The Mining Magazine

Managing Director and Editor : W. F. WHITE. *Assistants :* ST. J. R. C. SHEPHERD, A.R.S.M., D.I.C., F.G.S.; F. HIGHAM, A.R.S.M., M.Sc., F.G.S.

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CONTENTS

EDITORIAL

THE more extensive use of vacuum filtration on the Rand is a subject that is henceforth to claim the attention of Mr. Alfred James, who has decided to retire from consulting practice in London and to proceed to South Africa to pursue the study of this interesting development.

A COURSE of twelve lectures on geophysical prospecting is to be given by Mr. E. Lancaster Jones and Captain H. Shaw at the geological department of the Imperial College during October and November, the first being on October 20. The course is open to former students and others and particulars are obtainable from the Registrar.

IT is expected that the Government of the Union will be called upon to contribute £250,000 to the phthisis liability, which is now wholly a burden on the Rand mining industry, at the recommendation of the Miners' Phthisis Commission. The contribution would be derivable from mining leases revenue. Another recommendation is that the compensation scales should remain unchanged.

THE Secretary for Mines recently appointed Professor Henry Louis to hold a local inquiry into the possible development of the production of gold and other minerals in Merionethshire. The inquiry opened at Dolgelly on October 7. Whether it is the Minister's intention to open similar inquiries in other parts of the country has not been disclosed, nor what further action the Government may contemplate, but it is understood that the position of the metalliferous mining industry in general has been under consideration.

NEXT year the British Association for the Advancement of Science is holding its centenary meeting in London and to mark the occasion it has been decided to launch a Centenary Fund of £40,000, to enable the Association to extend that hospitality to its visitors from overseas which it has been accustomed to receive at their hands. Contributions will be welcomed by the General Treasurer, at Burlington House. Elsewhere in this issue will be found a reference to the Association's recent visit to Cornwall.

THE Colonial Development and Advisory Committee has suggested and the Government has approved a grant of money from the Colonial Development Fund towards the cost of a detailed survey to be undertaken immediately in connexion with a project for the construction of a railway from Haifa, on the Palestine coast, to Baghdad, in Iraq. The present motor-transport route runs via Damascus and the railway if laid would obviate a passage through French mandated territory, as it is expected to go south of the Yarmuh Valley and the Jebel Druze.

AERIAL communication between the West African colonies is a matter that is receiving the attention of the Government. A civil aviation officer of the Air Ministry is at present visiting the countries concerned and his tour is expected to last about two months. The main objects of the inquiry are to determine the extent to which the various colonies are willing to co-operate in such a service and to settle the lines along which development will have to take place. A keen desire has recently been expressed for local air services and for the establishment of links with the main Empire air routes.

REFERENCE was made here in March last to a proposal to change the headquarters of the Institution of Mining and Metallurgy and at the same time to link it more closely with a number of correlated bodies. A further step in this direction has been taken by the registration under the Companies' Act of the Association for the Promotion of Co-operation between Scientific and Technical Societies and Institutions within the British Empire, a regrettably lengthy and cumbersome title, although for general usage a shorter one—the Association of Scientific and Technical Institutions—has been adopted. The

management of this association is to be vested in a council of some 20 persons, most of whom are the presidents of the component bodies. In connection with the formation of the new association there is to be a dinner at the Guildhall, at which the Prince of Wales will be present.

