campaign of deep sinking will be met by the surplus earnings remaining after the payment of the dividends. The McIntyre has completed the oil flotation section of its new mill and is bringing the equipment into operation with a present capacity of 1,500 tons daily, which will be increased to 2,000 tons when the cyanide section goes into operation in about three months time. During the year it has been producing at the rate of about $4,800,000 a year and with the new mill in full operation the company expects to be in a position to produce approximately $6,000,000 yearly and show net profits of about $2,500,000. Exploration is being carried on in several directions with the object of opening up new

ore-bodies. A long cross-cut is being driven towards the Platt Vet claims, to pick up the Hollinger vein system and driving is proceeding east towards the Coniaurum property on several levels down to the 3,875 ft. horizon. At the Vipond the gold content of the ore has been found to diminish at depth, the ore at 1,000 ft. not being payable, but it is believed that deeper mining will bring favourable results. The shaft will be put down to 1,400 ft. at which horizon cross-cutting and driving will be undertaken on an extensive scale. The Canusa will install a pilot mill with a capacity of 50 tons a day and expects to enter upon the production stage before the end of the year. There is a considerable tonnage of development ore on the dump and a quantity of high-grade ore in sight. The shaft which is now down to 300 ft. will be sunk to 600 ft. and new levels opened up. The Coniaurum has encountered high-grade ore in driving on No. 2 vein on the 700 ft. level with gold content reported at more than $15 to the ton, over widths of from 3 to 4 ft. The mill is now treating about 300 tons daily, with a recovery of about $6 per ton. Porcupine United Gold is preparing to carry on an extensive development and exploration programme. Favourable mineralization was encountered in previous operations and deeper mining will be undertaken.

Kirkland Lake.—Ore values at the Wright Hargreaves are showing substantial improvement. Development on the 2,400 ft. level has opened up ore carrying more than $30 to the ton over a width of 40 ft. and other discoveries of importance have been reported. The mill is now treating 700 tons daily, mill heads running about $12 per ton. A new crushing equipment is being installed with a capacity of about 100 tons of ore per hour. Shaft sinking on the Lake Shore is proceeding steadily, the objective being 3,000 ft. Development work has recently opened up several large deposits with content well above the mine average. The latest find was on the 2,250 ft. level, where about 1,500 ft. of high-grade ore has been opened up. The management is giving special attention to reducing tailing losses and a small pilot mill has been installed at which experiments will be conducted with a new treating process which is expected to reduce tailing losses by $1 or $2 per ton. Teck-Hughes has practically completed its mill addition, bringing its total milling capacity up to 1,300 tons daily with mill heads stated to run approximately at $18 to the ton. The shaft has reached a depth of 3,600 ft., new hoisting equipment is being installed and, when this has been completed, shaft sinking will be resumed. Some development work has been carried out below the 3,000 ft. horizon, the ore showing values better than mine average. At the Kirkland Lake gold mine stoping at a depth of 4,000 ft. has encountered the downward extension of the high-grade ore-shoot opened up on the 3,875 ft. level. At the latter horizon the ore opened up was the best ever encountered at the property. As a result of the improved condition at these levels the mine has a year's ore in reserve. The Macassa is putting down a shaft to the 2,500 ft. level where a connexion will be made with a drive from the adjoining Kirkland Lake property, an arrangement having been effected between the companies under which the Kirkland will take the development ore from the Macassa, paying for it on a basis of the gold content. A new hoist is to be installed.

Rouyn.—The Noranda continues to curtail smelter operations in accordance with the understanding between the leading copper-producing companies. The ore reserves have been considerably increased by underground work. No. 3 shaft is being deepened from 1,500 to the 2,000 ft. level and is in solid sulphides from the 1,600 ft. to the 1,864 ft. horizon which is the present bottom of the shaft. No ore is being extracted below the 975 ft. level at present. Diamond drilling is being continued to ascertain the dimensions of a large body of ore indicated on the 1,475 ft. level which continues downward for 150 ft. The Aldermac will install a concentrator with a capacity of 500 tons to be ready for operation in the autumn. The purpose of the concentrator is to treat the pyrite ores of the mine in order to produce a pyrite concentrate, from which sulphur will be recovered by the Freeman process. The second flotation product consisting of copper concentrate will be shipped to the Noranda smelter. The mill of the Granada Rouyn mine is treating 70 tons daily with mill heads running $18 gold to the ton. Development work is being actively carried on at the 600 ft. level where good values have been encountered. The Pandora is installing a mining plant and will put down a shaft to the 500 ft. level, favourable mineralization having been encountered last year by diamond drilling. During March the Siscoe gold mine produced $49,739 from 4,626 tons of ore, with a recovery of $10.74 per ton.

Patricia District.—There is little mining activity at present in this field owing to the fact that work during the last few seasons on numerous prospects apparently promising proved disappointing. So far the only producing mine in the district is the Howey which, since it began production, has treated approximately 150,000 tons of ore with an average recovery of $4.70 per ton. Equipment for hand sorting the ore is being installed in order to increase the grade of ore going to the mill. A new company is being organized to take over and operate the Central Patricia property which has been closed down for some time owing to financial difficulties. It is proposed to install a 50 ton mill as there is sufficient ore in hand to furnish this supply for 2½ years. The Casey Mountain Operating Syndicate has begun active development on its property at Summit Lake in the northern section of the district. A shaft is being put down and a small test mill has been erected.

Manitoba.—The first annual report of the Hudson Bay Mining and Smelting Company since the properties were brought into production, shows an operating profit of $25,313, the plants were not brought into full production until the last few months of the year. Sales of metals brought a return of $497,162, while transport expenses reduced this to $440,699. Operating costs were $415,385, leaving a profit of $25,313. Expenses in excess of all income during the construction period were $22,397, reducing the amount carried forward to surplus to $2,915. Entirely satisfactory recoveries of the copper and zinc were not being made, but finer grading was expected to remedy this. The company has taken an option on the Searle claims in Northern Manitoba on which favourable gold showings had been obtained. The new concentrator at the Sherritt-Gordon mine is now treating more than 400 tons of ore daily and is running smoothly. The company recently shipped four cars of concentrates to the Flin Flon smelter and regular shipment will shortly be going forward. The company is considering the installation of a second unit, which will bring the total capacity to around 1,200 tons daily.

JOHANNESBURG

April 9.

New Goldfield in Rhodesia.—It is understood that several mining engineers have inspected and reported upon properties on the gold-bearing banket reef in the Victoria district, Southern Rhodesia. One of these engineers, Capt. J. K. Willis, A.I.M.M., says that for a distance of 10,000 ft., the property he examined is traversed by a ridge, which varies in height from a few feet to over 80 ft. above the surrounding country. This ridge contains a banket reef, which outcrops at or near its crest. Float banket is in evidence anywhere along this ridge. The reef is a true gold-bearing banket and where it has not been oxidized, but is in the sulphide zone, it is practically identical with the Rand banket, consisting of chert and quartz pebbles cemented with a siliceous cement containing iron pyrites. The walls of the reef are of quartzite, and the country rock is sandstone with occasional clay fissures and shale. The average width of the reef along the outcrop is 15 ft.

An Alluvial Goldfield.—It is anticipated that in the near future the scale of operations on the Fullerton Creek alluvial goldfields near Steynsdorp, Transvaal, will be considerably extended. The company which has taken up large blocks of claims in this area is at present carrying out prospecting work with the object of obtaining sufficient information regarding values and the general conditions in order to enable a decision to be arrived at with respect to the future of the undertaking.

New Morro Velho Claims Repegged.—The claims in the Barberton district which were abandoned some time ago by the New Morro Velho Gold Mining Company, a London concern, have been repegged by Barberton and Johannesburg Syndicates. It was notified in the *Government Gazette* that the claims had lapsed and a group of active peggers, including two running champions, were waiting in the leash at daybreak on the morning when pegging was again permissible. Two parties, it appears, were on the ground and when the little rush was over and it was possible to take stock of the results, the honours were fairly well divided, the local people having, if anything, the bigger score as far as actual area goes. It is rumoured that the portion that fell to the Johannesburg syndicate is at the moment under consideration in England.

Transvaal Torbanite Deposits.—A company has acquired an area of 21,000 acres containing torbanite in the Ermelo district, Transvaal, and it is stated that a well-known mining engineer has estimated from the development done that the deposits are

sufficient to maintain an oil-producing industry on an economic basis for 87 years.

Aerial Mapping.—At the annual meeting of the Geological Society of South Africa, the retiring president, Dr. Hans Pirow (Government Mining Engineer), in the course of his address, pointed out that the most recent equipment of the modern prospector, and one to which those in South Africa should pay serious attention, was the aeroplane. With South Africa's minerals scattered over wide areas and with climatic and ground conditions favourable to aviation, it seemed to him that the aeroplane must inevitably play a great role in geological reconnaissance if the country's mineral resources are to be exhaustively surveyed and mapped. It had been his good fortune to cover several thousand miles of country by air and he was very pleasantly surprised, after his first two or three trips, to find how much of the surface stratigraphy could, with the assistance of an experienced pilot, be observed from the air. This was particularly the case during a flight over the almost inaccessible mountain ranges of the Richtersveld, in South-West Africa, but even when travelling over comparatively flat country between Beaufort West and De Aar, in the Cape Province, he was astonished by the ease with which dykes and fault planes could be followed over miles of country. Trained observers equipped with the necessary photographic apparatus should in this country be able to map large areas in a remarkably short time.

Mining Apprentices.—At December 31, 1930, there were 535 apprentices undergoing the prescribed course of training at the Government Miners' Training Schools on the Rand, as compared with 461 at December 31, 1929. From the beginning of 1917 to December 31, 1930, 1,199 apprentices completed their indentures. The net cost of maintaining the schools for the twelve months ended March 31, 1930, was £50,527, of which £12,632 was contributed by the Union Government and £37,895 by the gold mining industry.

Memorial to Dr. David Draper.—The Council of the Geological Society is taking steps to establish a memorial to Dr. David Draper. This will take the form of a bust, which will be placed in the new public library of Johannesburg, and of a Draper Memorial medal, to be awarded in the discretion of the council for research work on South African geology.

PERSONAL

A. C. J. Anderson is returning from Nigeria.
H. Foster Bain is here from New York.
A. Bean is expected shortly from Ipoh, F.M.S.
Cyril Bond is home from Spanish Morocco.
J. Coggin Brown is home from Burma.
C. Burnett is home from Panama.
W. Brooke Howard is returning from India.
A. N. Lucie-Smith is returning from Venezuela.
D. B. Mackenzie is home from Nigeria.
H. H. Martin is returning from Ecuador.
Alex. Mather is returning from Nigeria.
Frank Merricks, in recognition of his services in developing friendly relations between the engineering communities of Great Britain and France through the medium of the Société des Ingénieurs Civils de France, has been created by the President of the French Republic Officier de l'Instruction Publique.
J. A. Nogara has left for Italy.
J. W. Pertwee has left for Venezuela.
Euan A. Richardson is home from Canada.
D. W. Rutter is home from Venezuela.
G. A. Smith is returning from Nigeria.
J. H. Southwood has returned to Nigeria.
R. S. Steedman is home from Malaya.
C. H. Trezise has left for Nigeria.
G. W. Eaton Turner is home from the Gold Coast.
C. W. Walker is returning from the Gold Coast.
A. Stanley Williams is home from Nigeria.
W. J. Wilson is returning from Nigeria.
E. W. Wright is home from Nigeria.

Clyde Allan died on March 17 in London.
Neil Macphail Galbreath died at Rodalquilar, Spain, on April 11.
Daniel Gibson died on his way home from Panama.

TRADE PARAGRAPHS

Hadfields, Ltd., of Sheffield, send us some notes on the use of "Era" manganese steel for the chains of tub creepers and all kinds of elevators and conveyors, which is yet another application of this most useful alloy steel.

Allen West and Co., Ltd., of Brighton, issue leaflets devoted to their totally enclosed air-break hand operated starters for squirrel-cage induction motors having a maximum h.p. of 15, volts 650, amps. 40; also to contactor starters for similar duty.

Fried. Krupp Grusonwerk, A.G., of Magdeburg-Buckau, Germany (London Agents: J. Rolland and Co., Abbey House, S.W.1), inform us that they have effected an amalgamation with the Andreas Machinery Manufacturing Co. to collaborate in the further development and improvement of cement machinery.

Wilfley Mining Machinery Co., Ltd., of Salisbury House, London, E.C. 2, state that recent shipments include Wilfley concentrating tables to Russia and the Far East, Wilfley sand pumps to Spain and India, and miscellaneous equipment to Burma, French Indo-China, South America, and for the home trade.

Ruston and Hornsby, Ltd., of Lincoln, inform us that an order has been secured for a six-cylinder Ruston vertical airless injection cold starting oil

engine of 600 b.h.p. for the Elgin Electric Supply Co. The new engine when installed will bring the engines of Ruston make in this station up to 1,000 b.h.p., representing a total of four engines of their manufacture.

Head, Wrightson, and Co., Ltd., of Stockton-on-Tees, send us a booklet describing the Colorado convertible discharge ball-mill which is well known and widely used in ore crushing. They also send us a booklet describing their Notanos tube-mill which is often used in the grinding of gold ores prior to the cyanide process, where it is commonly used in closed circuit with the Akins classifier.

Denver Equipment Co., of Denver, Colorado, U.S.A., issue a number of bulletins and leaflets describing their specialities, notably those devoted to accurate reagent control with Denver wet and dry reagent feeders, speed reducers and small motors, modern centrifugal sand pumps, and Denver " Sub-A " Fahrenwald flotation machines. All are fully illustrated and generally attractively prepared.

Leonard Hill, Ltd., of 231–2, Strand, London, W.C. 2, send us a copy of the 7th edition of their *Chemical Engineering and Chemical Catalogue*, which is a catalogue of heavy and fine chemicals, raw material, machinery, plant and equipment applicable to production industries, standardized, condensed, and cross indexed. Single copies of this are obtainable from the publishers at 15s., or an annual subscription may be entered for 10s. 6d.

Steatite and Porcelain Products, Ltd., of Stourport, Worcester, inform us that they have received an order for a further large quantity of their spring-ring insulators for the 257 miles of 132 kv. primary transmission lines which are being erected in this country under the South West England and Wales section of the Grid electrification scheme. These insulators are being used on all the English Grid schemes of the Central Electricity Board.

Rapid Magnetting Machine Co., Ltd., of Lombard Street, Birmingham, send us some particulars of a large magnetic pulley which has recently been supplied to an Indian colliery for the purpose of removing tramp iron from coal on a large conveyor, which is handling material at the rate of 200 tons per hour. The size of the pulley is 4 ft. diameter by 40 in. wide, and the weight 5½ tons. Its current consumption is 21 amperes at 220 volts d.c.

Genter Thickener Company, of Salt Lake City, U.S.A., issue a booklet covering 27 pages which is fully illustrated with photographs and cross sectional drawings describing the Genter thickener, its uses and advantages, capacities, principles of operation, valve timing and actuating mechanism, filtrate indicators, overload alarm, stock tanks for thickened sludge, assembly and installation, preliminary testing, operating cycle, lubrication and general suggestions for use.

Dressing and Screening Co., Ltd., of Mansfield Road, Alfreton, Derby, issue a booklet describing their indestructible " Gumco " screens which are protected against corrosion by a special form of rubber coating which is also strongly resistant to abrasion, and the screens are suitable for wet screening even in the presence of weak acids and alkalis. Another quality covering is described as being resistant to concentrated acids and a number of other corrosive chemicals. These screens are made in all the usual meshes.

Mining and Industrial Equipment, Ltd., of 11, Southampton Row, London, W.C. 1, report that new orders have been received for the following equipment : For England : One Andrews classifier (14 ft.) and one 8 ft. Hardinge thickener for very fine classification of special material. For France : One Ro-Tap testing sieve shaker and one 4 ft. by 10 ft. type 60, Hum-mer electric screen for coal, 60 tons per hour. For Australia : One 4 ft. by 5 ft. Hum-mer electric screen for gold ore. For Rhodesia : One 4 ft. by 6 ft. type 60, Hum-mer electric screen for copper ore, 100 tons per hour—yielding minus ⅜ in. product.

Edgar Allen and Co., Ltd., of Sheffield, send us a catalogue of their crushing rolls, including high-speed rolls, medium-speed rolls, cubing-rolls of different kinds, and special types of coal and coke-crushing rolls. They also send us their *Edgar Allen News* for April, which contains an article on the many functions of manganese steel which is exemplified with a number of its uses, such as for dredge buckets, and buckets and teeth of excavators and lip castings, pump castings, links for caterpillar mountings of tractors and excavators, conveyor bucket castings and for tail skid shoes for aeroplanes.

Ransomes and Rapier, Ltd., of Ipswich, issue a leaflet devoted to their petrol-electric super-mobile crane, which is a further development of the now well known standard mobile crane which has been widely adopted for use all over the world. The new model has a fully revolving superstructure enabling the jib to be slewed independently of the chassis. It is made in four sizes to carry 1, 2, 3½–5, and 6 tons respectively. The power is derived from a petrol-electric unit which consists of a substantial motor car engine, direct coupled to a specially designed variable speed electric generator, the principle being the same as that adopted in their excavating machinery, which is well known to readers of the MAGAZINE.

Argus South African Newspapers, Ltd., of Fleet Street, London, E.C. 4, send us the *South African Mining and Engineering Yearbook*, 1931 edition. This covers 628 pages, is very fully illustrated, and contains a number of large maps of South African mining fields. It is altogether a comprehensive work and gives also an alphabetical list of the engineering concerns in the Union of South Africa and in Rhodesia and elsewhere in the sub-continent. An important feature is the revised and amended list giving particulars of over 200 manufacturers represented in South Africa, with the names of their local representatives. It should prove to be a valuable reference work to engineering concerns in this country interested in the development of their overseas trade and is priced at 22s. 6d., post free.