RAILWAY development in Central Africa has been advanced a stage further. The conference of representatives of the Governments of Southern Rhodesia, South-West Africa, and the Bechuanaland Protectorate concluded its sittings last month and announced that the route which is to be examined for the line to connect Southern Rhodesia with Walvis Bay would start from a point between Matetsi and Dett, which are in the Wankie coalfield area, proceeding thence southward to the Botletle river and through Ghanzi (in the Kalahari), or a point south of Ghanzi, to Gobabis, which is already connected with Walvis Bay. If funds permit a route is also to be examined from a point situated in Bechuanaland. At the same time the report of the Tanganyika Railway Commission just published recommends the immediate construction of a line from Kilosa to Ifakara (with the object of subsequent extension to Manda, on the shores of Lake Nyasa), that the Governments of Northern Rhodesia and Nyasaland be consulted at an early date regarding projects for railway development affecting all three territories, that a junction between the Central Railway and the Tanga Railway be effected at Kilosa or Kimamba to go to Korogwe or Mombo, and that, pending the completion of the work, branch lines be built northwards and southwards respectively. The commission was not in agreement regarding these recommendations and a minority report declares for a line from Dodoma to Iringa and Ubena should negotiations with Northern Rhodesia and Nyasaland fail. The Central Railway referred to is, of course, the line from Dar es Salaam to Kigoma, on the Shores of Lake Tanganyika. Railways in this part of the continent are also likely to be affected by certain deliberations which have lately taken place in Brussels between the Belgian Prime Minister, the Governor of Uganda, and the General Manager of the Kenya and Uganda Railways, which had as their objective the linking of these lines with those of the Belglan Congo.

Secondary Metals in the United States

The yearly publication by the Bureau of Mines of detailed estimates of the output of secondary metals in the United States—that is, metal produced from scrap and waste—is of importance, as the figures afford great help in the determination of the total amount of metal coming on the markets of the world. It is estimated that the total value of the more important metals recovered from secondary sources in the United States during 1929 was $331,027,900, which is $56,416,600 more than in 1928. This increase was almost entirely due to the greater recovery and higher yearly average price of copper and copper alloys. There were also increases in the average prices of lead and zinc, but decreases in those of antimony and tin. As regards quantities, there was a large increase in the amount of secondary copper and brass produced and small increases in lead and aluminium, while the recoveries of secondary zinc, tin, antimony, and nickel showed small decreases. The following table gives the production of secondary metals within the United States for 1929 and the figures for 1928 are added for comparison :—

	1928. Short tons.	1929. Short tons.
Copper, including that in alloys other than brass	325,000	417,600
Brass scrap remelted	302,000	298,500
Lead as metal	138,000	138,500
Lead in alloys	170,600	172,500
Zinc as metal	70,700	65,400
Zinc in alloys other than brass	12,500	11,600
Tin as metal	8,200	7,400
Tin in alloys and chemical compounds	27,600	26,900
Antimony as metal and in alloys	11,900	11,131
Aluminium as metal	24,500	25,850
Aluminium in alloys	23,300	22,550
Nickel as metal	635	850
Nickel in non-ferrous alloys and salts	3,865	3,500

The amount of secondary copper produced as metal was 297,000 short tons, while 208,950 short tons of the metal was contained in secondary brass and 120,000 tons in other alloys, making a total recovery of 625,950 tons of copper. As regards lead, it will be seen that 138,500 tons was recovered from the smelters and 172,500 tons contained in remelted alloys, the total of 311,000 tons being equal to approximately 35% of the total lead production of the United States.

The statistics for zinc show that in addition to 65,400 tons of secondary spelter and 65,670 tons recovered in brass, 7,424 tons was obtained as zinc dust from dross and 12,871 tons was contained in lithopone made from zinc skimmings and ashes, while no less than 8,437 tons of zinc was contained in the zinc chloride made from similar sources. Details given for tin show that 221,643 long tons of clean tin-plate scrap was treated at detinning plants and 855 short tons of metallic tin recovered, in addition to 3,545 tons in the form of oxide and chlorides.

Comparisons between conditions during 1929 and those obtaining in the current year are difficult, but the weak state of the present metal market must undoubtedly make for the accumulation of scrap metal, as much material that could be profitably treated during 1929 will have to be discarded at present metal prices. In the United States the turnover of scrap metal during the year under review was larger than normal in many directions and business, especially in the manufacture of secondary copper and copper alloys, was the most profitable experienced for several years. Finally it might be added that the outputs of primary copper, lead, and zinc in the United States during 1929 were 1,237,500 tons, 797,250 tons, and 560,770 tons respectively, as against 626,550 tons, 311,000 tons, and 172,295 tons of the secondary metals.

The Diamond Situation

It has been apparent for some considerable time past that relations between the Union Government and the Diamond Syndicate were not altogether of a cordial nature. In April last, however, it was officially stated that agreement had been reached, a basis of understanding between the Government, the producers, and the syndicate having been found, and that only items of secondary importance remained to be settled. The reason why so far a definite agreement has not been concluded has recently been said to be solely a geographic one—namely, the distance which separates South Africa from Europe—but that its signature might be expected within the next few weeks. Whether this proves to be the case or not, the events which have led to the present position of affairs in the diamond market merit examination.

The exploitation of the famous alluvial fields of the Vaal River, carried on for many years, resulted in intensive prospecting along the course of the Orange River, and diamonds were discovered at isolated points up as far as Aliwal North, but it was generally held that the profitable gravels were largely confined to the Vaal valley, or to some of its tributaries. During recent years more attention has been paid to the lower Orange, owing to persistent rumours of diamond discoveries in the arid region of the Namaqualand coast, although these had been discredited by various expeditions to the Atlantic seaboard. In 1925, however, diamonds were discovered south of Port Nolloth in gravels flooring a depression among the sand dunes and in the succeeding year more stones were found, this time in gravels capping some cliffs to the north of that harbour. These discoveries, which are quite distinct from the well-known occurrences in South-West Africa, led to intensive investigations, by Dr. Hans Merensky and others, of the mouth of the Orange, which resulted in the discovery of the rich terraces of Alexander Bay. At the same time it was realized that the stones occurred in raised beaches and surveys by standard geological methods revealed that there were at least eight terraces, four of them productive, the richness of certain portions of the deposits being phenomenal. It has been recorded that from two trenches, together about 1,000 yards long by 6 yards wide made in the two main terraces, over one million carats of good quality stones was extracted, having a value almost equal to the world's annual consumption of diamonds. The territory is on Crown Land and, after the original claims had been worked out, the fields were developed as State diggings. The success attending further investigations is an outstanding example of scientific prospecting, but at the moment it is rather the resulting situation in diamond affairs and the attitude of the Union Government with which we are concerned.

With control of enormous quantities of good quality stones, which were to be realized for the benefit of the Union exchequer, it became necessary, in order to prevent the spoliation of the market, that some arrangement should be made with the London Diamond Syndicate. At this stage the world capacity to absorb the precious stones was affected by several

factors, the general depression, particularly in the United States, and the uncertainty of the tariff intentions in that country making the diamond outlook very uncertain. With the settlement of the American tariff the position was more clearly defined, but the continuance of depressed conditions in the biggest markets for large precious stones —the United States and the South American republics—made it evident that normal conditions could not be expected until a general revival in world trade was witnessed. The desire to keep diamond cutters in the Union fully employed and probably an intention to give an artificial stimulus to the industry led the Union Government at this point to sell Namaqualand stones to the Union cutters at prices below those quoted by the syndicate in Europe. Such a step could have only an unfavourable effect on the diamond market and the necessity for agreement with the syndicate became imperative. The visit of Mr. Fourie, the Union Minister of Mines, to Antwerp has, therefore, been of the utmost importance to the industry and the progress of negotiations will be watched with interest. It is to be hoped that, in deciding the steps to be taken in regard to the agreement with the syndicate, the Union Government, in addition to the creation of an official bureau for the valuation of uncut stones, will recognize that the export premium on diamonds should be sufficient to compensate Union cutters for their higher cost of living and that their supplies should not be available at a cheaper rate than those offered in Europe. Such recognition would undoubtedly make for stability in the diamond market.