WILSON PLASTIC ARC WELDERS

G. D. Peters and Co., Ltd., of Windsor Works, Slough, recently afforded us an opportunity of visiting their works and of examining the operation of the Wilson Plastic Arc electric welding process with " Colour-tvpt " electrodes. Examples of welded work of all kinds including both repair and construction jobs were in evidence and it appears that the applications of this means of dealing with machinery breakages, as also of substituting it for costly and time-losing riveting jobs in a variety

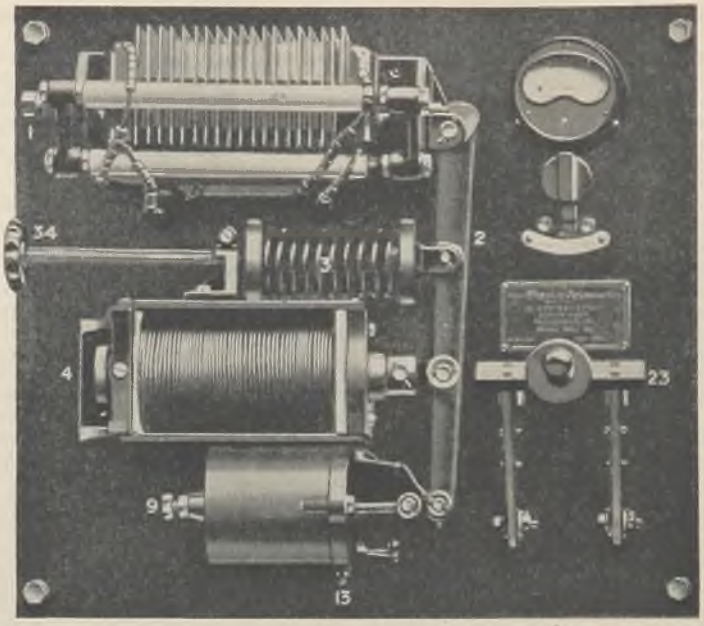


FIG. 1.—AUTOMATIC CURRENT CONTROL PANEL.

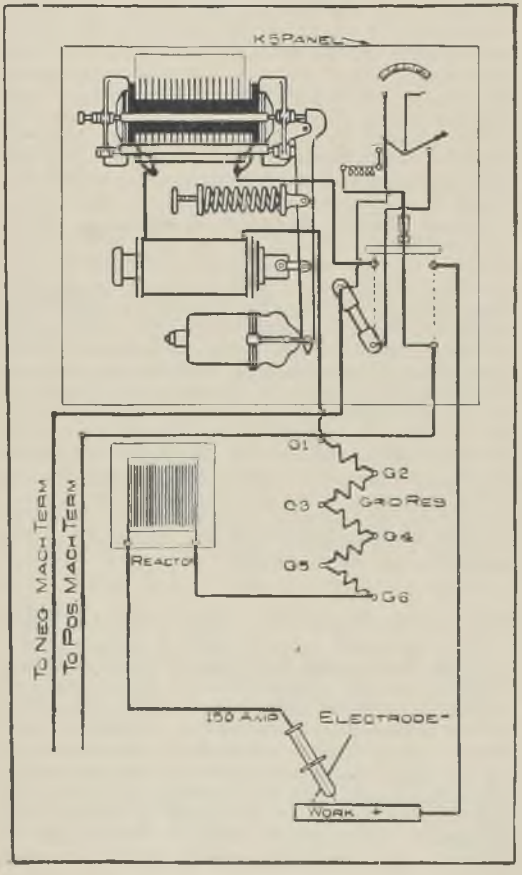


FIG. 2.—WIRING OF CURRENT CONTROL PANEL.

of constructional erection, should only be more generally appreciated to receive wider adoption.

It is not proposed in the present instance to deal specifically with applications of arc welding except in so far as they have been generally outlined above but rather to indicate the salient features which distinguish the Wilson process. Essentially these are associated with the automatic current control panel, described in what follows, and in the use of special electrodes which, as their name implies, are identified by colour tips.

The current control panel, which is illustrated in the accompanying photograph (Fig. 1), is designed to keep the total resistance in the welding circuit constant within very close limits and as the Wilson system incorporates a level compound wound type of generator, i.e. a constant voltage machine, a constant welding current is obtained. It consists essentially of a carbon pile, the pressure on which is varied by a lever actuated by a series solenoid, a simple air dash pot being used as a damping medium. The corresponding wiring diagram is shown in Fig 2.

From this it will be seen that the carbon pile and the solenoid are in series with the arc; therefore, the pull of the solenoid varies with every fluctuation of the welding current. If the current falls—due to the arc lengthening, i.e., arc resistance increasing—the pull on the solenoid core which is attached to the lever (2) is less, the spring (3) forces the lever over on its fulcrum, and the heel of the lever exerts greater pressure on the carbon inserts, and reduces the total resistance across the pile in the same proportion as the arc resistance has increased. The total resistance is therefore corrected to its original setting and the current is kept at its proper value. In the case of the arc shortening, and its resistance thereby increasing, the current increases and the pull of the solenoid is more, thus moving the lever (2) against the spring pressure and decreasing the pressure on the carbon pile. This increases the resistance, and the welding current is kept down to its value.

The normal range of the panel is from 75 to 185 amps. or in electrode diameter, from $\frac{3}{32}$ in. to $\frac{1}{16}$ in., but currents below 75 can be obtained by unscrewing the stop (4) in the solenoid. Any value of current within the panel range is obtained by adjusting the main spring (3) by means of the hand wheel (34). It will be seen, therefore, that the spring pressure is balanced by the solenoid pull and any bias one way or the other due to variation of welding current results in a change of the carbon-pile resistance value, inversely to the change in the arc resistance. The total welding circuit resistance is thus kept to its original setting and this, in conjunction with the constant impress voltage results in a constant current. Tests have proved that the current is kept constant with less than 5% variation.

The constant voltage and current give a constant wattage or heat in the arc which is an absolute essential of any welding operation. Fluctuation of arc heat due to inconstant voltage and/or current results in bad mechanical properties in the weld due to burnt metal and segregation of elements.

The electrodes used in this process are identified as stated above by their coloured tips. The composition of each grade of metal is the result of exhaustive tests to ascertain that which will give the best flowing qualities, penetration, and subsequent characteristics as deposited metal. They are made in lengths of 18 in. and are coated with a rust proof material. The different grades are designated by numbers and the duty for which each is suitable is indicated under this numerical (and colour) classification as is also the corresponding current requirement. Besides a variety of iron and steel (including alloy steel) welding metals are those for brass, bronze and light gauge copper.

METAL MARKETS

Copper.—This market opened in April with a rather firm tone, Standard values in London being marked up somewhat, whilst electrolytic in New York advanced from 9·87½ cents to 10 cents per lb. By the middle of the month, however, the tone was definitely weak again, sentiment being unable to withstand the pessimistic character of general trade advices and the knowledge that copper producers were saddled with huge surplus stocks which so far had shown no signs of seriously diminishing. Electro slipped back to 9·50 cents and Standard also weakened. It is understood than an international meeting of copper producers is taking place in New York during May, when the possibility of further curtailing output will probably be discussed. The immediate outlook, failing a quick trade revival, is not very cheerful.

Average price of Cash Standard Copper: April, 1931, £42 14s. 8d.; March, 1931, £44 17s. 2d.; April, 1930, £62 3s. 3d.; March, 1930, £69 5s. 10d.

Tin.—April was a black month for the tin market, values slipping back relentlessly, so that a loss of about £14 was sustained. In view of the hopes based on the Tin Quota Scheme, this result was almost catastrophic for the "bull" element, which has again seen its plans go astray. So far the producers have reaped no definite advantage from the scheme, as their lessened output has not resulted in higher prices by way of compensation. It looks as if the rate of curtailment will have to be increased if the object of the project is to be achieved to any extent. The statistical position has not improved, the April figures indicating that supplies are still accumulating faster than consumers can absorb them. Despite the decline which has been witnessed in values and the fact that world consumption is not desperately bad, it is difficult to take a very cheerful view of the market, though of course it still remains to be seen what the ultimate effect of the Quota Scheme will be.

Average price of Cash Standard Tin: April, 1931, £112 16s. 9d.; March, 1931, £121 18s. 4d.; April, 1930, £162 14s. 7d.; March, 1930, £164 19s.

Lead.—The London market opened with a fairly firm tone during April, sentiment being buoyed up by anticipations that the meetings of producers would result in something definite being done to rehabilitate the market and put a stop to the accumulation of surplus supplies. World stocks are estimated at the formidable figure of about 350,000 tons. Producers actually succeeded in coming to a fairly comprehensive agreement to curtail output by 15%, but this was followed by easier market conditions, the opinion being held that the "cut" was inadequate in view of the setback in consumption. Prices receded and by the close of the month touched the lowest level witnessed since 1904.

Average mean price of soft foreign lead: April, 1931, £12 9s. 9d.; March, 1931, £13 4s. 9d.; April, 1930, £18 6s. 9d.; March, 1930, £18 17s. 5d.

Spelter.—After a temporary burst of strength at the beginning of April, prices were weak throughout the remainder of the month and fell to an extraordinary low level. Demand continued slack and the market was overshadowed by the huge world stocks, which are estimated to be in excess of 250,000 tons. Very few producers can be making profits with quotations around their present level and the tendency is for more works to shut down. An attempt by certain European interests (who were, incidentally, responsible for the breakdown of the last Zinc Cartel negotiations) to secure an agreement with North American producers regarding export markets, is reported to have failed. Unless world demand unexpectedly revives in the near future, it is difficult to take a very cheerful view of price-prospects, but the position should eventually be restored as economic forces squeeze the weaker producers out of existence.

Average mean price of spelter: April, 1931, £11 11s. 10d.; March, 1931, £12 8s. 7d.; April, 1930, £18 1s. 11d.; March, 1930, £18 11s. 1d.

Iron and Steel.—The situation on the British pig-iron market became worse during April and makers were faced with the dismal possibility of having to blow out further furnaces. Cleveland prices were unaltered at their fixed minima, No. 3 foundry being 58s. 6d., but East Coast hematite, Mixed Numbers, eased to 65s. to 66s. per ton. The British steelworks benefited from substantial railway orders and a certain amount of home engineering business, but, generally, they remained short of contracts owing to the stagnation in the shipbuilding industry and the paucity of export demand. British official steel prices were unchanged. Continental steel tended to firm up during April owing to a revival in overseas demand, but at the close interest fell away again.

Iron Ore. — Business during April was, if anything, even quieter than in the first quarter of the year. Only a few odd cargoes changed hands, and prices are almost wholly nominal on the basis of about 15s. per ton c.i.f. for best Bilbao rubio.

Antimony.—At the close of April, British regulus was priced at from about £35 up to £42 10s. per

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.	Forward.	
Apr.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	d.	d.	s. d.
13	44 3 9	44 15 7½	46 10 0	—	115 3 9	116 13 9	11 18 9	13 0 0	14 10 0	12 1/16	12 1/16	84 10½
14	43 8 1½	44 1 3	46 10 0	44 10 0	115 13 9	117 3 9	11 15 0	12 17 6	14 5 0	13 1/16	13 1/16	84 10½
15	43 3 9	43 16 10½	46 10 0	—	114 16 3	116 6 3	11 11 3	12 15 0	14 5 0	13 1/16	13	84 10
16	42 16 10½	43 9 4½	46 5 0	—	111 16 3	113 3 9	11 7 6	12 12 6	14 5 0	13⅛	13 1/16	84 10½
17	42 15 0	43 8 1½	46 5 0	44 10 0	111 18 9	113 8 9	11 7 6	12 11 3	14 0 0	13 1/16	13 1/16	84 9¾
20	42 11 3	43 5 0	46 0 0	—	112 3 9	113 11 3	11 5 0	12 13 9	14 0 0	13 1/16	13 1/16	84 10½
21	42 11 10½	43 6 3	46 5 0	43 10 0	110 18 9	112 6 3	11 3 9	12 10 0	14 0 0	13 1/16	13 3/16	84 9¾
22	42 11 10½	43 5 7½	46 5 0	—	111 1 3	112 8 9	11 5 0	12 5 0	13 15 0	13	12 15/16	84 9¾
23	42 8 1½	43 1 10½	45 15 0	—	111 8 9	112 13 9	11 5 0	12 5 0	13 15 0	13 1/16	13 1/16	84 9¾
24	42 13 1½	43 5 7½	45 15 0	43 10 0	111 1 3	112 8 9	11 0 0	12 2 6	13 10 0	13 1/16	13 1/16	84 10½
27	41 13 1½	42 6 10½	45 0 0	—	108 3 9	109 8 9	10 11 3	11 17 6	13 5 0	13⅛	13 1/16	84 10½
28	41 16 10½	42 9 4½	45 0 0	43 0 0	107 6 3	108 13 9	10 11 3	12 2 6	13 10 0	13 1/16	13 1/16	84 9¾
29	41 14 4½	42 8 1½	44 15 0	—	107 18 9	108 16 3	10 12 6	11 17 6	13 5 0	13 1/16	13 1/16	84 9¾
30	41 4 4½	41 16 10½	44 10 0	—	104 11 3	105 18 9	10 10 0	11 12 6	13 0 0	13 1/16	13⅛	84 9¾
May												
1	40 18 9	41 10 7½	44 12 6	42 5 0	105 11 3	106 16 3	10 12 6	11 12 6	13 0 0	13	13	84 9¾
4	39 18 9	40 10 7½	44 0 0	—	103 18 9	104 6 3	10 8 9	11 8 9	13 0 0	13 1/16	13 1/16	84 9¾
5	40 1 3	40 14 4½	43 10 0	42 0 0	103 17 6	105 3 9	10 10 0	11 13 9	13 0 0	13 1/16	13 1/16	84 10½
6	40 7 6	41 0 0	43 10 0	—	105 11 3	106 16 3	10 13 9	11 17 6	13 5 0	13 1/16	13 1/16	84 11½
7	39 19 4½	40 13 1½	43 10 0	—	104 13 9	106 1 3	10 10 0	11 18 9	13 5 0	13⅛	13⅛	84 11½
8	39 18 1½	40 13 1½	43 10 0	41 2 6	104 16 3	106 1 3	10 12 6	11 18 9	13 5 0	13 1/16	13 1/16	84 9¾
11	40 4 4½	40 18 1½	43 15 0	—	104 11 3	105 16 3	10 12 6	11 11 3	13 0 0	13 1/16	13	84 9¾

ton. Chinese regulus was rather easy at £24 to £24 10s. ex-warehouse, whilst metal for shipment from China realized about £21 7s. 6d. c.i.f.

ARSENIC.—Cornish 99% white remains very scarce, but is quoted nominally at £19 10s. per ton f.o.r. mines. High grade Mexican remains at £17 10s. c.i.f. Liverpool.

BISMUTH.—Towards the end of April competition became keener and on May 1 the Trust reduced its official price to 5s. per lb. for merchant quantities.

CADMIUM.—Quiet conditions have ruled in this market, but prices have been steady at 1s. 9½d. to 1s. 10½d. per lb.

COBALT METAL.—The official price remains at 10s. per lb., but demand is slow and rebates are granted for contracts.

COBALT OXIDES.—There is no change in the official prices, which are 8s. per lb. for black and 8s. 10d. for grey, but actual business is passing at about 30% under these prices.

CHROMIUM METAL.—A fair demand continues at about 2s. 6d. to 2s. 7d. per lb.

TANTALUM.—In the absence of any appreciable enquiry, prices are nominally unchanged at between £40 and £50 per lb.

PLATINUM.—The failure of leading producers to agree upon a policy for the maintenance of prices, led to easy conditions, and, although a fair business was done at the lower levels, prices remain at about £4 15s. to £5 per oz. for refined metal.

PALLADIUM.—Quotations are unchanged at £3 12s. 6d. to £4 per oz.

IRIDIUM.—Very little interest has been shown in this metal recently, but prices are nominally unaltered at £27 10s. to £30 per oz. for sponge and powder.

OSMIUM.—In sympathy with platinum, prices eased during April, current quotations being about £13 to £14 10s. per oz.

TELLURIUM.—There is no demand just now and prices are quite nominal at 9s. 6d. per lb.

SELENIUM.—High grade black powder continues to change hands at about 7s. 8d. to 7s. 9d. per lb. ex-warehouse.

MANGANESE ORE.—Deadly dull conditions rule in this market and, in the absence of sales, it is difficult to give a clear indication of prices. Best Indian is around 1s. to 1s. 0½d. per unit c.i.f. and good 48% ore about 10¾d. c.i.f. Washed Caucasian is nominally 11d. c.i.f.

ALUMINIUM.—Business has been distinctly poor recently and stocks continue to accumulate. Prices, however, are unchanged at £85, less 2%, delivered, for ingots and bars.

SULPHATE OF COPPER.—Despite an easier tone in copper prices, British sulphate is still quoted at £21 to £21 10s. per ton, less 5% f.o.r.

NICKEL.—A slight improvement in demand is reported, with prices steady at £170 to £175 per ton.

CHROME ORE.—Only a restricted call is noticeable for this article and competition has become keener. Prices are slightly easier at about 77s. 6d. c.i.f. for good 48% ore.

QUICKSILVER.—Throughout the past month there has been very little moving in this market, but prices are unaltered at £22 7s. 6d. per bottle, full terms, for spot material.

TUNGSTEN ORE.—Demand has continued at a distinctly low ebb, but, with sellers manifesting a rather firmer attitude, prices are a little higher on balance, forward shipment from China now being held for about 14s. to 14s. 3d. per unit c.i.f.

MOLYBDENUM ORE.—Leading sellers continue to quote as much as 35s. 6d. per unit c.i.f., but odd parcels have been offering at down to 30s. and even less.

GRAPHITE.—A lack of business has led to easier prices, 85 to 90% Madagascar flake being held for about £15 to £16 per ton c.i.f., and 90% Ceylon lumps for about £17 to £18 c.i.f.

SILVER.—April opened with the market dull and rather easier, spot bars losing some ground from the price of 12 1/16d. on April 1. China, however, bought a little and by April 15 spot bars had recovered to 13⅛d., and rose to 13½d. a few days later. The second half of the month, however, witnessed a quiet market and spot bars closed at 13 3/16d. on April 30.

STATISTICS

PRODUCTION OF GOLD IN THE TRANSVAAL.

	Rand.	Elsewhere.	Total.
	Oz.	Oz.	Oz.
April, 1930	831,996	36,610	868,606
May	876,893	39,320	916,213
June	847,352	40,515	887,867
July	871,468	41,184	912,652
August	878,474	42,607	921,081
September	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

TRANSVAAL GOLD OUTPUTS.