African Native Policy

Certain brief references in these columns from time to time have drawn attention to Government policy in East Africa and Northern Rhodesia and have made it evident that a strong feeling has been aroused in certain quarters against the insistence of the Colonial Office on what has been termed the "paramouncy" of the native interests. While it may be beyond the province of the MAGAZINE to enter into a controversy which is almost wholly political in character, the subject is one which deserves some consideration for the twofold reason that mining engineers and prospectors are themselves colonists, and as such often responsible for the initial development of new territories, and that in time the conditions of their life and tasks may be quite considerably affected by the attitude that may be taken on this question by the Government of the country concerned.

In eastern and central Africa the native question has quite suddenly become one of supreme importance politically, the objections which have been raised by the white settlers in these regions to the British Government's declared intentions—which are after all, it should be remembered, but a reiteration of a policy first laid down in 1923—having lately been championed by the Government of the Union, as evidenced by the views expressed by General Hertzog and others. The significance of this intervention is a matter of purely political interest and need not be considered further here. Its incidence, however, affords an opportunity for some comparison of the differing conditions which exist in tropical or central Africa, on the one hand, and, on the other, in that part of the continent south of the Zambesi. For climatic reasons, as those who are familiar with the circumstances are aware, there is a much greater permanent white population to the south of the arbitrary dividing line mentioned than to the north of it. In other words, the ratio of white residents to natives in the Union of South Africa is much greater than in Northern Rhodesia. It may be said that with the mineral development which is now in progress in the latter this ratio will change, but will it change sufficiently to put the two regions even approximately on the same level?

The guiding principle of the Colonial Office in the administration of tropical territories would seem to be the view that they are never likely to support a large white settlement which may rightly be regarded as permanent. Consequently the permanent inhabitants are the natives themselves, and it is to them that the development of the country is of the greater import. Where British Colonial administration in the tropics may perhaps be questioned is as to the wisdom of granting immigration facilities too easily to other than white pioneers. In any consideration of this subject it must be realized that the native policies in central and southern Africa respectively are devised to meet different conditions.

REVIEW OF MINING

Introduction.—The depression in metal prices continues heavily to cloud the immediate outlook in mining affairs. Copper and zinc are at the time of writing at their lowest price during the present century, whilst the price of tin and lead continues to fall, so that the improved outlook in the gold-mining situation provides at present the only bright spot.

Transvaal.—The output of gold on the Rand for September was 860,311 oz. and in outside districts 42,865 oz., making a total of 903,176 oz., as compared with 921,081 oz. in August. The natives employed on the gold mines at the end of the month totalled 205,061, as compared with 202,257 at the end of August.

In a report to a recent meeting of the Transvaal Chamber of Mines the Gold Producers' Committee stated that it had addressed the Union Cabinet on the subject of native labour, pointing out that a crisis could only be avoided if permission was given to employ natives recruited from areas now closed, to which the Minister of Mines replied that the Government did not consider it necessary to depart from its present attitude. The recent suggestion of Dr. Pirow, Acting Minister of Mines, that the percentage of native labour underground should be increased, correspondingly increasing the number of Europeans on surface work, is of interest, especially as natives are less susceptible to phthisis.

During the year ended June 30 last the New Modderfontein Gold Mining Company treated 1,811,000 tons of ore in the mill and recovered 870,222 oz. of gold, worth £3,691,141, silver, osmiridium, and diamonds increasing the total revenue to £3,709,823, or 41s. per ton. Working costs amounted to £1,521,646, or 16s. 10d. per ton, and the working profit to £2,188,177. Dividends absorbing £1,925,000 were paid, equal to 137½%. The available ore-reserves at the end of June were estimated to be 7,431,900 tons, averaging 8·6 dwt., as compared with 7,857,600 tons, averaging 8·9 dwt., at the end of the previous year.

The New Kleinfontein Company have received news that small stopes have been opened up on reef found in the footwall of an old stope above the 7th level. The occurrence is being investigated. Recent rumours of an amalgamation of the New Kleinfontein with the Van Ryn Deep have been denied by the former company.