	March.		April.	
	Treated Tons.	Yield Oz.	Treated Tons.	Yield Oz.
Brakpan	95,000	£144,978	90,000	£139,041
City Deep	95,000	24,016	88,000	23,104
Cons. Main Reef	67,500	23,032	64,000	21,930
Crown Mines	266,000	84,037	241,000	79,045
D'rb'n Roodepoort Deep	46,800	14,992	46,300	14,963
East Rand P.M.	154,400	42,209	149,500	40,793
Geduld	85,500	27,131	81,000	26,063
Geldenhuis Deep	72,000	16,141	70,500	16,034
Glynn's Lydenburg	6,600	2,400	6,200	2,364
Government G.M. Areas	203,000	£399,776	196,000	£388,027
Kleinfontein	52,000	10,755	50,700	10,027
Langlaagte Estate	80,000	£116,812	76,000	£113,736
Luipaard's Vlei	33,000	8,022	29,300	7,431
Meyer and Charlton	18,400	£17,686	17,800	£18,221
Modderfontein New	166,000	70,281	157,000	67,707
Modderfontein B	73,500	21,785	72,000	21,362
Modderfontein Deep	44,200	22,500	43,500	22,107
Modderfontein East	72,000	21,452	70,500	21,125
New State Areas	79,000	£170,698	77,000	£166,812
Nourse	69,000	20,632	66,000	20,129
Randfontein	225,000	£260,995	213,000	£246,955
Robinson Deep	98,000	28,212	92,000	27,221
Rose Deep	63,500	12,821	60,000	12,299
Simmer and Jack	76,200	22,156	71,900	21,768
Springs	66,400	£144,217	67,500	£144,278
Sub Nigel	32,000	28,212	32,000	28,108
Transvaal G.M. Estates	15,700	4,898	15,500	5,002
Van Ryn	43,000	£42,610	43,000	£41,881
Van Ryn Deep	63,000	£97,371	59,000	£92,403
West Rand Consolidated	94,000	£108,743	91,000	£106,991
West Springs	68,000	£73,244	64,500	£70,473
Witw'tersr'nd (Knights)	56,000	£48,332	54,000	£48,891
Witwatersrand Deep	38,700	12,430	37,100	11,754

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.	£
January, 1930	2,618,600	28 2	19 9	8 5	1,103,718
February	2,421,100	28 5	20 0	8 5	1,019,482
March	2,663,820	28 1	19 8	8 5	1,121,216
April	2,549,250	28 7	20 1	8 6	1,084,504
May	2,741,634	28 1	19 8	8 5	1,153,549
June	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

NATIVES EMPLOYED IN THE TRANSVAAL MINES.

	Gold Mines.	Coal Mines.	Diamond Mines.	Total.
April 30, 1930	202,434	15,109	5,565	223,108
May 31	202,182	15,028	5,340	222,550
June 30	201,324	14,943	5,126	221,393
July 31	201,111	14,670	5,490	221,271
August 31	202,257	14,788	5,754	222,799
September 30	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

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	—
May	47,323	48,189	47,645	—
June	51,762	48,406	45,208	—
July	48,960	46,369	45,810	—
August	50,611	46,473	46,152	—
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.

	March.		April.	
	Tons.	Oz.	Tons.	Oz.
Cam and Motor	24,800	10,286	24,600	10,363
Globe and Phœnix	6,016	5,129	6,028	5,307
Lonely Reef	6,500	3,225	6,400	2,324
Luiri Gold	1,705	£2,517	—	—
Rezende	6,400	2,679	6,400	2,653
Sherwood Star	4,400	£10,281	4,600	£9,803
Wanderer Consolidated	15,000	3,078	15,000	3,694

WEST AFRICAN GOLD OUTPUTS.

	March.		April.	
	Tons.	Oz.	Tons.	Oz.
Ariston Gold Mines	3,990	£8,204	—	—
Ashanti Goldfields	12,018	14,146	11,900	14,044
Taquah and Abosso	10,605	£16,747	10,310	£16,209

AUSTRALIAN GOLD OUTPUTS BY STATES.

	Western Australia.	Victoria.	Queensland
	Oz.	Oz.	Oz.
April, 1930	36,652	1,812	1,081
May	32,967	3,480	580
June	41,738	812	673
July	34,174	2,327	728
August	38,579	1,864	323
September	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	458	—
March	34,946	—	—
April	30,491	—	—

AUSTRALASIAN GOLD OUTPUTS.

	March.		April	
	Tons.	Value £	Tons	Value £
Associated G.M. (W.A.)	4,889	7,861	4,898	7,919
Blackwater (N.Z.)	2,854	4,774	3,460	4,993
Boulder Persev'ce (W.A.)	6,673	15,347	6,700	14,301
Grt. Boulder Pro. (W.A.)	10,324	27,603	10,058	25,668
Lake View & Star (W.A.)	8,335	21,354	—	—
Sons of Gwalia (W.A.)	12,298	15,450	12,024	14,688
South Kalgurli (W.A.)	8,957	14,733	8,246	14,516
Waihi (N.Z.)	17,154	{ 5,767* 24,629†	—	{ — —

* Oz. gold. † Oz. silver.

GOLD OUTPUTS, KOLAR DISTRICT, INDIA.

	March.		April.	
	Tons Ore	Total Oz.	Tons Ore	Total Oz.
Balaghat	3,000	2,108	3,350	2,109
Champion Reef	8,500	5,609	8,100	5,455
Mysore	17,205	9,243	15,571	7,704
Nundydroog	12,184	7,254	12,639	7,282
Ooregum	9,600	4,525	12,000	4,607

MISCELLANEOUS GOLD, SILVER, AND PLATINUM OUTPUTS.

	March.		April.	
	Tons	Value £	Tons	Value £
Chosen Corp. (Korea)	9,580	15,430	9,430	14,000
Frontino & Bolivia (C'lbia)	2,510	11,663	2,150	10,535
Marmajito (Colombia)	1,100	4,559	980	4,263
Fresnillo	89,284	6,312*d*	—	—
New Goldfields of Venezuela	—	—	4,844	1,890*
Oriental Cons. (Korea)	16,827	113,185*d*	—	111,256*d*
St. John del Rey (Brazil)	—	44,000	—	35,500
Santa Gertrudis (Mexico)	34,447	55,470*d*	—	—
West Mexican Mines	1,190	24,000*d*	—	—

d Dollars. * Oz. gold.

PRODUCTION OF TIN IN FEDERATED MALAY STATES.

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

July, 1930	5,525	January, 1931	5,450
August	4,153	February	5,470
September	4,048	March	4,461
October	4,807	April	4,510
November	4,812	May	—
December	5,019	June	—

OUTPUTS OF MALAYAN TIN COMPANIES.

In Long Tons of Concentrate.

	Feb.	Mar.	Apr.
Ayer Hitam	142⅔	107½	131
Batu Caves	16⅔	24	18
Changkat	67	40	55
Gopeng	73	59½	59½
Hongkong Tin	56	50½	107
Idris Hydraulic	32⅔	20⅔	22
Ipoh	33½	37½	36
Kampar Malaya	49	67	83
Kampong Lanjut	52	82	84
Kamunting	—	152½	194
Kent (F.M.S.)	21	28	28
Kinta	30	22½	22½
Kinta Kellas	81½	68⅔	37⅔
Kramat Tin	76	75	85
Kuala Kampar	95	42	77
Kundang	—	8	14
Lahat	19½	20½	18
Larut Tin Fields	—	—	—
Malaya Consolidated	48½	63	42½
Malayan Tin	144⅔	131	137
Malim Nawar	28	18	30
Pahang	255⅔	255⅔	221½
Penawat	53½	69½	83½
Pengkalen	63	65½	65½
Petaling	195	176	133
Rahman	59½	65½	89½
Rambutan	11	9½	9½
Rantau	21	22	29
Rawang	56	65	65
Rawang Concessions	50	40	45
Renong	47½	63½	32
Selayang	—	—	17
Southern Malayan	170⅓	163⅔	190⅓
Southern Perak	50⅔	35½	53⅔
Southern Tronoh	40	45	54
Sungei Besi	47	42	42
Sungei Kinta	23⅓	38½	35⅔
Sungei Way	107½	119	119
Taiping	14⅓	23	33
Tanjong	51	44½	35⅓
Teja Malaya	22⅓	26⅔	30
Tekka	63⅓	33	37½
Tekka-Taiping	56	57½	62
Temengor	10⅔	11½	—
Temoh	46⅔	41	37½
Tronoh	83	93	84
Ulu Klang	—	26⅔	34

OUTPUTS OF NIGERIAN TIN MINING COMPANIES.

In Long Tons of Concentrate.

	Feb.	Mar.	Apr.
Amari	—	—	—
Anglo-Nigerian	64	58	48
Associated Tin Mines	205	220	200
Baba River	7	7	7
Batura Monguna	3½	5	—
Bisichi	44	49	40
Daffo	7	6	—
Filani	3	2½	2½
Jantar	22	21	—
Jos	20	20	13⅓
Juga Valley	6½	5	8
Kaduna Syndicate	22	25	—
Kaduna Prospectors	9	7	—
Kassa	9	12½	12
London Tin	140	220	130
Lower Bisichi	6½	—	5
Naraguta	22	21	14½
Naraguta Durumi	6	7	4½
Naraguta Extended	12	10	10
Naraguta Karama	19½	21⅔	14
Naraguta Korot	7	10½	9
Nigerian Consolidated	14	14	12
Offin River	5½	3½	4⅔
Ribon Valley	9	8	6½
South Bukeru Areas	10	11	8
Tin Fields	4½	4½	5½
Tin Properties	—	—	—
United Tin Areas	18	18	18
Yarde Kerri	11	—	—

OUTPUTS OF OTHER TIN MINING COMPANIES.

In Long Tons of Concentrate.

	Feb.	Mar.	Apr.
Anglo-Burma (Burma)	14	15½	15
Aramayo Mines (Bolivia)	269	198	214
Bangrin (Siam)	69½	82½	—
Beralt	—	—	38*
Consolidated Tin Mines (Burma)	120	90	92
East Pool (Cornwall)	41	43⅔	—
Fabulosa (Bolivia)	90	115½	86½
Geevor (Cornwall)	—	—	—
Kagera (Uganda)	16	20	20
Kamra	38	48½	—
Malaysian Tin	24½	28½	21
Mawchi	265*	312*	—
Patino	—	1,416	—
Pattani	35½	47½	—
Rooiberg Minerals	28	27	—
San Finx (Spain)	—	27⅔*	—
Siamese Tin (Siam)	175½	188⅔	—
Tavoy Tin (Burma)	49⅔	61	46½
Tongkah Harbour (Siam)	32	70	75
Toyo (Japan)	72½	64½	50
Zaaiplaats	20½	—	—

* Tin and Wolfram.

COPPER, LEAD, AND ZINC OUTPUTS.

		Mar.	Apr.
Broken Hill South	Tons lead conc.	5,001	4,907
	Tons zinc conc.	—	2,435
Burma Corporation	Tons refined lead	6,700	6,700
	Oz. refined silver	530,000	530,000
Electrolytic Zinc	Tons zinc	4,149	4,175
Indian Copper	Tons copper	350	346
Messina	Tons copper	753	683
Mount Lyell	Tons concentrates	3,161	3,014
North Broken Hill	Tons lead conc.	5,280	4,930
	Tons zinc conc.	—	1,940
Poderosa	Tons copper ore	392	392
Rhodesia Broken Hill	Tons V_2O_5	23	15
	Tons slab zinc	1,335	1,010
San Francisco Mexico	Tons lead conc.	3,823	3,588
	Tons zinc conc.	4,097	3,585
Tetiuhe	Tons lead conc.	946	—
	Tons zinc conc.	1,862	—
Trepca	Tons lead conc.	3,549	3,129
	Tons zinc conc.	2,421	2,643
Zinc Corporation	Tons lead conc.	5,371	—
	Tons zinc conc.	4,067	—

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

		February.	March.
Iron Ore	Tons	180,035	211,441
Manganese Ore	Tons	11,670	4,835
Iron and Steel	Tons	177,056	210,467
Copper and Iron Pyrites	Tons	15,281	21,428
Copper Ore, Matte, and Prec.	Tons	3,063	3,239
Copper Metal	Tons	12,564	11,985
Tin Concentrate	Tons	5,158	3,227
Tin Metal	Tons	1,080	1,680
Lead Pig and Sheet	Tons	20,147	21,792
Zinc (Spelter)	Tons	9,780	15,178
Zinc Sheets, etc.	Tons	2,002	1,536
Aluminium	Tons	1,287	2,703
Mercury	Lb.	106,217	80,343
Zinc Oxide	Tons	485	734
White Lead	Cwt.	12,919	11,426
Red and Orange Lead	Cwt.	2,502	3,393
Barytes, ground	Cwt.	38,897	43,618
Asbestos	Tons	2,222	1,621
Boron Minerals	Tons	1,004	654
Borax	Cwt.	12,319	24,999
Basic Slag	Tons	3,081	4,106
Superphosphates	Tons	16,156	22,843
Phosphate of Lime	Tons	25,065	32,323
Mica	Tons	179	252
Sulphur	Tons	3,154	8,642
Nitrate of Soda	Cwt.	93,294	51,572
Potash Salts	Cwt.	220,947	369,023
Petroleum: Crude	Gallons	42,624,621	33,403,763
Lamp Oil	Gallons	26,863,079	21,934,514
Motor Spirit	Gallons	57,514,583	96,975,648
Lubricating Oil	Gallons	4,295,166	7,487,620
Gas Oil	Gallons	4,066,517	6,619,568
Fuel Oil	Gallons	32,422,896	41,627,720
Asphalt and Bitumen	Tons	14,580	18,696
Paraffin Wax	Cwt.	88,821	98,991
Turpentine	Cwt.	27,927	8,691

OUTPUTS REPORTED BY OIL-PRODUCING COMPANIES.

In Tons.

	February.	March.	April.
Anglo-Ecuadorian	14,890	15,541	16,824
Apex Trinidad	36,900	45,930	48,080
Attock	1,492	1,619	1,542
British Burmah	4,105	4,559	4,299
British Controlled	31,721	36,043	36,416
Kern Mex	725	815	898
Kern River (Cal.)	1,496	1,790	2,027
Kern Romana	1,431	1,140	1,015
Kern Trinidad	5,322	5,626	4,898
Lobitos	23,662	25,418	24,767
Phœnix	52,219	61,249	67,936
St. Helen's Petroleum	5,228	5,921	5,418
Steaua Romana	80,790	85,710	73,670
Tampico	2,789	3,209	2,940
Tocuyo	2,518	2,348	2,396
Trinidad Leaseholds	20,000	20,050	13,650

QUOTATIONS OF OIL COMPANIES' SHARES.

Denomination of Shares £1 unless otherwise noted.

	April 10, 1931.			May 11, 1931.		
	£	s.	d	£	s.	d.
Anglo-Ecuadorian		8	9		6	0
Anglo-Egyptian B.	2	1	9	1	15	0
Anglo-Persian 1st Pref.	1	5	6	1	5	6
" " Ord.	2	1	9	1	15	0
Apex Trinidad (5s.)		10	0		8	9
Attock		15	6		12	6
British Burmah (8s.)		4	0		3	9
British Controlled ($5)		2	0		1	3
Burmah Oil	3	2	6	2	10	0
Kern River Cal. (10s.)		2	3		1	6
Lobitos, Peru	1	1	9		16	3
Mexican Eagle, Ord. (4 pesos)		8	9		6	9
" " 8% Pref. (4 pesos)		9	3		7	0
Phœnix, Roumanian		6	0		4	9
Royal Dutch (100 fl.)	23	0	0	19	10	0
Shell Transport, Ord.	3	3	0	2	13	0
" " 5% Pref. (£10)	10	0	0	10	0	0
Steaua Romana		3	6		3	9
Trinidad Leaseholds	1	1	3		13	9
United British of Trinidad (6s. 8d.)		5	0		3	9
V.O.C. Holding	1	11	3	1	9	3

PRICES OF CHEMICALS. May 11.

These quotations are not absolute; they vary according to quantities required and contracts running.

		£	s.	d.
Acetic Acid, 40%	per cwt.		18	9
" 80%	"	1	16	3
" Glacial	per ton	58	0	0
Alum	"		8	7	6
Aluminium Sulphate, 17 to 18%	"		6	15	0
Ammonium, Anhydrous	per lb.			11
" 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.	"	9	10	0
Antimony, Tartar Emetic, 43/44%	per lb.			10
" Sulphide, crimson	"		1	4
Arsenic, White	per ton	19	7	6
Barium, Carbonate, 94%	"	4	10	0
" Chloride	"	8	15	0
" Sulphate, 94%	"	6	15	0
Benzol, standard motor	per gal.		1	5
Bleaching Powder, 35% Cl.	per ton	7	0	0
Borax	"	13	10	0
Boric Acid	"	22	0	0
Calcium Chloride, solid, 70/75%	"	5	5	0
Carbolic Acid, crude 60's	per gal.		1	2
" " crystallized, 40°	per lb.			5⅜
Carbon Disulphide	per ton	16	10	0
Citric Acid	per lb.		1	0
Copper Sulphate	per ton	18	15	0
Creosote Oil (f.o.b. in Bulk)	per gal.			4¼
Cresylic Acid, 98-100%	"		1	8
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	"	32	7	6
" Nitrate (ton lots)	"	28	15	0
" Oxide, Litharge	"	27	10	0
" White	"	38	0	0
Lime, Acetate, brown	"	7	5	0
" " grey, 80%	"	12	0	0
Magnesite, Calcined	"	9	10	0
Magnesium, Chloride	"	5	10	0
" Sulphate, comml.	"	3	15	0
Methylated Spirit 64° Industrial	per gal.		1	9
Nitric Acid, 80° Tw.	per ton	23	0	0
Oxalic Acid	per cwt.	1	11	6
Phosphoric Acid. S.G. 1·500	per ton	29	15	0
Pine Oil	"	42	10	0
Potassium Bichromate	per lb.			4½
" Carbonate, 96/98%	per ton	25	0	0
" Chlorate	"	27	10	0
" Chloride 80%	"	9	5	0
" Ethyl Xanthate	per 1,016 kilos	55	15	0
" Hydrate (Caustic) 88/90%	per ton	28	10	0
" Nitrate	"	19	17	6
" Permanganate	per lb.			5⅜
" Prussiate, Yellow	"			6¾
" " Red	"		1	8
" Sulphate, 90%	per ton	10	10	0
Sodium Acetate	"	17	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	"	26	5	0
" Cyanide 100% NaCN basis	per lb			7
" Ethyl Xanthate	per 1,016 kilos	53	5	0
" Hydrate, 76%	per ton	14	10	0
" Hyposulphite, comml.	"	9	2	6
" Nitrate (ordinary)	"	10	0	0
" Phosphate, comml.	"	10	0	0
" Prussiate	per lb.			4¾
" 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%	"	8	15	0
" Sulphite, pure	per cwt.		14	0
Sulphur, Flowers	per ton	10	10	0
" Roll	"	10	10	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.			11½
Turpentine	per ton	48	0	0
Tin Crystals	per lb.			11½
Titanous Chloride	"			10
Zinc Chloride	per ton	9	10	0
Zinc Dust, 90/92%	"	20	0	0
Zinc Oxide (White Seal)	"	35	0	0
Zinc Sulphate	"	8	5	0

SHARE QUOTATIONS

Shares are £1 par value except where otherwise noted.