During the year ended June 30 last the net profit of the Johannesburg Consolidated Investment Company was £565,192, as compared with £593,199 for 1928–29. The report stated that the gross profits had been well maintained, but that provision had had to be made for abnormal depreciation in the value of certain holdings. The results obtained by the various subsidiaries have all been satisfactory.

A rockburst at the City Deep towards the end of September involved four levels. The main fall was 5,000 ft. underground on the 23rd level, the burst travelling upwards to the 20th level. One European and three natives were killed.

At an extraordinary general meeting to be held in Johannesburg towards the end of November it will be proposed that the capital of the Ferreira Estate be reduced from £192,765 in £1 shares to £154,212 in 16s. shares, by returning 4s. per share in cash and lowering the nominal share value by the same amount.

Southern Rhodesia.—The output of gold from Southern Rhodesia during August was 46,152 oz., as compared with 45,810 oz. for the previous month and 46,473 oz. for August, 1929. Other outputs for August were: Silver, 6,333 oz.; copper, 107 tons; coal, 83,129 tons; chrome ore, 14,908 tons; asbestos, 3,816 tons; mica, 7 tons; scheelite, 3 tons; antimony, 38 tons.

A circular to shareholders of the Gaika Gold Mining Company announces that Mr. Edwards, the chairman, to whom a power of attorney was given, has informed the board by cable that he has signed agreements for the disposal of the mine and all Rhodesian assets to a new company, in which, it is understood, shareholders are to be given an opportunity to acquire an interest.

Northern Rhodesia.—Shareholders in the Rhodesian Congo Border Concession have been advised of the final results of bore-hole N.E. 21 A and also of preliminary results from N.E. 41. In the former 40 ft. of the upper or Dambo lode horizon averaged 2·98% copper, whilst in the lower or River lode horizon 45 ft. averaged 4·6% copper.

The ore was mixed oxides and sulphides. Bore-hole N.E. 41, which is situated about 1,200 ft. west of the N'Changa New Discovery boundary, entered the lower or River lode horizon at 430 ft. and to 480 ft. the ore averaged approximately 6·1% copper.

The report of Rhodesian Selection Trust for the year ended June 30 last shows that the company continued development work in the Mufulira area until February 3 last, when 45,000,000 short tons of sulphide ore carrying 4·68% copper had been proved. Further drilling by the Mufulira company has considerably increased this amount. The mine is being opened up by four subsidiary shafts and the sinking of a main hoisting shaft has been started. This is being sunk in the footwall and will be equipped to handle 2,000,000 short tons of ore per annum. Drilling in the Chambishi area has met with encouraging results and is being continued, but drilling in the Baluba area, where 21,000,000 tons of sulphide ore averaging 3·47% copper has been proved, has been suspended. Encouraging results have also attended operations in the Luansobe area.

A circular to shareholders in Luiri Gold Areas, Ltd., states that labour conditions at the Dunrobin mine have not been satisfactory, and in consequence the progress of development has been slow. Recently, however, there has been an improvement and developments are reported to be promising. As some time must elapse before results can be reflected in the monthly returns, it has been decided to give option holders a longer period in which to exercise their rights.

Uganda.—A circular to shareholders of Kagera (Uganda) Tinfields, Ltd., states that the Billiton Tin Company now holds nearly 30% of the issued capital and that Mr. J. Van den Broek has been appointed to a seat on the board as representative of Billiton interests. A new dressing plant, capable of treating 200 tons of detrital material or 100 tons of mine ore daily, is in course of erection in Uganda and is expected to be ready within the next month. Meanwhile a large amount of development work has been done at the Mwirasandu mine, in addition to prospecting in the Mwirasandu, Namherere, and Kitembe areas.