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

COPPER:		
Bwana M'Kubwa (5s.) Rhodesia	6 0	3 6
Esperanza Copper	13 9	13 9
Indian (2s.)	1 3	1 3
Loangwa (5s.), Rhodesia	1 9	1 0
Luiri (5s.), Rhodesia	2 9	2 6
Messina (5s.), Transvaal	10 0	8 6
Mount Lyell, Tasmania	16 9	15 0
Namaqua (£2), Cape Province	5 0	6 3
N'Changa, Rhodesia	1 15 0	1 15 0
Rhodesia-Katanga	18 9	15 0
Rio Tinto (£5), Spain	26 2 6	19 15 0
Roan Antelope (5s.), Rhodesia	17 6	13 9
Tanganyika Con.	1 5 6	1 3 9
Tharsis (£2), Spain	3 3 9	2 14 0

LEAD-ZINC:	April 10, 1931. £ s. d.	May 11, 1931. £ s. d.
Amalgamated Zinc (8s.), N.S.W.	6 3	6 3
Broken Hill Proprietary, N.S.W.	10 6	10 0
Broken Hill, North, N.S.W.	1 13 9	1 12 6
Broken Hill South, N.S.W.	1 6 3	1 5 0
Burma Corporation (10 rupees)	8 9	6 9
Electrolytic Zinc Pref., Tasmania	17 6	15 0
Mount Isa, Queensland	11 9	10 0
Rhodesia Broken Hill (5s.)	1 0	1 0
San Francisco (10s.), Mexico	12 6	10 6
Sulphide Corporation (15s.), N.S.W.	5 9	4 6
ditto, Pref.	10 0	8 6
Zinc Corporation (10s.), N.S.W.	16 9	13 9
ditto, Pref.	2 12 6	2 6 3

TIN:		
Aramayo Mines (25 fr.), Bolivia	1 5 0	1 1 3
Associated Tin (5s.), Nigeria	5 3	3 9
Ayer Hitam (5s.)	11 9	11 0
Bangrin, Siam	13 3	11 6
Bisichi (10s.), Nigeria	5 9	4 9
Chenderiang, Malay	1 6	1 6
Consolidated Tin Mines of Burma	3 0	2 6
East Pool (5s.), Cornwall	6	6
Ex-Lands Nigeria (2s.), Nigeria	1 6	1 6
Geevor (10s.), Cornwall	3 6	3 0
Gopeng, Malaya	1 18 9	1 15 0
Hongkong (5s.)	16 6	15 3
Idris (5s.), Malaya	7 6	6 6
Ipoh Dredging (16s.), Malay	15 9	14 0
Kaduna Prospectors (5s.), Nigeria	5 6	5 9
Kaduna Syndicate (5s.), Nigeria	12 6	12 6
Kamunting (5s.), Malay	5 3	4 6
Kepong, Malay	10 0	10 0
Kinta, Malay (5s.)	7 6	6 6
Kinta Kellas, Malay (5s.)	6 6	5 6
Kramat Pulai, Malay	1 1 0	1 0 0
Lahat, Malay	5 3	5 3
Malayan Tin Dredging (5s.)	17 6	16 6
Naraguta, Nigeria	10 0	7 6
Nigerian Base Metals (5s.)	6	6
Pahang Consolidated (5s.), Malay	5 6	4 3
Penawat ($1), Malay	1 6	1 0
Pengkalen (5s.), Malay	10 9	10 6
Petaling (2s. 4d.), Malay	9 0	8 3
Rambutan, Malay	6 3	5 0
Renong Dredging, Malay	16 3	15 0
Siamese Tin (5s.), Siam	8 0	6 3
South Crofty (5s.), Cornwall	3 3	1 9
Southern Malayan (5s.)	11 0	10 0
Southern Perak, Malay	1 8 9	1 7 6
Southern Tronoh (5s.), Malay	6 0	5 9
Sungei Besi (5s.), Malay	7 0	6 6
Sungei Kinta, Malay	13 0	10 0
Tanjong (5s.), Malay	7 6	6 9
Tavoy (4s.), Burma	4 9	3 9
Tekka, Malay	14 3	13 0
Tekka Taiping, Malay	13 0	12 6
Temengor, Malay	1 6	1 6
Toyo (10s.), Japan	2 0	1 9
Tronoh (5s.), Malay	13 9	12 0

DIAMONDS:		
Consol. African Selection Trust (5s.)	15 0	13 9
Consolidated of S.W.A. (10s.)	5 9	4 6
De Beers Deferred (£2 10s.)	5 2 6	3 18 9
Jagersfontein	1 5 0	1 1 0
Premier Preferred (5s.)	2 10 0	2 0 0

FINANCE, ETC.:		
Anglo-American Corporation (10s.)	16 9	13 9
Anglo-French Exploration	12 6	8 9
Anglo-Continental (10s.)	4 6	3 9
Anglo-Oriental (Ord., 5s.)	7 9	6 6
ditto, Pref.	10 6	8 6
British South Africa (15s.)	1 7 3	1 3 0
Central Mining (£8)	8 10 0	6 15 0
Consolidated Gold Fields	1 10 9	1 3 0
Consolidated Mines Selection (10s.)	9 3	8 0
Fanti Consols (8s.)	8 0	5 9
General Mining and Finance	1 1 3	16 3
Gold Fields Rhodesian (10s.)	5 6	4 0
Johannesburg Consolidated	1 10 3	1 3 6
London Tin Corporation (10s.)	13 0	9 9
Minerals Separation	4 0 0	3 3 9
National Mining (8s.)	6	3
Rand Mines (5s.)	3 2 6	2 18 9
Rand Selection (5s.)	11 6	10 0
Rhodesian Anglo-American (10s.)	12 6	10 0
Rhokana Corp.	7 5 0	4 15 0
Rhodesian Selection Trust (5s.)	16 9	13 9
South Rhodesia Base Metals	2 6	2 0
Tigon (5s.)	12 6	9 6
Union Corporation (12s. 6d.)	2 16 3	2 16 3
Venture Trust (10s.)	4 6	4 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.

FLOTATION AT THE AMULET MINE, QUEBEC

The treatment of copper-zinc-iron ore at the Amulet mine, Quebec, is described by W. G. Hubler in the *Canadian Mining and Metallurgical Bulletin* for February. The author says that when an attempt was made to use the methods of lead-zinc separation on copper-zinc ores, it was found that the depressant reagents added to inhibit the flotation of the iron and zinc minerals would, under certain conditions, depress a large part of the copper. It was also recognized that, in the grinding of copper-zinc ore, soluble salts were generated which were detrimental to flotation unless properly controlled. The main part of this paper is a discussion of solutions in the grinding circuit in relation to the production of soluble salts and their effect on flotation.

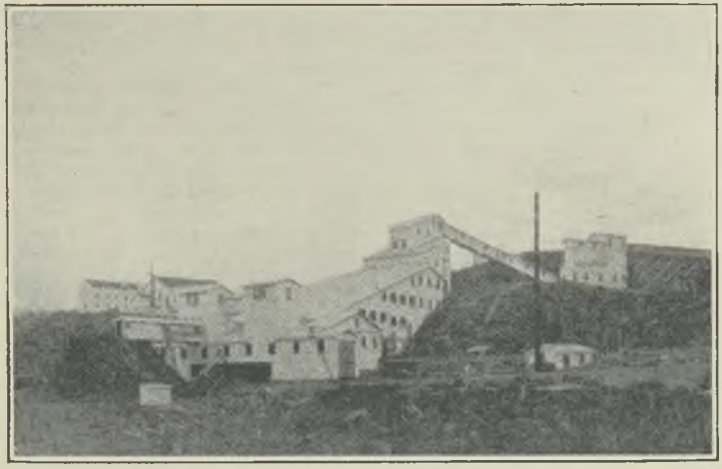


FIG. 1.—THE AMULET MILL.

After extensive investigations by the Mines Branch at Ottawa, and the General Engineering Company at Salt Lake City, decision was made to construct a 300-ton preferential flotation plant at the Amulet mine. While it was realized that the operation would be rather a pioneering venture in metallurgy, as no operating data were available, the test work was so favourable that little doubt was entertained that the operation would be a success. The mill was designed and constructed by the General Engineering Company in co-operation with the Amulet staff. Construction work was started late in September, 1929, and completed April 1, 1930. A three-mile spur was constructed to the mill-site by the Canadian National Railways. This work was all carried on during the cold winter months and progressed smoothly to completion. Operation was commenced on April 6, 1930, and the mill functioned well mechanically. Only minor adjustments were necessary and capacity tonnage was reached two weeks after starting. The mill was designed for 300 tons daily capacity, but 400 tons have been milled with good metallurgical results. The mill was finally stabilized at 350 tons per day.

The crushing equipment consists of a 28 in. by 36 in. Traylor Bulldog primary crusher, set to crush to 4 in. This crusher is fed by means of a drop-bar grizzly of local design. The crushed ore is conveyed to a 300-ton intermediate bin ahead of the Symons cone crusher by means of a 24-in. conveyor belt having a belt grade of 18°. The ore from the intermediate bin is fed by means of a steel pan conveyor and is passed over a 3 ft. by 6 ft. Leahy vibrating screen with ½-in. screen cloth before going to a 4-ft. Symons cone crusher. Crushing in the Symons cone is to ¾-in. The discharge from the Symons crusher, together with the screen undersize, is raised by a bucket elevator to the mill bins. Only one of the crushers is operated at a time, thereby preventing high peaks in the power load.

The fine ore is fed to the ball-mills by means of belt conveyors. The feeders are equipped with revolution counters and hourly box-weights are taken of the ore stream: the box-weights are averaged for the day, and actual feeder time is arrived at from the revolution counter. Daily tonnage is easily arrived at from these figures. The grinding circuit consists of two 75 Marcy mills in parallel, each operated in closed circuit with an 8-ft. Dorr classifier. The classifier sands are returned to the mills by means of 14-in. helicoid spiral steel conveyors.

The classifier overflow goes by gravity to an automatic sampler and from there to two 15-ft.

MacIntosh flotation cells operated in parallel as copper primaries; the tailings from the primaries are treated in two 15-ft. MacIntosh cells, also in parallel. The tailings from these roughers go to one 15-ft. scavenger cell, making a final copper tailing for zinc treatment. The primary froth is cleaned once in a 15-ft. cleaner cell. The cleaner tailings, together with the rougher and scavenger froth, are returned to the primary cells. The cells are arranged in parallel, so that any one or two of the cells may be shut down for repairs without interrupting the operation of the mill. The copper tailings are pumped to a 10 ft. by 14 ft. conditioning tank equipped with a Devereaux agitator, the overflow of which goes to seven 15-ft. MacIntosh cells for the zinc flotation. The zinc flow-sheet is the same as that for copper, except that the zinc concentrates are cleaned twice.

The concentrates are thickened in two 40 ft. by 10 ft. Dorr thickeners and filtered on two 6 ft. 6 in. five-disc American filters, one for copper concentrate and one for zinc. The filtered concentrates discharge directly to storage bins and from them into railway cars; no shovelling of concentrates is necessary other than trimming the cars. During the winter months, the zinc concentrate is trammed to a stock pile in 16 cu. ft. mine cars. Zinc concentrate from the stock pile is reclaimed in summer with a drag-line scraper. Wilfley pumps are used throughout for the handling of pulp and Dayton-Dowd pumps for clear solution.

The Amulet ore-bodies are tabular—evidently replacement deposits lying at or near the contact of lava flows. The dip varies from zero to 30°. The ore is an intimate mixture of chalcopyrite, sphalerite, marmatite, silver, gold, galena, pyrite, and pyrrhotite, the minerals being named in the order of their commercial importance. Free gold is present in the ore. Approximately 40% of the gold is associated with the chalcopyrite, and 20% to 30% is probably associated with the pyrite. The silver is largely associated with the lead. The ore varies from massive chalcopyrite, sphalerite, and pyrite to all grades in between. The average specific gravity of the ground ore is 3·5. The following is an approximate analysis of the ore treated: gold 0·02 oz., silver 3·5 oz., copper 3·5%, zinc 13%, iron 20%, insoluble 36%, and the balance sulphur and minor constituents. There is no talc, mica, or graphite in the ore to interfere with flotation. The iron occurs mostly as pyrite. The gangue is the unreplaced and largely unaltered portion of the rhyolitic country rock.

The operation of the Amulet mill may be divided into two periods, the first covering the time from the commencement of operations on April 15, 1930, to September 26, 1930, and the second from September 26, 1930, to October 20, 1930, when the mill closed down. During the first period, the mill operated on a soda circuit, and to a large extent with the reagents as worked out in the preliminary tests. During the second period a change was made to a lime circuit.

The operation of these two circuits and their characteristics and results are described separately. The test work had indicated that it would be necessary to grind to 80% − 200 mesh, but it was found in practice that grinding to 65% − 200 mesh gave excellent results; in fact, less trouble was experienced in controlling the flotation with the coarser grind. The reagents indicated by laboratory work for the copper circuit were 2 to 3 lb. of sodium carbonate per ton of ore, 0·10 to 0·30 lb. of cyanide, 0·15 lb. of thio-carbonalide, with cresylic acid for the frothing agent. However, in the mill, it was found that the amount of cyanide indicated by the laboratory work not only inhibited the flotation of the copper, but floated a large percentage of the zinc in the copper circuit, due to the formation of copper cyanide, which is an active zinc reagent. Reducing the NaCN to 0·03 lb. per ton allowed the copper to float and stopped the flotation of an excessive amount of zinc with the copper. However, it was found that, on reducing the NaCN, the large amount of Na_2CO_3 was activating the iron and producing a low-grade copper concentrate. The sodium carbonate was then reduced to 0·15 lb. per ton of solution; the fresh soda added varied from 0·08 to 1·0 lb., depending on how long the ore had been broken. The thio was cut to 0·07 lb., xanthate was introduced, pine oil substituted for cresylic acid, and results were obtained which compared favourably with the test work.

Zinc reagents used in mill practice in the first period were 1·5 lb. copper sulphate, 0·10 lb. potassium ethyl xanthate, 0·10 lb. cyanide, 0·05 lb. aero-float 25, and 0·10 lb. pine oil. The amounts used differed greatly from those indicated by the tests, but the application was substantially the same.

In operation, this circuit was erratic and flotation was difficult to control, the pulp condition being very sensitive to the least change in dilution or in the frothing agent and requiring constant attention to keep the conditions right. It was especially difficult to control the degree of alkalinity, and it was observed that such control was one of the most important features in securing good metallurgical results. The Amulet ore, as it is delivered to the mill, varies greatly in its physical features, degree of oxidation, and natural alkalinity, and these natural difficulties enhanced the instability of the circuit. The result of this operation was to produce an 18% copper concentrate with an 89% recovery, and a 52% zinc concentrate with a 76% recovery, and to recover 50% of the gold and 75% of the silver in the copper concentrate, which results were very close to those indicated in the preliminary laboratory tests.

While these results were in general satisfactory, experiments were carried on in the mine testing laboratory with a view to increasing the grade of the concentrates and, if possible, finding a more stable circuit. These experiments suggested in a change to a lime circuit the condition and this change was made on September 22, 1930, and the second period of operation entered upon.

The result of the lime circuit used in the second period was to raise the grade of the copper concentrate from 18% to 24%; to increase the copper recovery from 89% to 92%; to increase the zinc recovery from 76% to 80%, with the grade of the zinc concentrate remaining the same; and to raise the gold recovery to 75%. Flotation conditions were stable and easily controlled. Rather wide variations in the oxidation or alkalinity of the ore made little difference in the metallurgical results, and the pulp condition was less sensitive to changes in dilution or frothing agent.

One of the most important results of the new circuit was the improvement in alkalinity control. The graphs (Figure 3) illustrate the different alkalinity curves when using soda and lime.

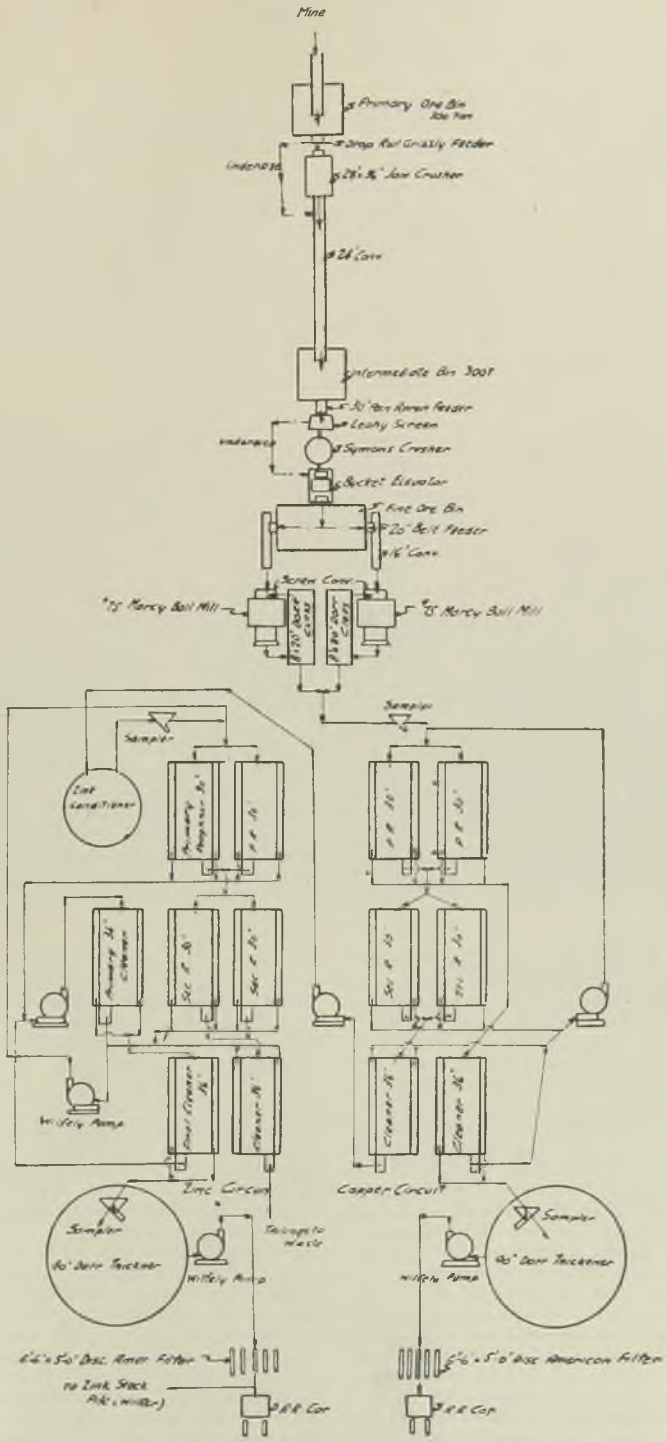


FIG. 2.—FLOW-SHEET: AMULET MILL.

respectively. These curves explain a considerable part of the difficulty experienced when using the sodium carbonate circuit. It will be noted that the use of lime flattens out the alkalinity curve, giving a more stable condition.