Australia.—Shareholders of Lake View and Star, Ltd., have been reminded by circular that at the last annual meeting reference was made to the necessity for spending a large sum in new equipment and in reconditioning certain sections of the mine. This condition has continued into the current year and altogether £80,000 has been so spent. The new flotation unit, brought into successful operation in July, is capable of treating 5,000 tons of ore per month and is the first of several similar units, which will, it is estimated, bring the capacity of this plant up to 20,000 tons monthly. Orders have been given for the erection of these extra units and it is also stated that when the necessary alterations to the power plant have been decided upon the flotation section will be still further extended to enable it to handle 40,000 tons per month.

The liquidators of the Mount Morgan Gold Mining Company propose to make a final distribution of 10½d. per share on December 15 next and then at the end of three months finally to close the books.

The Electrolytic Zinc Company of Australasia has decided, in view of the present prices of metals, to postpone the commencement of operations at the Rosebery mill.

India.—Operations at the Ooregum mine during the first six months of the current year have shown a substantial falling off in the production of gold, rockbursts having affected important stopes, thereby lowering the grade of ore available for the mill. The strike which occurred in April last also had a serious effect, the result being that the directors have decided not to declare either the preference or interim ordinary dividends usually announced at this period.

Malaya.—Pangnga River Tin Concessions, Ltd., was formed in 1927 to acquire tin dredging areas in Siam from Kamunting Tin Dredging, Ltd. It is now proposed that the latter company shall purchase the assets and undertaking of the Pangnga River Company, paying all its liabilities and allotting that company 1,000,000 fully paid 5s. shares at a premium of 1s. per share, Pangnga Concessions to remain in being as a holding company. Subject to the approval of the amalgamation proposals by shareholders, arrangements have been made for the subscription of £100,000 of 8% debentures of the Kamunting company, such debentures bearing a three years' option, at 8s. per share, on five Kamunting 5s. shares for each £1 debentures subscribed.

Colombia.—The dispute between the Colombian Government and the Colombian Mining and Exploration Company has been finally settled, a bill ratifying the agreement with the company having been passed in the Colombian Congress and sanctioned by the President.

Venezuela.—At the annual meeting of the New Goldfields of Venezuela, held at the end of September, it was proposed to make an issue of £130,000 of 7½% First Mortgage Debenture Stock, carrying option rights.

Bolivia.—For the year 1929 the Corocoro United Copper Mines, Ltd., which is controlled in Paris, reported a net profit of £2,020, which was carried forward. Owing to the fall in the price of copper it was decided in May last temporarily to suspend exploitation at the mine, but to continue research work and equipment. The revolution which broke out recently has prevented the carrying out of this programme.

Mexico.—Shareholders of the Mazapil Copper Company, Ltd., have been informed that it has been decided to suspend operations on the property as from September 8 last. Essential pumping and development work are to be continued for the time being.

London, Australian, and General Exploration Company.—The accounts of the London, Australian, and General Exploration Company, Ltd., for the year ended July 31 last, show a profit of £3,360, which, with the balance of £2,076 brought in, made an available total of £5,436. Out of this £4,500 was transferred to reserve and £936 carried forward. The general conditions ruling in the base metal industry have had an adverse effect on the company's business, but it is reported that the properties in which it is interested have been maintained in an efficient manner and should quickly feel the benefit of any improvement in trade.

Tigon Mining and Finance Corporation.—The report of the Tigon Mining and Finance Corporation, Ltd., for the year ended March 31 last shows that tests of the treatment plant on the Spanish sulphur properties had revealed defects in certain parts, which required modification. With this work completed it has been estimated that production of brimstone could be commenced at the rate of 5,000 to 6,000 tons per annum. The acquisition of sulphur-bearing properties in Chile, referred to in the last issue of the MAGAZINE, is now completed and these properties, which consist of three groups of mines in the Tacora district, adjacent to the Arica–La Paz railway, were estimated to contain 11,000,000 tons of proved ore, averaging 76% sulphur, in addition to 7,500,000 tons of probable ore of a similar tenor. Work on the antimonial silver-lead, tin, and gold properties in Spain is in abeyance, but the company is interested in the results of an examination of the Barima and Barama Rivers, in British Guiana, which is in progress.