The reagents introduced in the grinding circuit were lime 0·5 to 0·8 lb., cyanide 0·05 to 0·06 lb., thio-carbonalide 0·05 to 0·07 lb., and sodium sulphide 0·06 lb., per ton of ore. Steam-distilled pine oil is added to one mill only at the rate of 0·10 lb. per ton of total mill-feed. The lime was fed dry with the ore in sufficient quantity to maintain an alkalinity of 0·25 (when titrating 50 c.c. of mill solution with standard H_2SO_4 solution, one gram to the litre of water).

The lime acts as a modifying agent, forming a protective alkalinity for the cyanide and sodium sulphide, and also precipitates any excess of ferrous

The following table gives the soluble constituents of the pulp in the grinding circuit:

	Lb. soluble salts per ton of solution.		
	Cu	Zn	Fe
Ore ground without reagents .	0·16	0·18	2·0
Ground with 0·8 lb. lime .	0·15	0·18	0·6
,, ,, 0·8 lb. Na_2CO_3 .	0·08	0·10	Trace
,, ,, Na_2S and CaO .	Trace	0·06	0·4
,, ,, Na_2S, CaO, NaCn.	0·01	0·05	Trace

It will be observed that, when grinding with Na_2CO_3, no ferrous sulphate is left available for the reaction with the cyanide to depress the iron; while, in the lime circuit, enough is available to allow the reaction to progress. It is the practice in some mills to use ferrous sulphate in conjunction with cyanide as an iron depressant, commercial

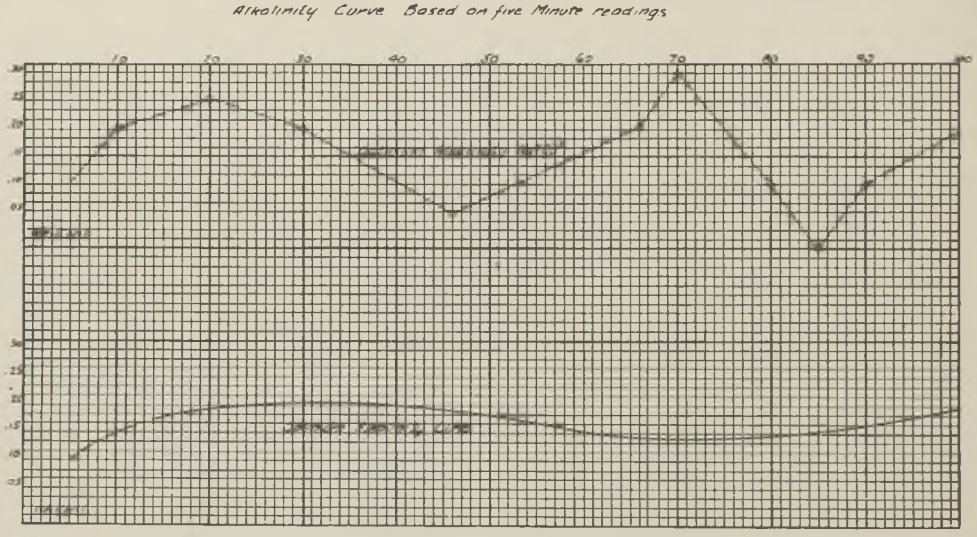


FIG. 3.

sulphate that may be present. Little or no pyrite depressant action can be noted from the small amount of lime used. The cyanide, in conjunction with the ferrous sulphate left in solution, tends to depress the pyrite. The sodium sulphide reacts with the soluble copper produced in the grinding circuit and precipitates it as copper sulphide, destroying its promoter action on the zinc minerals. It is considered to be the zinc depressant reagent. Pine oil is added as a frothing agent, and one grinding mill is kept free of it so that conditions on the classifier are not obscured. The operator keeps close watch of the classifier to make certain the conditions are right for copper flotation. If a film of chalcopyrite is floating on the classifier, the operator knows his reagents, dilution, etc., are correct. If the film of chalcopyrite is lost, immediate steps are taken to find the trouble. If the copper is not in condition to float when overflowing the classifier, no amount of conditioning or other treatment will lead to optimum results. Alkalinity titrations are made every half hour.

Dilution of the classifier overflow is maintained at 1·416 specific gravity, or approximately 42% solids. Density readings are taken by means of scales and bottles. Quick density tests are taken by means of a hydrometer.

ferrous sulphate being added to the circuits when they are found to be deficient in soluble iron. The lack of ferrous sulphate when grinding in the Na_2CO_3 solution probably explains the failure of the cyanide to depress the iron. Under these conditions, when there is no reaction between the cyanide and the iron, flotation results in the copper circuit are comparatively poor.

It will be noted that, in addition to precipitating the soluble copper, the sodium sulphide also reduces the amount of soluble zinc, probably forming zinc sulphite, which is an active zinc depressant.

An excess of ferrous sulphate inhibits the flotation of all minerals, in so much that it produces poor froth conditions. The probable benefit of the lime as a modifying agent is to reduce the soluble-iron content to an amount that would leave just sufficient for the reaction with the cyanide. The practice at Amulet is to add just enough lime to leave 0·4 to 0·6 lb. $FeSO_4$ in solution.

Sodium ethyl xanthate is added to the copper primaries at the rate of 0·03 to 0·08 lb. per ton of ore. The xanthate acts as a froth controller and assists materially in the gold recovery. When introduced in the grinding circuit, xanthate interferes with the other reagents to some extent. It was observed that when the xanthate was added

at the ball-mill, the zinc content of the copper concentrate increased 4 to 5%. The logical explanation of this fact is the formation of copper xanthate in the grinding circuit activating the zinc. When xanthate is introduced in the flotation cells, the soluble copper has been previously precipitated, so no reaction that would form copper xanthate can take place. When introduced in the grinding circuit, xanthate also interferes with the action of the sodium sulphide.

Zinc reagents used are: 1·3 lb. copper sulphate fed at the copper tails pump-sump before going to the conditioner—0·36 lb. of water-gas-tar is also fed at this place; 1·5 lb. lime fed to conditioner, along with 0·08 lb. cyanide and 0·05 lb. steam-distilled pine oil; and 0·06 to 0·10 lb. of sodium xanthate fed to the zinc primaries. The zinc concentrate is cleaned twice, and all rougher concentrate and cleaner tails are returned to the primaries.

When operating with a soda-ash circuit, the alkalinity was reduced as it passed through the copper cells—due to the aeration of the flotation pulp—until the copper cleaner tailings were neutral. As there is no reaction with the $CuSO_4$ in a neutral pulp, this reaction was delayed until the pulp reached the conditioner and was again made alkaline. It is also possible that oxidation in the copper cells was deadening the zinc float, as laboratory tests on Amulet ore indicated that air conditioning prior to copper flotation in a sodium carbonate pulp so effectually deadened the zinc minerals that they could not be reactivated to a point where satisfactory recovery could be obtained. With the lime circuit, this effect was overcome and the recovery raised from 76% to over 80%.

With the lime circuit, the alkalinity is found to be as high in the copper tailings as it is in the copper feed, so the reaction of the copper sulphate starts as soon as the reagent is introduced. The zinc pulp is given 10 minutes conditioning with the cyanide and lime to depress the iron.

The water-gas-tar is used to stiffen the froth, making a better condition for the "black-jack", which is difficult to float. Xanthate is used largely as a froth controller and, in addition, has some promoter action on the zinc. The iron is so effectually deadened that only a small amount is activated by the xanthate.

Test work had indicated that the use of lime would lower the gold recovery. In actual practice, however, it was found the gold recovery increased from 50% to over 70%.

The Amulet ore carries a small amount of galena (under 0·5%), with which is associated the bulk of the silver values. Experiments were conducted with a view to making a lead concentrate. The results were favourable, indicating a lead concentrate could be made assaying approximately 30% lead and 80 oz. of silver. The lead recovery in this product would be about 40%, and the silver recovery 70%. The galena crystallization is extremely fine and grinding to −200 mesh would be required for its release. This is not warranted, as the cost of the −200 mesh grinding more than offsets the additional lead and silver recovery that could be expected.

The oxidation of the Amulet ore is rapid. It had been noted that the oxidation penetrates the apparently solid pieces of ore along planes of cleavage. In stopes which have been opened-up for a period of three or four months, the oxidation was found to have penetrated several feet into the ore "in place". Trouble was expected from this source, some metallurgists even going so far as to recommend that the ore be milled within 24 hours after it was broken. Treating dump-ore and ore from stopes that had been opened-up for some months gave a good opportunity to observe the effect of oxidation. When using soda-ash, difficulty was experienced due to the inability to control the alkalinity, and consequently the soluble constituents, of the pulp. The alkalinity would change so rapidly that the operators could not keep track of it, and the consequent variation of flotation conditions. After the circuit was changed to lime and a better understanding gained of the reactions taking place in the grinding circuit, ore that had been broken for six months was treated with as good results as freshly broken ore.

Zinc sulphate is used to settle the colloidal slimes in the concentrate thickeners and to assist in the filtering. It was thought that the use of this reagent could be discontinued when using lime. It proved to be more necessary than when using soda-ash. The lime produced a flocculent mass of slimes which refused to settle; the use of zinc sulphate breaks up the flocculations and accelerates the settling. The filter cake carries approximately 10% moisture, both on the copper and the zinc. The concentrates are free filtering and the capacity of the filters is high.

DEEPHOLE DRILLING AT THE ROSEBERY MINE, TASMANIA

In the issue of the *Proceedings* of the Australian Institute of Mining and Metallurgy for September 30, 1930, I. D. Cameron describes the drilling of prospecting holes with a pneumatic hammer-drill at the Rosebery mine, Tasmania. This method, known generally as "deephole," or "longhole" drilling, has been successfully applied on mines in the United States, especially in cases where diamond drilling has proved to be too costly, as in drilling pocketty limestones. The drilling bit is of the same form and is prepared in the same way as ordinary rock drill steel and is extended to the bottom of the hole by sectional hollow rods, through which water is forced. The cuttings from the hole provide a sample of the ground drilled.

From the descriptions of this method which have been published the following data have been drawn by the author:—

Rock.	*Average advance per 8-hr. shift.*	*Length of greatest hole. Feet.*	*Cost per foot.* s. d.
Granite and quartz	21·2	95	—
Siliceous porphyry	18·1	118	—
Limestone	23·5	227	4 1
Quartzite	12·0	129	9 2
Flint and limestone	13·5	—	8 10

This method of prospecting is in use at the Rosebery and Hercules mines of the Electrolytic Zinc Company of Australasia Ltd., and the following description is advanced, although the amount of

drilling done to date does not permit of definite conclusions on all points. Sufficient work has been done to show that deephole drilling is economical and satisfactory in the types of rock encountered at Rosebery.

Equipment.—After experimenting with rods and couplings made in the mine shops, and meeting with little success owing to breakage of the rods, the standard equipment made by the Gardner-Denver Co. was purchased. The equipment had been developed and used successfully, in the United States, in rock ranging from limestone to quartzite. The equipment consists of: (1) Heavy drifter—weight 225 lb., (2) drill rods and couplings, (3) drill bits, (4) "water swivel" for introducing water into the hollow steel without passing it through the machine, and (5) columns, arm, clamps, and "fishing" tools. Dollies for forging the larger sizes of bits, and dies for forging threads, are also required. A gauging block, for gauging the bits to the required diameter and imposing the 5° portion

Set-up for Deephole Drilling.

of the standard double taper, is also desirable. This was made in the mine shops, following the pattern of the gauging block for standard sizes of steel, being machined from cast steel and the gauging surfaces case-hardened.

The distinctive feature of the drill is that the rotation of the steel is accomplished by means of an air turbine, operating independently of the piston, and reversible. Strong rotation gear is necessary for rotating a long length of rods; the independent control makes the feature useful in reaming, and in screwing and unscrewing rods.

The coupling for joining the lengths of rod is a threaded sleeve of cast steel, into which the threaded ends of the rods are screwed. The thread has a coarse pitch, $\frac{1}{4}$ in. The sleeve is not a tight fit on the rods, enabling them to be screwed in until they butt, thus ensuring that the force of the hammer blow is borne mainly by the rods and only in a minor degree by the threads of the coupling.

Rods are of $1\frac{1}{4}$ in. diam. hollow round steel, and can be made any suitable length—multiples of 3 ft. are usual, since the feed screw on the machine is made for a 3 ft. run. The threads are forged in the drill sharpener by means of the dies. Forging with light blows, while screwing the steel into the die, gives a better thread than forging the whole thread in two or three blows. The axial hole is not distorted by forging. The ends of the rods (and also the threaded bit-ends), after forging, are turned in a lathe to ensure an even face. Turning gives a more even surface than grinding on the emery wheel, and takes only about five minutes per rod.

The "bits" consist of a 2 ft. length of $1\frac{1}{4}$ in. hollow round steel, the bit proper being forged at one end, the thread at the other. It was found that 3 ft. is a more economical length, since when a bit wears down to 1 ft. in length it is too short for the smith to handle in the sharpening machine. The bits range in diameter from $3\frac{1}{4}$ in. to $2\frac{1}{4}$ in., with $\frac{1}{8}$ in. changes in gauge, $2\frac{1}{4}$ in. being the smallest diameter that will make clearance for the couplings. Bits are built up by first forging a $1\frac{1}{2}$ in. bit, then increasing to 2 in., to $2\frac{1}{4}$ in., and subsequently increasing the diameter by $\frac{1}{8}$ in. at each operation until the desired gauge is attained.

Drilling.—The machine is set up on a horizontal arm supported by two vertical columns to provide a rigid mounting. The minimum length from feed screw crank to bit of starting steel is 7 ft. 6 in. For comfortable working, 10 ft. clearance is desirable (see fig.). Since there are nine changes of gauge from $3\frac{1}{4}$ in. to $2\frac{1}{4}$ in., then, supposing the rock to be penetrated is of uniform hardness throughout, the amount of hole that must be gained with each diameter of bit is the length of hole desired divided by nine. Suppose a hole of 90 ft. is the desideratum, then 10 ft. must be gained with each gauge—that is, the allowable loss of gauge in 10 ft. is $\frac{1}{8}$ in. The wear in diameter of each separate bit must be less than $\frac{1}{16}$ in., otherwise a bit of the same gauge will not follow. Hence it is very necessary, when first beginning to drill, to withdraw the bit after a few inches, measure with calipers, and, in the event of wear, to replace, before it has lost $\frac{1}{16}$ in. in gauge, with a bit of the original diameter. If the $\frac{1}{8}$ in. wear happens before the 10 ft. has been gained, the hole can be enlarged by reaming, using a bit as a reamer, and drilling with full power on the rotation, and but little on the hammer. The hole thus enlarges by chipping. By this means an enlargement of $\frac{1}{8}$ in. was made in 6 ft. of a hole in one shift, the average drilling rate for the original hole being 8 ft. per shift. It was found that, even in very abrasive ground, the desired diameter can be maintained by changing the bits frequently, so that reaming, except for a few inches at a time, has been avoided. A bit is not a suitable reaming tool; a suitable one has not yet been evolved.

It will usually be found that, in collaring the hole and in drilling the first few feet, the hole deviates slightly from the line on which the drill is set, and if drilling is continued with the machine and the steel even slightly out of line, a rod or bit will break at a threaded end. Water squirting from a coupling is a sign of mis-alignment. The machine must be adjusted to follow the hole. Usually there is no apparent deviation after 10 ft. has been drilled.

A fishing tool is provided for recovering rods and bits broken in the hole. This is a sleeve with a lip at one end projecting $\frac{1}{2}$ in. for one third of the circumference. The other end is threaded to take a 1 in. diam. pipe. In use, the sleeve, with the lip uppermost, is pushed into the hole until the broken rod is met. Then the sleeve is rotated so that the lip passes underneath the rod and lifts it. The sleeve may then be driven on to the rod, and the rod withdrawn or unscrewed. On only two occasions has it been necessary to "fish" for broken rods, and on both the broken end was picked up and withdrawn.

The equipment is most suitable for drilling holes inclined above the horizontal at angles between 5° and 30.° These angles permit ready handling of the steel, and ensure that cuttings run freely from the hole. For holes inclined at steeper angles, counterweights are required to keep the weight of steel off the machine, and a clamp to hold the rods in the event of their breaking. For depressed holes, the recovery of the sludge and the accuracy of the sample it gives requires consideration.

At Rosebery, experience has been limited to holes drilled at an angle of 15° above the horizontal. The deepest hole drilled was 138 ft. long and could have been drilled further had it been desired. Two men were able to handle the rods to this depth without mechanical aid other than the machine. By rigging a small block near the collar of the hole, the rods could be pulled into the hole with a rope, more readily than they could be pushed by hand. Air consumption averaged 110 cub. ft. per minute for the first 50 ft. of the hole. Air pressure was 85 lb. at the drill. With greater depths, the air consumption increased until, at 100 ft., the drill was taking its full rating—225 cub. ft. per minute. Water from the mine supply at 70 lb. per sq. in. pressure was used at the rate of 4 gal. per minute. The manufacturers of the equipment, for holes 50 ft. in depth, recommend 3 to 5 gal. of water per minute, at not less than 50 lb. pressure.

The following is a record of the drilling at the Rosebery mine up to the time the article was written :—

Total distance drilled . . .	893 ft.
Number of holes . . .	15
Number of drilling shifts (8 hrs.) .	83
Average distance per drilling shift .	10·7 ft.
Total number of shifts . . .	95
Average per shift . . .	9·4 ft.
Greatest distance drilled in one shift	30 ft.
Men required to run drill . .	2

The following record, from the log book of the deepest hole (138 ft. deep), shows the irregular variation in drilling speed :—

Hard ground.		Softer ground.	
Day.	*Drilled per shift, ft.*	*Day.*	*Drilled per shift, ft.*
1st.	2	4th.	21
2nd.	4	5th.	29
3rd.	6	6th.	7
		7th.	16
		8th.	20
		9th.	20
		10th.	13
		Total	138

It must be borne in mind that the starting bits are of large diameter, and, therefore, for the same impressed force do not cut as deeply as the bits of smaller diameter. Then again, owing to vibration and play in the rods, during the first 20 ft. of the hole, the drill must be operated carefully.

"Drilling shifts" are shifts actually spent in drilling, including incidental delays, but excluding time spent in rigging machine and shifting gear. "Total time" includes the time so occupied.

Detailed costs are not given, because the method has not been in use a sufficient time to allow the collecting of authoritative figures on such items as steel consumption and drill repairs. Also, since the mine is not in full production, the proportioned charges for compressed air and steel sharpening are unduly heavy. The main item of expense is the labour cost per foot drilled, and since this varies with the hardness of the ground drilled, the important thing in estimating cost is to find out at what rate the drilling can be done in a given rock formation. However, to give some idea of the cost of drilling, the following principal items are extracted from the records :—

	s.
Labour . . .	4·25 per ft.
Compressed air . .	1·52 ,,
Steel sharpening . .	0·86 ,,
	6·63 ,,

Under "Labour" is included only the wages of the two men required to run the drill.

In the absence of a universally applicable scale of rock hardness, it is difficult to compare performances in different localities even in the same rock-type. Rock names, as granite, limestone, basalt, give some idea of hardness characteristics, but only in vague terms. The rock drilled at Rosebery has been close-textured quartz-sericite schist, with occasional bands of quartzite, seams and veins of quartz, and zinc-lead sulphide ore (fine grained inter-crystallisation of galena, blende, and pyrite). Diamond drilling (1 in. core) in ground typical of that in which the deephole drilling was carried out, averaged 9 ft. per 8 hr. shift. A deephole, 83 ft. deep, was drilled at the rate of 6 ft. per shift in quartz-sericite schist and quartzite. In a cross-cut in similar ground, the average amount of drilling per 8 hr. shift, while drilling continuously, was 72 ft., drilling with an Ingersoll Rand R-72 and 1¼ in. hollow round steel.

SAMPLING.—Cuttings from the drilling are caught in a shallow trough, 4 ft. long, 10 in. wide, and 6 in. deep. The overflow carries away some quantity of slime which can be settled only with difficulty. It seems the general practice to assume that the slime carries the same values as the coarser material, and that its loss does not affect the accuracy of the sample. To gather data on this point, the overflow from the sample box was run into a carbide drum, until the drum was full. The slime was allowed to settle, and the water siphoned off. The coarse cuttings in the box, and the slime, were collected, dried, weighed, and assayed, with the following result :—

Material drilled was massive pyrite, containing blende and galena.

	Weight.	*Assay values.*	
		Zn.	*Pb.*
Coarse cuttings .	840 gm.	1·4	0·2
Slime .	110 ,,	4·6	1·5

Here the slime is roughly 10% of the total. The friable sphalerite and galena had enriched the slime.

In another case, drilling in schisty ore, the coarse cuttings assayed Zn 11·2%, Pb 4·2%, while the slime assayed Zn 13·0%, Pb 2·5%. The quantities of coarse cuttings and slime were not determined. This aspect of the sampling is being investigated as opportunity offers, i.e., when ore is encountered. As yet, there has not been an opportunity to check drill-holes by face sampling.

While drilling, changes from rock to sulphide ore can be readily detected by change in the colour of the sludge. The cuttings vary in coarseness according to the texture of the rock. The biggest

particles in schist cuttings are $\frac{3}{8}$ in. in diameter; in quartzite $\frac{1}{16}$ in. The more definite rock types can be readily distinguished, and less definite types when the rock is already known. In a case where distinction rests on microscopical characters, the cuttings may be mounted on a slide with Canada balsam and prepared as a thin section.

Deviation of Deepholes.—At Rosebery, diamond drill-holes deviated against the dip of the rocks; that is, tended to cross the strata at right angles. This tendency has not been noticed in deepholes drilled in the same direction as the dip, possibly because the weight of the rods counteracts the tendency to approach the normal to the dip. In a deephole drilled west against east-dipping schist, the hole, begun at 10° above the horizontal, at 50 ft. was directed below the horizontal, as proved by water remaining in the hole. This conforms to the experience with diamond drill-holes, the tendency to deviate being accentuated by the weight of the rods.

Summarizing the experience to date, it can be said that longhole drilling is a satisfactory means of prospecting country for 100 ft. or so on either side of the workings of an ore-body. It is particularly useful for prospecting for parallel veins and branches of the lode, after a level has been opened up by driving. It is also useful for determining sill floor areas and values in the case of wide and massive ore-bodies.

FLOTATION OF OXIDIZED SILVER ORES

Technical Publication No. 401 of the American Institute of Mining and Metallurgical Engineers covers an investigation on the flotation of oxidized silver ores. The author, H. S. Gieser, says that the flotation of oxidized silver ores offers an interesting problem to the operating metallurgist. The advances made in the art of selective flotation by the use of newer collectors with accelerating and inhibiting reagents suggests that there should be something to help to decrease tailing losses. For many years there was no working hypothesis, but with the publication of a paper by Taggart, Taylor and Ince[1] giving results of flotation tests with many organic compounds and presenting a tentative theory, a better foundation has been laid and henceforth progress should be more rapid.

Over a period of one and one-half years there was much experimenting with the flotation of oxidized silver ores at El Tigre, Sonora, Mexico. The material coming to the mill was straight sulphide ore in a silicified rhyolite gangue, the ore minerals being sphalerite, galena, pyrite, and tetrahedrite. This came largely from the lower levels of the mine. With the approaching exhaustion of these ore-bodies, attention was turned to oxidized ores left behind during higher prices of silver. Of late oxidized ore has been at times 25% of mill tonnage. Aerofloat 25, in considerable quantity, together with ethyl xanthate, has been used in the mill. The former raises large quantities of "insoluble" or gangue, which is difficult to reject when the density of the tailing pulp approaches 33% solids, as it did during periods of water scarcity. The mill tailing at times contained as much as 5 oz. of silver on a 32-oz. mill head.

The most difficult material to float was a high-grade, high-sulphide ore from one of the upper levels of the mine, which acted as though it was partly oxidized or tarnished. An effort was made to find an inorganic salt to make a sample containing some of this ore more amenable to flotation. The sample contained 28·24 oz. silver per ton. Salts of mercury, among others, were tried. Usually 1 lb. of the salt per ton ore was added to the pebble-mill and the crushed ore, which passed 65 mesh, was mixed with an equal weight of water and ground 10 min. Flotation took place with 1 lb. soda ash, 1 lb. sodium silicate; $\frac{1}{4}$ lb. pine oil and 1 lb. ethyl xanthate. The pH value of the tailing was about 8·0 (slightly pink to phenolphthalein). Comparable results are given in Table 1.

[1] A. F. Taggart, T. C. Taylor and C. R. Ince: Experiments with Flotation Reagents. *Trans.* A.I.M.E., Milling Methods (1930), 285.

Table 1.

Flotation of Tarnished Metallic Sulphides.

Reagent	*Concentrate, Ag, Oz.*	*Tailing, Ag, Oz.*	*Recovery, Ag, %*	*Efficiency, %*
Metallic Salts with Composite No. 5 (Ag, 28·24 oz. per Ton).				
Ethyl xanthate	301·6	3·20	90·0	100·0
Ethyl xanthate + Aerofloat	184·0	2·70	92·1	102·2
Amyl xanthate (Z-6)	165·2	2·24	92·7	103·0
Lead oxalate (PbC_2O_4)	212·4	2·90	91·3	101·4
Lead nitrate ($Pb(NO_3)_2$)	268·5	2·92	91·0	101·0
Zinc sulphate ($ZnSO_4$)	578·9	2·90	90·5	100·5
Sodium plumbite (Na_2PbO_2)	133·0	2·70	92·4	102·6
Sodium aluminate ($NaAlO_2$)	236·0	2·50	92·0	102·1
Sodium zincate (Na_2ZnO_2)	150·8	2·52	92·1	102·3
Mercuric chloride ($HgCl_2$)	185·3	2·20	92·3	102·5
Mercurous chloride (HgCl)	180·0	2·80	91·5	101·6
Mercuric oxide (HgO)	288·0	2·60	92·2	102·3
Sodium Aluminate with Composite No. 5.				
Aluminum powder, 0·50 lb.	162·4	2·38	93·4	103·8
Aluminum powder, 1·00 lb.	160·8	2·00	93·8	104·0
Aluminum powder, 1·50 lb.	280·0	2·26	92·5	102·6
Aluminum powder, 2·00 lb.	257·2	2·30	92·3	102·5
Doctor Solution with Composite No. 6 (Ag, 26·2 oz. per Ton).				
Ethyl xanthate	190·8	3·62	86·6	100·0
Lead oxide in Doctor solution, 1·5 lb.	182·8	2·86	89·2	103·0
Lead oxide in Doctor solution, 1·5 lb.	326·1	3·52	86·5	99·9
Lead oxide in Doctor solution, 1·0 lb.	192·4	3·8	87·0	100·3

The mercury salts tested have some accelerating action but are expensive. Sodium aluminate appeared promising, so different amounts of aluminum powder were disolved in a 10% caustic soda solution and then tested. No soda ash was used. Under the conditions of the tests, results were similar whether the aluminum and caustic soda were added to the pebble-mill or were previously dissolved. Doctor solution is used in petroleum refining to remove organic sulphides, so it was tested to ascertain its cleansing action on tarnished metallic sulphides. A small amount of this sodium plumbite solution was made up according to directions given in *Technical Paper* 298 of the U.S. Bureau of Mines. Again no soda ash was used. Results are also given in Table 1.

It appeared that while compounds such as sodium aluminate have a slight accelerating action on Tigre oxidized silver ores more consistent results would be obtained in flotation by the use of organic sulphides. These inorganic compounds may be of value on other ores. From previous testing it was known that both copper sulphate and sodium sulphide were depressors of the silver in Tigre ores, but it was desirable to know the effect of some other sulphur compounds. Using composite No. 6, pine

oil and ethyl xanthate gave a recovery of 86·8% of the silver. With 1 lb. of sodium sulphide the recovery dropped to 61·6%; with 2lb. flowers of sulphur the recovery was 82·6%, and with ½ lb. sodium sulphydrate the recovery was 83·8% of the silver.

Amyl xanthate, freshly made at the mill from amyl alcohol (Pentasol), carbon disulphide and caustic soda, is reported to be more effective than the commercial salt. When so made, sodium trithiocarbonate (Na_2CS_3) etc. results from side reactions. These give a bright red colour to the solution. To test the effect of Na_2CS_3 on Tigre oxidized ore, a sample was prepared by allowing an aqueous solution of sodium sulphide to remain in contact with carbon disulphide some four weeks. On the addition of ¼ lb. Na_2CS_3 the recovery was 84·0% and with ½ lb. it dropped to 76·7%, which proves it to be quite effective as a depressor. A number of samples of amyl xanthate, prepared in test tubes, gave a slightly higher recovery than the commercial article, showing the Na_2CS_3 not to be harmful in the concentration used.

The flotation testing of the different organic compounds took place over a period of about one year and tests were conducted on a number of different samples of ore to keep pace with material coming to the mill. Assays were not consistent, probably because of metallic silver present, so tests were frequently repeated. If a reagent appeared promising, tests were made on different ore samples; thus, while amyl xanthate appears very efficient, Aerofloat 25 in quantity (about three times the usual amount) gave more consistent recovery, and No. 404 was good on some samples and but little better than ethyl xanthate on others. A bright red ore was particularly difficult to treat.

Many organic sulphides were tested on Composite No. 7, which contained 36·3 oz. Ag per ton, and which, with pine oil and ethyl xanthate, gave a tailing of 4·7 oz. Ag. Therefore improvement in results would be noticeable and not attributed to experimental error. The usual procedure with these compounds was to grind 1 lb. of reagent as before for 15 min. in a pebble mill, which gave about 80% — 200 mesh and a pH value of the tailing of about 8·0. The frothing properties of the different compounds were not investigated, neither was their solubility, but 1 to 2 c.c. of a 10% solution of caustic soda was added to 100 mg. of a number of compounds with the idea of converting the organic base into a sodium salt and thus increasing its solubility. Improved results were obtained in a few cases.

Sulphur dyes are used in large quantity in the textile industry, and some of them are relatively cheap. The blues, greens, blacks and bordeaux are made by refluxing dye intermediates with sodium polysulphide, with or without sulphur. The browns and yellows usually are made by fusion of the intermediate with sulphur. As sulphur dark brown from the Newport Chemical Co. appeared promising, this class of compounds was considerably investigated. Most of them gave a higher tailing than with pine oil alone.

Xanthates made from higher alcohols offered possibilities, but it was understood that other workers were experimenting in this field. Also, alcohols with six or more carbon atoms are relatively expensive; for instance, a hexyl alcohol made from petroleum was quoted at $2·50 per gallon. Therefore, after study of the data, it was concluded that further investigation of organic sulphur-nitrogen compounds was warranted. A tabulated list showing the flotation efficiency of some organic compounds on oxidized ore is given in the paper.

A phenol, an organic amine, and sulphur react under suitable conditions to form compounds similar to thio-amido-phenol, which may be very complex. Various proportions of high-grade cresylic acid and sulphur were refluxed in a small flask with amines, such as aniline, ortho-toluidin and para-toluidin, xylidin, alpha naphthylamine, etc., until the sulphur disappeared. The warmed reaction product was tested by flotation as before, using the equivalent of 1 lb. per ton. A mixture that gave good results consisted of 120 c.c. cresylic acid, 30 c.c aniline, 30 c.c. orthotoluidin and 50 g. sulphur. Slightly inferior results were obtained without the orthotoluidin. The reaction product upon cooling separated into a liquid and small crystals. These were tested separately and the liquid was found more efficient. In Table 2 are given comparative data testing an oxidized sample with two reaction products made with slightly different amounts of aniline, the other ingredients as before. Tests were also made on a composite mill-head sample, largely sulphide, and a recovery of 98% of the silver was obtained. Testing indicated that the new reagent would give a higher grade of concentrate with a slightly greater recovery than other compounds tested on Tigre oxidized ores. Largely because the price of silver collapsed, it was not possible to test this reagent in the mill. In connexion with the use of organic sulphur-nitrogen compounds in the flotation of oxidized silver ores, it is interesting to note that G. H. Wigton reconstructs a mixture of an amino compound ($R.NH_2$), an alcohol and phosphorus pentasulphide at low temperature. In this case the amino compound may be ammonia.

The principal silver mineral in the upper part of the Tigre mine is stromeyerite $(CuAg)_2S$, in the lower part tetrahedrite, Cu_8SbS_7, but cerargyrite, AgCl, is usually present in oxidized silver ores and it is uncertain how this floated. A small piece of cerargyrite, variety horn silver, was obtained and a synthetic sample containing 51·7 oz. silver prepared by grinding with rhyolite. This was floated with a few of the more promising reagents, with results as given in Table 2.

Table 2.

Tests on Composite No. 7 and Synthetic Sample.

Reagent.	*Concentrate, Ag, Oz.*	*Tailing, Ag, Oz.*	*Recovery, Ag, %*	*Efficiency, %*
Pine oil	165·68	11·46	68·2	76·9
Pine oil—ethyl xanthate	208·4	4·70	88·7	100·0
Aerofloat—ethyl xanthate	104·6	4·60	90·3	101·7
G 16—pine oil	154·0	3·52	90·0	101·4
G 17—pine oil	162·1	3·80	90·5	102·0
Silver Chloride-rhyolite Synthetic Ore (Ag 51·7 oz.)				
Aerofloat 25-ethyl xanthate	301·4	1·10	98·2	
Z-G	489·2	1·72	98·0	
M. B. T.	458·1	1·04	98·4	
G 16	276·0	1·46	97·9	

The following are the author's conclusions. Organic sulphur compounds are used as dyes for cotton, rubber accelerators and flotation reagents. Therefore the number of these compounds readily available is limited. The sulphur dyes, while of no value for this ore, may have a use where sodium sulphide helps flotation.

Benzyl mercaptan, benzyl sulphide and disulphide show interesting results. The high tailing using thioureas was not anticipated. The froth when using the diethyl phenyl and di-o-tolyl thioureas was

white and barren. Iso-amyl trithiocarbonate is very similar in composition to the corresponding xanthate, the oxygen of which is replaced by sulphur, but it is less efficient. Mercapto benzo thiazole is of some value with a number of oxidized precious metal ores. It is used as a rubber accelerator, but costs 65 c. per pound in New York. Thioacetanilid gives fair results, while thiobenzanilid when made more soluble is better. This shows the influence of replacing a methyl group (CH_3) with a phenyl group (C_6H_5). However, it is doubtful whether thiobenzanilid could be made cheaply. By analogy, tetramethyl thiuram disulphide, an accelerator, would probably be better were phenyl groups substituted in place of the methyl groups, but here again cost would enter. Thiodiphenylamine might be improved with a CS grouping in place of the S.

Reagent solubility is known to be an important factor in flotation; this is confirmed. Sufficient hydrocarbon loading of the molecule is stressed by Taggart, Taylor and Ince. In aromatic compounds two phenyl group loading has given good results in a number of cases.