Imperial Smelting Corporation.—During the period ended June 30 last the net profit of the Imperial Smelting Corporation was £231,373, of which £196,012 was distributed as dividends, leaving £35,361 to be carried forward.

Murex, Ltd.—The accounts of Murex, Ltd., for the year ended June 30 last show a net profit of £52,276, to which must be added £20,898 brought forward, making an available total of £73,173. After making provision for income tax and dividends, which absorbed £31,438, there remained a balance of £26,775, which has been carried forward. It will be recalled that during the past year this company has acquired the Premier Electric Welding Company, Ltd., in addition to the control of Alloy Welding Processes, Ltd.

Tin.—The continued fall in the price of tin, which on October 10 was around £109 per ton, has had noticeable effects during the past month. Many companies carrying out the recommendations of the Tin Producers' Association have suspended operations for varying periods and statistics issued by the same body show that the tin production of the world for the eight months ended August 31 last totalled only 113,379 tons, as against 122,035 tons in the corresponding period of 1929. Among other effects of the decline it may be noted that the London Tin Corporation has decided to pass its preference dividend. The Penpoll smelter, probably owing to the heavy falling off in ore supplies from Bolivia and Cornwall, is to be closed. It may be also noted that the Siamese Government has decided for the time being not to consider the granting of new mining leases or prospecting licences. The news of the resignation of Mr. F. E. Mair from the council of the Tin Producers' Association has been followed by a statement from Sir William Peat that this does not indicate any disagreement on Mr. Mair's part with the Association's policy.

A PROPOSAL FOR SHAFT SINKING

By G. P. CHAPLIN, B.Sc., M.I.M.M., A.M.I.P.T.

The author outlines a suggestion for simplifying shaft sinking conditions and decreasing the time required.

INTRODUCTION. — Considerable oil-well drilling experience has led the author to consider the applicability of that practice to aid in shaft sinking with the object of increasing the speed of sinking and overcoming certain difficulties inherent in present methods. In shaft sinking the principal conditions which cause the rate of advance to be relatively less than that of other rock excavations of a comparable size and shape are—(*a*) the difficulty of keeping the shaft bottom sufficiently dry to allow of the best conditions for drilling and blasting and (*b*) the time lost in removing and loading into kibbles or skips the broken rock after each blast. The rate of sinking would also be increased and a saving effected in the quantity of explosives required if a partially free face were available for blasting to.

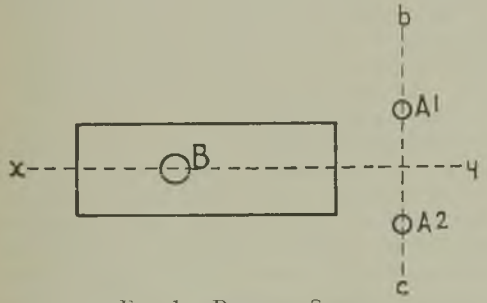

FIG. 1.—PLAN OF SHAFT.

APPLICATION.—The proposals here outlined are only applicable to vertical shafts of moderate or larger depths and it is not suggested that any considerable economies are going to be effected by these means in cases where only one shaft of 1,000 ft. or less has to be sunk. The author is of opinion, however, that in all circumstances where the following procedure is applicable a saving of from 20 to 30% could be effected.

OUTLINE OF THE SCHEME.—The plan, which will be developed in some detail in what follows, consists essentially in drilling one or two sets of bore-holes by ordinary oil-well drilling methods with standard rig (percussion) to a depth somewhat in excess of the intended depth of the shaft. These sets of bore-holes are to be considered as entirely independent of each other since they will have different objectives. One set, consisting of two bore-holes of comparatively small diameter according to the expected quantity of water which will be encountered, will be required for the sole purpose of unwatering and the other set of one or more large diameter holes would be used for the purpose of providing the face to blast to and to facilitate the clearing of the shaft bottom after each blast.