CYANIDE EXTRACTION FOR OXIDIZED COPPER ORES

A short paper by E. T. Dunstan on the extraction of copper from oxidized ores by cyanide solution appears in the *Journal* of the Chemical, Metallurgical and Mining Society of South Africa for January and full extracts of it are given here. The author says that the solubility of oxidized copper minerals in potassium cyanide has long been known. In the treatment of such ores, however, the cyanide consumption is necessarily very high, compared with that in the extraction of gold by cyanide, due to the incomparably greater amount of copper present in the ores. This would appear to render the use of ordinary potassium or sodium cyanide impracticable and the aim of the author's investigation was to ascertain whether a cheap brand of cyanide manufactured from cyanamide would be effective as a solvent and allow of regeneration of cyanide by electrical precipitation of the copper. The cyanide used in the experiments was the "Aero Brand," which is a black flakey material containing a marked percentage of carbon and sulphide. Calcium carbide and oxide are also present due to the process of manufacture. Owing to the presence of these impurities, it is necessary, for solution of the cyanide, to agitate very thoroughly, or the heat evolved decomposes the cyanide and ammonia is formed. After precipitating the sulphide with litharge or lead acetate the usual silver nitrate titration for cyanide can be carried out.

The strength of the "Aero Brand" cyanide in terms of potassium cyanide was first determined, using a standard silver nitrate solution. It was found to be equivalent to 64·72% KCN, and also contained the equivalent of 16·8% CaO.

The ore used in the experiment was a malachite ore from Katanga. It was assayed by the "iodide" method, using the aluminium foil separation, and showed 9·36% copper and was therefore considerably richer than ores to which it was hoped the contemplated process would be applicable. It also contained 0·50% sulphur, of which 0·13% was "sulphate" sulphur, showing that the copper sulphides were not completely oxidized. The material was crushed to pass a 60-mesh (I.M.M.) sieve before use.

In test No. I a portion, 500 gm., of the ore was taken, with 2,000 cc. of water and agitated by a propeller. To the agitated pulp 300 gm. of "Aero Brand" cyanide were added gradually, this being equivalent to 194·7 gm. potassium cyanide. At the end of half an hour the agitation was stopped, the pulp allowed to settle and a sample of the solution taken. This was tested for cyanide and for copper by the method described later. The pulp was reagitated and a similar sample taken after three hours and again after twenty hours agitation. The results are shown in Table No. 1.

The residue was filtered in a vacuum filter, dried, sampled and assayed for copper giving 3·19%, showing an extraction of 63·9% of the possible. The residue was retreated with a fresh solution of 5% KCN strength, 284 gm. "Aero Brand" cyanide being used to 3,000 cc. water. The pulp was agitated as before and samples of the solution taken at ½ hour, 2 hours, 4 hours, and 6 hours, the experiment being stopped after 7½ hours. Assay of the residue showed 1·2% copper, that is, the total copper extracted is 8·16% or 87·2% of the available. An analysis for sulphur showed that 0·11% sulphur was still present in the residue. Sufficient litharge was added to the pulp in each case to precipitate soluble sulphide so that titrations for cyanide were made upon sulphide free solution.

TABLE No. 1.

	0 *Hr.*	½ *Hr.*	3 *Hrs.*	20 *Hrs.*
Copper in solution	—	17·0 gms.	not determined	24·07 gms.
KCN strength of Solution	9·7%	6·54%	5·16%	4·92%

In the first treatment the amount of cyanide consumed was 95·6 gm. (expressed as KCN equivalent) and in the second 44·4 gm., making a total of 140 gm. (KCN equivalent) or a consumption of 560 lb. potassium cyanide per ton of ore. In terms of "Aero Brand" cyanide this would be 865 lb., that is 5·3 lb. Aero cyanide per lb. copper. An allowance was made for the cyanide left in solution. From this point of view alone the process would not be economical unless the cyanide could be regenerated in separating the copper.

Much difficulty was experienced in assaying the

TABLE No. 2.

	0 *Hr.*	½ *Hr.*	2 *Hrs.*	4 *Hrs.*	6 *Hrs.*	7½ *Hrs.*
Copper in solution	—	3·24 gms.	4·52 gms.	not determined	6·34 gms.	7·29 gms.
KCN strength of Solution	5%	3·82%	3·80%	3·74%	3·68%	3·52%

copper cyanide solution, and various methods were tried. The method finally adopted was as follows. The copper cyanide solution (50 cc.) was diluted to about 600 cc. and approximately 40 gm. sodium sulphide added. The solution was then warmed in a fume cupboard, sufficient hydrochloric acid being added to make the solution acid. It was brought to the boil and allowed to cool. When cool the precipitate was filtered off, the filtrate being tested with hydrogen sulphide water, and if a precipitate formed sulphuretted hydrogen gas bubbled through till all the copper was brought down. The copper sulphide thus precipitated was treated as in the iodide method of assay. It was found that all the copper could be precipitated by this procedure when care was taken not to make the solution too acid and if sufficient sulphide had been added.

In test No. II a sample of 100 gm. of the ore crushed to −200-mesh linear was made. From theoretical considerations the amount of cyanide required to dissolve the copper present was calculated and the amount added. The copper was taken to be in the cupric state, in which case 1 lb. copper requires 4·08 lb. potassium cyanide for solution. One litre of water was used and 51 gm. "Aero Brand" cyanide giving a potassium cyanide equivalent of 33·0 gm. This was agitated for seven hours continuously, no sample being taken, allowed to stand for 17 hours, and then vacuum filtered and washed and the residue sampled and assayed. The residue was retreated with 1,000 cc. water and 17 gm. "Aero Brand" cyanide (11 gm. KCN). Agitation was carried on for six hours and the residue vacuum filtered and washed. The residue from this second treatment was roasted in a muffle at a bright red heat for 3½ hours. After cooling it was reagitated with the final solution from the last treatment. Agitation was performed for 7½ hours and then the residue was vacuum filtered, washed and the residue sampled and assayed. The roasting apparently brought more of the copper to a soluble state. The figures for these three treatments are given in table No. 3.

Table No. 3.

First Treatment.

	Copper in ore.	*KCN.*
Before treatment	9·36%	3·3%
After treatment	3·25%	1·38%

Second Treatment.

	Copper in ore.	*KCN.*
Before treatment	3·25%	1·1%
After treatment	1·85%	0·75%

Third Treatment.

	Copper in ore.	*KCN.*
Before treatment	1·85%	0·75%
After treatment	0·75%	0·52%

The residue was now divided and one portion treated with potassium cyanide and the other portion with an equivalent of "Aero Brand" cyanide. To remove carbonaceous and other insoluble matter from the cyanide it was first dissolved and the solution filtered before adding to the residue. Agitation was carried on for 6 hours in each case, the residue being filtered and washed over vacuum. The results, as shown in Table 4, show no advantage of one over the other, and are practically identical, showing that just as good results can be expected using "Aero Brand" cyanide. The residues were assayed with the results shown below.

These tests show that it is possible to dissolve the copper quite readily, but that the cyanide consumption, as expected, is extremely high. Experiments were then made upon solution from the first extraction test to investigate the possibility of recovering copper and regenerating cyanide by electrolysing the solution. These experiments were carried out using a simple electrolytic circuit of cell, battery, key rheostat and ammeter, with a volt-meter across the terminals of the anode and cathode. The anode used was of lead peroxidized by electrolysis in a potassium permanganate solution, except in cases otherwise stated, and the cathode was a piece of pure copper foil. Readings were taken when the circuit was made and at intervals during a run. A summary of the results will be found in Table 5.

In all cases the solution became a very dark brown, much effervescence took place and a sludge was formed in the bottom of the cell. In test "B" this was analysed, giving (not analysed completely) :—

Fe_2O_3	0·5%
CaO	48·2%
MgO	2·2%
Copper	nil.

It will be noticed that in two of the tests no copper was deposited, the deposit found upon the cathode proving to be a calcium compound. In test "C" qualitative analysis showed the presence of lead, iron, calcium and magnesium in the sludge,

Table 4.

	Potassium Cyanide.		Aero Brand Cyanide.	
	Copper in ore	*KCN*	*Copper in ore*	*KCN*
Before treatment	0·75%	0·50%	0·75%	0·50%
After treatment	0·50%	0·43%	0·46%	0·42%

Table 5.

Test.	*Amps.*	*Volts.*	*Cathode area sq. cm.*	*Current density amps/sq. dm.*	*Time.*	*Cu. deposited.*	*KCN before.*	*KCN after.*
A.	0·277	2·80	—	—	17½ hrs.	nil	2·93%	0·31%
B.	0·636	4·14	61·25	0·52	22½ hrs.	0·103 gm.	2·93%	0·24%
C.	0·540	4·04	—	—	6¾ hrs.	nil	3·00%	0·29%

Remarks :—A.—Added 5 Gms. KOH ; B.—Sludge at bottom ; C.—Added 5 Gms. Na_2SO_3.

but no copper. In all cases the cathode was found to be coated with a flakey deposit of a calcium compound.

It was thought that the difficulties met with in this electrolysis were due to the presence of calcium salts and other impurities introduced by the use of calcium cyanide. To verify this point a solution of copper in potassium cyanide, containing the same percentage of copper as that used in the previous electrolysis was made up by dissolving 15 gm. cuprous oxide and 110 gm. potassium cyanide in 2 litres of water. The resulting solution was a clear brown in colour and contained 0·6% copper and 2·93% KCN. 250 cc. of this solution was electrolysed in exactly the same manner as the tests made previously. A total of four such tests was made and a summary of the results will be found in the following table.

TABLE 6.

Test.	Amps.	Volts.	Cathode area. sq. cm.	Current density amps/sq. dm.	Time. hrs.	Cu. deposited.	KCN before.	KCN after.
1 . .	0·13	2·47	not meas'd	—	24	nil.	2·93%	2·74%
2 . .	0·34	5·70	119·4	0·285	23	0·155	2·93%	2·33%
3 . .	0·72	3·04	119·4	0·603	24	0·368	2·93%	1·26%
4 . .	0·89	3·07	154·9	0·574	24	0·026	2·93%	1·92%

Remarks: 1. No copper deposited, trace of sludge; 2. Sludge contained no copper; 3. Carbon anode, sludge mainly carbon; 4. Passive iron anode; smell of ammonia.

In each case the solution changed colour to a deep brown, and not until this change had taken place was any copper deposited or a sludge formed. Sludge was collected from the bottom of the cell in every text. Directly electrolysis was stopped it was filtered off and tested for copper and in no case was any found. In tests 1 and 2 it was possibly some lead compound from the anode, while in test 3, when a carbon anode was used, the amount of sludge was greater and upon ignition only a trace of it was left, showing that it consisted chiefly of carbon. The smell of ammonia in test 4 was faint but quite distinct.

At this stage of the investigation an abstract of a paper by E. H. Koenig and S. E. Woodworth came into the hands of the author. The writers of this paper point out discrepancies between the results of previous investigators, some of whom found an increase in cyanide strength and others a decrease during electrolysis of cyanide solutions. In their investigation various materials for anode and cathode and a large range of current densities were employed, but in all cases they found a loss in cyanide. Their investigation included all the various cyanide solutions used in electrolysis. They concluded that in no circumstances was there a regeneration of cyanide during electrolysis. The results of the experiments just described confirm this conclusion with regard to copper cyanide solutions. The disappointing results obtained in the electrolytic experiments, together with the enormous cyanide consumption convinced the author that an extraction process along these lines was not economically practicable.

Tin Dredging.—At a meeting of the Malayan Tin Dredging, Mining, and Research Association held on November 26 last, O. B. Williams gave some elementary notes on dredging operations. The author summarized his survey as follows:

1. Use depth recorder and depth chart to—

(*a*) Ascertain how deep one can go at top speed.

(*b*) To check speed from time to time during the cut.

2. Drop lightly and swing fast.

3. See that where it is possible to drop the ladder at each end of the cut, time is not lost by traversing across and back without dropping before the return.

4. See that time is not lost on "Wants."

5. See that dredging on bottom and between pinnacles is carried out correctly.

6. Keep a daily running total of stoppages and check up on those which are recurrent to see if part at least cannot be eliminated.

In conclusion he stated that often it is the obvious which is forgotten, and the operator looks about for some outside extraordinary cause for some trouble on the dredge, when if only thought over quietly, starting from first principles, it would be found most often that the trouble was caused by neglect of these principles and not by any extraneous cause. After all, dredging consisted mainly in the use of organization and common sense.

SHORT NOTICES

Open-Stope Mining.—M. J. Elsing describes open-stope methods of mining in the *Engineering and Mining Journal*, March 9.

Iron Mining in Australia.—In the *Proceedings* of the Australasian Institute of Mining and Metallurgy for September, 1930, F. R. Hockey describes the iron-ore industry conducted by the Broken Hill Proprietary Company at Iron Knob, South Australia.

Sulphur Mining.—The mechanical mining and treatment of sulphur in Texas are described by J. B. Nealey in *Engineering and Mining Journal* for March 23.

Reinforced Concrete Supports Underground.—In the *Iron and Coal Trades Review* for April 10 a summary is given of a paper by A. Marshall and J. Chadwick on the use of reinforced concrete underground, which was given at a recent meeting of North Staffordshire Institute of Mining Engineers.

Shaft Surveying at Broken Hill South.—In the *Proceedings* of the Australasian Institute of Mining and Metallurgy for September, 1930, A. R. Black describes the survey work in connexion with the sinking of No. 7 shaft, Broken Hill South.

Rock-Drill Maintenance.—Prof. W. J. Walker and S. F. Gimkey deal with rock-drill lubrication, maintenance, and testing in the *Journal* of the Chemical, Metallurgical, and Mining Society of South Africa for February.

Alluvial Gold in the Bolivian Andes.—The occurrence and winning of gold in the Bolivian Andes is described by Dr. Ing. Ahlfeld in *Metall und Erz*, 1 Aprilheft.

Anyox Concentrator, B.C.—W. B. Maxwell gives a description of the Anyox concentrator of the Granby Company in the *British Columbia Miner* for March.

All-Flotation at North Broken Hill.—The effects of the replacement of May jigs and Wilfley tables by flotation machines, at the plant of North Broken Hill, is described by A. Lowry in the *Proceedings* of the Australasian Institute of Mining and Metallurgy for September, 1930.

Flotation Circuit Change at Zinc Corporation Mill.—R. D. Nevett describes the change over from acid to alkaline circuit in flotation practice at the mill of the Zinc Corporation, Broken Hill, New South Wales, in the *Proceedings* of the Australasian Institute of Mining and Metallurgy for September, 1930.

Ore Treatment at Broken Hill.—Members of the Broken Hill branch describe the development of processes for the treatment of crude ore and accumulated tailings at Broken Hill, in the *Proceedings* of the Australasian Institute of Mining and Metallurgy for December 31 last.

Copper Ore Flotation in Portugal.—In *Metall und Erz*, 2 Märzheft, Dr. Ing. G. Teufer describes the flotation practice carried out on copper ores from the Minas do Valle do Vouga, Portugal.

Electrolytic Refining.—C. L. Mantell gives operating data on electrolytic metal production and refining in *Engineering and Mining Journal* for March 23.

Detection of Cadmium.—J. S. Pierce and W. T. Forsee outline the steps necessary for the satisfactory detection of cadmium in *Industrial and Engineering Chemistry* for April 15.

Geophysical Prospecting.—A theoretical study of apparent resistivity in surface potential methods is given by J. N. Hummel in Technical Publication No. 418 of the American Institute of Mining and Metallurgical Engineers.

Applications of the Ground Resistivity Map.—In the *Canadian Mining and Metallurgical Bulletin* for February, C. and M. Schlumberger discuss the method of the ground resistivity map and its practical applications.

Geothermal Gradient.—Dr. Ing. H. Börger discusses the relationship between the geothermal gradient and the heat conductivity of rocks in *Glückauf* for April 25.

Radiore Methods of Geophysical Prospecting.—Recent results obtained by the Radiore method are outlined by L. H. Henderson and V. P. Pentegoff in the *Chemical Engineering and Mining Review* of Melbourne for January 5.

Betts Cove-Tilt Cove Area, Newfoundland.—The geology and ore-deposits of the Betts Cove-Tilt Cove Area, Notre Dame Bay, Newfoundland, are described by A. K. Snelgrove in the *Canadian Mining and Metallurgical Bulletin* for April.

Coppermine River Area, Canada.—J. P. Norrie describes the prospecting carried out by Dominion Explorers, Ltd., in the Great Bear Lake-Coppermine River area of Arctic Canada, in the *Canadian Mining and Metallurgical Bulletin* for March.

Nickel-Copper on Hudson Bay.—In the *Canadian Mining and Metallurgical Bulletin* for March, J. Drybrough describes a nickel-copper deposit on Hudson Bay, Canada.

Prospecting Areas in North-West Manitoba.—J. F. Wright describes the prospecting areas of North-West Manitoba in the *Canadian Mining and Metallurgical Bulletin* for January.

Gold in New Zealand.—The first part of an article by J. Henderson, on gold in New Zealand, appears in the *Chemical Engineering and Mining Review* of Melbourne for March 5.

Vermont Copper District.—C. S. Anderson discusses mining and milling in the Vermont copper district in *Engineering and Mining Journal* for March 9.

Tin in China.—The first part of an article on the tin industry of Yunnan, China, by M. D. Draper, is given in *Mining and Metallurgy* for April.

Turkish Chromite.—W. Henckmann deals with chromite deposits in Asia Minor in an article in *Metall und Erz*, 2 Aprilheft.

Precious Metal Economics.—The economics of the production of the precious metals is dealt with by G. E. Collins in a series of articles which appeared in the *Magazine* of the Colorado School of Mines.

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.*

29,186 of 1929 (344,465). Dr. R. Ambronn, Gottingen, Germany. Apparatus for the complete determination of the direction and strengths of magnetic fields.

36,697 of 1929 (343,618). Fried. Krupp A.-G. Friedrich-Alfred-Hütte, Rheinhausen, Germany. In a process for obtaining sponge iron by forcing a current of blast-furnace gas through a subsidiary shaft containing iron ore, it has been found necessary to cool, purify, and reheat the gas drawn off, in order to prevent the choking of the ore layer.

36,934 of 1929 (344,059). New Jersey Zinc Co., New Jersey, U.S.A. A method and apparatus for the most efficient condensation of zinc vapour.

37,016 of 1929 (344,492). Meyer Mineral Separation Co., Pittsburg. Ores subjected in a quasi-wet condition to the action of gaseous reagents are rendered readily amenable to the extraction of their metal values.

38,306 of 1929 (344,899). H. Wade, J. W. Hinchley, and J. D. Parsons, London. Tin is recovered from tin-metal scrap by extraction with a solution of lead hydroxide in caustic alkali, the hydroxide being obtained by precipitation from a solution of lead acetate by caustic alkali. The tin dissolved by this solution, which is stable at normal temperatures, is precipitated as calcium stannate by the addition of milk of lime.

39,139 of 1929 (344,959). Sulphates Proprietary Ltd., Melbourne. Alkaline aluminates are prepared by mixing a suitable aluminous material, such as bauxite or alunite, with an alkali acid sulphate or with an alkaline sulphate mixed with sulphuric acid, and heating the mixture in an atmosphere of reducing gas.

39,331 of 1929 and **39,332 of 1929 (344,569-70).** New Jersey Zinc Co., New Jersey, U.S.A. The production of coked agglomerates, particularly of mixed zinciferous material and carbonaceous material, for subsequent treatment in vertical zinc distillation retorts.

3,359 of 1930 (344,165). I. G. Farbenindustrie A.-G. Frankfort-on-Main, Germany. In the

destructive hydrogenation of carbonaceous materials, it has been found of advantage to use hydrogen obtained by the treatment with the electric arc of waste gases containing hydrocarbons obtained from the process itself.

15,078 of 1930 (344,292). Compagnie de Produits Chimiques et Electrometallurgiques Alais, Froges et Camargue, Paris. In the preparation of cell baths employed in the electrolytic manufacture of aluminium, the cryolite is wholly or partially replaced by a mixture of aluminium fluoride, dry or moist, and of chloride of sodium or potassium.

22,018 of 1930 (345,186). Metallgesellschaft A.-G., Frankfort-on-Main, Germany. Barytes is refined, after separating impurities such as quartz, by calcining at high temperatures, cooling in water-cooled shaking troughs, and then treating the spar with hot hydrochloric acid.

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.

Spectrum Analysis in Mineralogy. By Dr. A. A. Fitch. Paper boards, 52 pages, illustrated. Price 1s. 9d. London: Adam Hilger.

Determination of the Opaque Minerals. By C. M. Farnham. Cloth, octavo, 236 pages. Price 17s. 6d. London: McGraw Hill.

Field Geology. By Dr. F. H. Lahee. 3rd edition. Cloth, octavo, 789 pages, illustrated. Price 25s. London: McGraw Hill.

Patterns for Eight Simple Relief Models: Illustrating Geological structures. By Dr. Frank Smithson. Price 5s. 6d.; mounted on cards, 13s. 6d. London: Thomas Murby and Co.

Outlines of Historical Geology. By Prof. C. Schuchert. 2nd edition. Cloth, octavo, 348 pages, illustrated. Price 15s. London: Chapman and Hall.

Secondary Aluminium (Metallurgy, Technology, Raw Materials, Production, Economics and Utilization). By Dr. R. J. Anderson. Cloth, octavo. Cleveland: Sherwood Press.

Non-Interpolating Logarithms, Cologarithms, and Antilogarithms. By F. W. Johnson. No. 2 of the Simplified Series. Gratis. San Francisco: Simplified Series Publishing Co.

Geology of the Country West of Mount Darwin. By B. Lightfoot and R. Tyndale-Biscoe. Southern Rhodesia Geological Survey Bulletin No. 10. Paper covers, 54 pages, illustrated, with map. Price 2s. 9d. Salisbury: Geological Survey.

Southern Rhodesia: Report of the Director, Geological Survey, 1930. Folio, 13 pages. Salisbury: Geological Survey.

Tanganyika Territory: Notes on the Mineral Deposits in the Newala-Lindi Area. By G. M. Stockley, with petrological notes by Frank Oates. Short Paper No. 7 of the Geological Survey. Paper covers, 31 pages, illustrated, with sketch maps. Price 2s. London: Crown Agents for the Colonies.

British Guiana: Geological Report on the Buck Canister-Oranapai Section of the Mazaruni Diamond Field. By S. Bracewell. Paper, folio, 18 pages, with sketch map. Georgetown: Demarara: Department of Lands and Mines.

Arizona: Iron Ore on Canyon Creek, Fort Apache Indian Reservation. By E. F. Burchard. United States Geological Survey Bulletin 821-C, pp. 51–75. Price 15 cents. Washington: Superintendent of Documents.

The Union of South Africa: The Manufacturing Industries of the British Empire Overseas, Part III. Folio, 76 pages. Price 2s. 6d. London: Erlangers, Ltd.

COMPANY REPORTS

West Rand Consolidated Mines.—This company, belonging to the General Mining Group, was formed in 1903 and works gold mining property in the Far West Rand. The report for the year 1930 shows that 1,342,838 tons of ore was mined, the tonnage milled being 1,087,000, a new record figure. The yield of gold totalled 290,671 oz. and the working revenue was £1,232,591. Working costs amounted to £994,493 and the working profit was £238,098 and, of this amount, £225,582 was appropriated for capital expenditure. The ore reserves at the end of the year were estimated to be 4,039,000 tons, averaging 5·6 dwt. over a stoping width of 48 in., as compared with 4,005,000 tons, of the same value, at the end of the previous year.

Meyer and Charlton Gold.—This company, also belonging to the General Mining Group, works a property in the Central Rand. The report for the year 1930 shows that 256,913 tons of ore was mined, 213,400 tons being crushed. The gold yield was 53,085 oz., worth £224,922. Working costs amounted to £202,716 and the working profit was £22,205. The payable ore developed at the end of the year consisted of certain blocks of South Reef, which have been opened up in claims leased from the City Deep, Ltd., together with isolated areas in other sections which are being mined at the present time.

East Rand Proprietary.—This company was formed in 1893 and belongs to the Central Mining Group. It is working a property in the East Rand. The report for the year 1930 shows that 2,020,300 tons of ore was mined and that, after sorting out waste, 1,814,500 tons was milled, yielding 491,094 oz. gold, worth £2,083,467. Silver and osmiridium brought the total revenue up to £2,088,833. Working costs amounted to £1,951,325 and the working profit was £137,508. Expenditure on capital account totalled £101,175. The available ore reserves at the end of the year were estimated to be 3,255,550 tons of an average value of 6·2 dwt., as compared with 3,414,270 tons, averaging 6·3 dwt., at the end of the previous year.

City Deep.—This company, formed in 1899, also belongs to the Central Mining Group and works a deep-level gold property in the Central Rand. The report for the year 1930 shows that 1,299,698 tons of ore was mined and, after sorting out waste, that 1,157,400 tons was milled, the gold recovered amounting to 306,425 oz., worth £1,300,164. Silver and osmiridium recovered brought the total revenue up to £1,302,893. Working costs amounted to £1,325,933, resulting in a working loss of £23,040. This loss compares with that of £139,234 in the previous year and it is considered that by operating on a smaller scale the company has a sounder chance of earning profits. The ore reserves available at the end of the year were estimated to be 1,268,200 tons, averaging

6·0 dwt., as compared with 1,323,400 tons, averaging 6·2 dwt., at the end of the previous year.

Witwatersrand Deep.—This company, formed in 1895, works a gold mining property in the East Rand. The report for the year 1930 shows that 498,100 tons of ore was mined and sent to the mill, where 113,689 oz. of gold was recovered which, together with the yield of silver and osmiridium, realized £481,682. Working costs amounted to £474,530 and the working profit was £7,152, which was carried forward. The ore reserves at the end of the year were estimated to be 582,600 tons, averaging 6·4 dwt. over a stoping width of 48 in., a decrease of 91,700 tons, an increase of 0·3 dwt., and a decrease of 6 in., when compared with the previous year.

New Kleinfontein.—Formed in 1894, this company works a gold mining property in the East Rand. The report for the year 1930 shows that 704,407 tons of ore was mined and that 619,200 tons was milled, the gold recovered amounting to 134,816 oz., the net working revenue being £571,690. Working costs amounted to £535,500 and the working profit was £36,191. It is stated that the ore reserves are difficult to estimate in view of the position at the mine, but that there is sufficient ore available to permit of effective prospecting of the Vertical Reef and the more promising of the old workings.

Globe and Phoenix Gold.—This company, formed in 1895, works a gold property in the Sebakwe district of Southern Rhodesia. The report for the year 1930 shows that 72,297 tons of ore was milled, the gold recovered totalling 65,961 oz. The bullion output realized £277,753, and the net profit for the year was £117,214. Two dividends, each of 1s. per share, were paid during the year, absorbing £80,000, leaving a balance of £37,214 to be carried forward. The ore reserves at the end of the year were estimated to be 109,200 tons, containing 135,200 oz. gold, as against 101,000 tons, containing 119,200 oz., in June, 1930. The continued development of rich ore in the deep levels of the mine is very encouraging and work is proceeding vigorously in the expectation of substantial extensions during the current year.

Naraguta Extended.—This company was formed in 1929 and works an alluvial tin property on the Bauchi plateau, Northern Nigeria. The report for the period from the date of incorporation to the end of 1930, shows that 285½ tons of tin concentrates was recovered, the average price realized being £88 9s. 9d. per ton. The profit for the period was £3,232 and, after making allowance for income tax, the balance of £2,556 was carried forward. The ore reserves are estimated to be 2,500 tons of 70% concentrates.

South Bukeru Areas.—This company was formed in August, 1929, and works an alluvial tin property in Northern Nigeria. The report for the period from the date of incorporation to the end of 1930 shows that 178 tons of tin concentrates was produced, the average price realized being £87 6s. 11d. per ton. All expenditure in Nigeria has been charged to revenue and the accounts show a working profit of £423. The known ore reserves are estimated to be 700 tons, but the development of new ground will probably add to this amount.

Waihi Gold Mining.—This company was formed in 1887 and works gold mining properties in the Thames district, New Zealand. The report for the year 1930 shows that the ore crushed from the Waihi and Junction companies' grounds totalled 222,984 dry short tons and, in addition, 446 tons of residues from the old Waihi mill and concentrates from the Victoria mill were treated, and 176 tons of ore for the New Zealand Government Mining Department. The value of the bullion produced at the Victoria mill and sent to the Refinery or shipped as slag, amounting to 491,752 oz. from sands and slimes and 172,351 oz. from concentrates, totalled £388,184. The gross profit for the year was £131,644 and £99,181 was distributed as dividends, equal to 2s. per share. The ore reserves at the end of the year were estimated to be 180,166 tons, assaying 32s. 11d., in " General Account " and 184,596 tons, assaying 34s. 6d., in " Suspense Account ", a total reduction of 11,653 tons when compared with the previous year. As regards the company to operate in Siam, Puket Tin Dredging, in which the Waihi company is interested together with Tronoh Mines, Ltd., it is stated that affairs with respect to transference of property are progressing and that the construction of a dredge is in hand.

Ooregum Gold Mining.—This company, formed in 1880, works a gold mining property in the Kolar district of Mysore, India, and is under the management of Messrs. John Taylor and Sons. The report for the year 1930 shows that 53,450 oz. of gold was produced from 143,761 tons of ore milled, and 10,250 oz. was recovered from 225,739 tons of tailings re-treated, making a total of 63,700 oz. of gold. Sales of bullion amounted to £269,989. Working costs amounted to £245,522 and the final profit on the year's operations was £18,101. Dividend paid on the preference shares, equal to 5% on these shares, left a balance of £13,192 to be carried forward. The ore reserves at the end of the year were estimated to be 215,500 tons, a decrease of 55,288 tons, although ore developed in Bullen's section has not been added to the reserves.

Sungei Kinta Tin Dredging.—Formed in 1925, this company operates an alluvial tin property in the State of Perak, F.M.S. The report for the year 1930 shows that 242½ tons of tin concentrates was produced from the treatment of 1,062,300 cu. yd. of ground, as compared with 477 tons of concentrates from 1,398,100 cu. yd. in the previous year. The area worked out during the year amounted to 20·29 acres. The year's working resulted in a loss of £2,432, which reduces the balance carried forward to £1,068.

Pengkalen.—Formed in 1907, this company works an alluvial tin property in the State of Perak, F.M.S. The report for the year ended September 30 last shows that the two dredges treated 2,643,170 cu. yd. of ground, recovering 711½ tons of tin concentrates which realized £70,056. In the previous year the 845½ tons recovered realized £150,936. The revenue from alluvial workings and other sources was £1,038, and the working profit £33,785. After allowing for depreciation and income tax, the net profit was £20,360, which together with the balance brought in from the previous year, gave an available total of £42,179. Dividends distributed during the year absorbed £15,000, equal to 15% on the ordinary shares, and the balance of £27,179 was carried forward.

Tekka-Taiping.—This company was formed in 1919 and works an alluvial tin property in the

State of Perak, F.M.S. The report for the year ended October 31 last shows that 2,412,000 cu. yd. of ground was treated, the total output of the three dredges being 513 tons of concentrates, as compared with 533 tons from two dredges only in the previous year. The total revenue was £46,292, and the working profit £6,927. After allowing for depreciation, etc., the net profit was £6,096, and dividends paid during the year absorbed £5,000, equal to 3d. per share, and the balance of £19,175 was carried forward.

Sinai Mining.—This company was formed in 1913 and works manganese deposits in the Sinai Peninsula. The report for the year 1930 shows a net profit of £32,055, which, together with the balance of £8,820 brought in gave an available total of £40,875. Dividends absorbed £18,500, equal to 5% on the ordinary shares, and the balance of £22,375 was carried forward.

St. John del Rey.—This company has worked the Morro Velho gold mine in Minas Geraes, Brazil, since 1830. The report for the year 1930 shows that 202,500 tons of ore was crushed, yielding 123,161 oz. gold, worth £521,693. In addition, bullion to the value of £12,788 was recovered from old workings and mine explorations and silver to the value of £2,135 was also recovered. The tonnage crushed shows an increase of 37,700 tons, due to an improvement in labour supply, but there was a decrease in the yield of 4s. 3¾d. per ton owing to the treatment of a larger proportion of low-grade ore, met by a decrease of 4s. 6d. in costs per ton in consequence of the larger output. Working costs in Brazil amounted to £346,841, development expenditure was £25,669 and London expenses were £12,221, leaving a profit of £124,423. Dividends absorbed £81,187 and £40,000 was transferred to capital works account, a balance of £41,369 being carried forward. Exploration of the main and north-west lodes at the lowest level (horizon 26), has resulted in the opening-up of a large body of ore, but of low grade. Winzes are being sunk to develop both lodes at horizon 27. Discoveries of bodies of ore at upper horizons encourages the belief that further lateral exploration will bring good results.

Oroville Dredging.—This company was formed in 1909 and has a controlling interest in Pato Mines (Colombia), Ltd. The report for the year ended September 30 last shows that 3,283,724 cu. yd. was dredged by the Pato company for a yield of gold worth $568,077, as compared with 3,405,106 cu. yd. for $631,774 in the previous year. Dividends received from the Pato company amounted to £49,954 and the profit was £48,740, to which should be added the sum of £44,193 brought in. Dividends amounting to 1s. 6d. per share were paid during the year, the balance carried forward being £48,262.

Buena Tierra Mining.—This company was formed in 1912 and owns a silver-lead property in the State of Chihuahua, Mexico, which has been leased to the Potosi Mining Company, for a period of years. The report for the year 1930 shows that the output from the mine was 8,205 metric tons of carbonate ore and 45,067 tons of sulphide ore, equivalent together to 58,722 short tons, averaging 10·3% lead with 9·94 oz. silver and 1½ grains gold per ton. The accounts show a net profit for the year of £3,824, which reduces the debit balance brought in to £73,256. The lessees of the property have actively continued its development, but the fall in metal prices has compelled them to give notice to terminate the lease on January 31, 1932.

DIVIDENDS DECLARED

Changkat Tin Dredging.—6d., less tax, payable May 30.

Kramat Tin Dredging.—6d., less tax, payable April 30.

Minerals Separation.—3s., less tax, payable May 5.

Pahang Consolidated.—Pref. 3½%, less tax, payable May 1.

Petaling Tin.—2½%, less tax, payable May 7.

Sinai Mining.—6d., free of tax, payable May 14.

Waihi.—1s., free of tax, payable May 8.

NEW COMPANIES REGISTERED

Anglo-American Alaska Association.—Registered April 25. Nominal Capital: £6,000 (20,000 5s. Preferred Ordinary and 20,000 1s. Founders' shares). Objects: To acquire mines and other rights and to carry on the business of metallurgists. Directors: P. M. de Friedlander and E. C. Powell. Office: 59, Gracechurch Street, E.C. 3.

Assoba Mines.—Registered as a private company April 16. Nominal capital: £100 in 4s. shares. Objects: To search for gold and other minerals and precious stones, and to acquire mining and other rights and any petroleum or oil-bearing lands in West Africa or elsewhere. Office: 5, Copthall Buildings, London, E.C. 2.

Awkrat Mines.—Registered as a private company on April 16. Nominal capital: £100 in 4s. shares. Objects: To search for gold and other minerals and precious stones, and to acquire mining and other rights and any petroleum or oil-bearing lands in West Africa or elsewhere. Office: 5, Copthall Buildings, E.C. 2.

Gold Coast Consolidated Lands.—Registered April 25. Nominal Capital: £50,000 in 2s. 6d. shares. Objects: To acquire and amalgamate Gold Coast Consolidated Lands, Ltd., Tokatea, Ltd., and the Zungon Tin Syndicate, Ltd., all in liquidation. Directors: E. H. Eldridge and S. Bratchell. Office: Broad Street House, Old Broad Street, E.C. 2.

Itnaf Mines.—Registered as a private company April 16. Nominal Capital: £100 in 4s. shares. Objects: To search for gold and other minerals and precious stones, and to acquire mining and other rights and any petroleum or oil-bearing lands in West Africa or elsewhere. Office: 5, Copthall Buildings, London, E.C. 2.

Land and Royalty.—Registered as a private company April 24. Nominal Capital: £25,000 in £1 shares. Objects: To adopt an agreement with the International Geophysical Prospecting Company, to prospect for oil, minerals, etc. Office: 181, Queen Victoria Street, E.C. 4.

Oil Properties and Holdings.—Registered as a private company April 17. Nominal Capital: £4,200 in 4,000 Proprietors· Preference shares of £1 each and 4,000 Ordinary shares of 1s. each. Objects: To adopt an agreement with Associated Financial Investment Trust, Ltd.; to acquire any petroleum or oil-bearing lands in any part of the world; to carry on the business of dealers in and refiners of petroleum and other mineral oils, etc. Directors: Sir Frank M. Crisp, Bt., and Dr. Murray Stuart. Office: Dashwood House, Old Broad Street, E.C. 2.