UNWATERING BORE-HOLES.—For simplicity it is proposed to consider first the case where only one set of bore-holes is sunk, namely those referred to in Figs. 1, 2, and 3, as A1 and A2, which are to be used for the purpose of unwatering the shaft as sinking proceeds. Figs. 1 and 2 represent respectively a plan and section of a typical rectangular shaft in process of sinking and it will be seen that the present proposal is that these two holes (A1 and A2) should be sunk outside the area of the shaft but sufficiently near it to drain effectively all the water within its area and that these

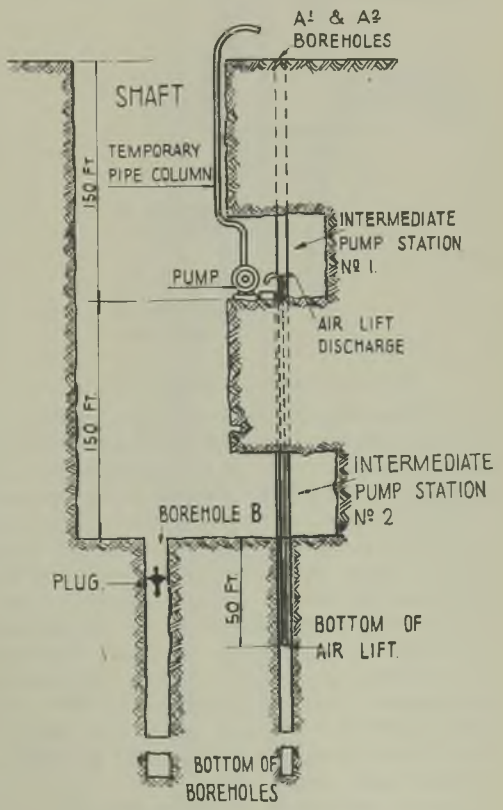

FIG. 2.—TRANSVERSE SECTION OF SHAFT.

bores should be entirely completed before any work in the shaft proper is started. As indicated already the diameter of these bores is dependent on the quantity of water which it is expected will have to be handled through them.

When this method of simplifying shaft sinking was first tentatively worked out, the use of specially designed turbine pumps, directly connected to a motor suspended vertically in as large a bore-hole as practicable, was considered. Although it was possible to design a pump which would

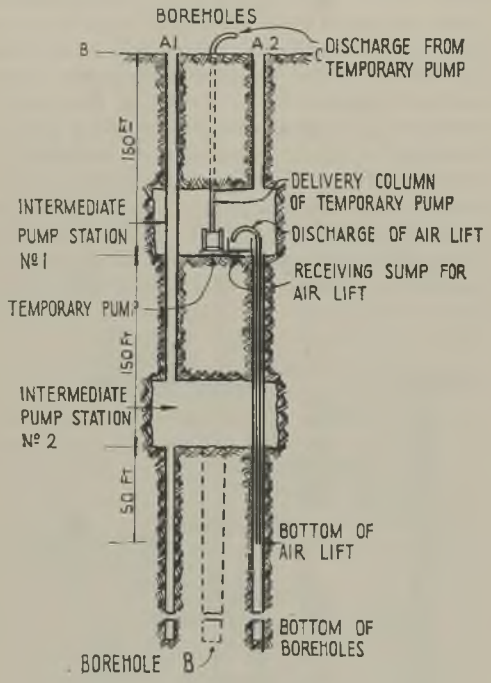

Fig. 3.—Section on bc in Fig. 1.

work under the special conditions called for, the complications inherent in remote control and regulation, due to changing head and quantity of water to be handled, by a class of pump which for satisfactory operation requires to work against a constant head and to pass approximately the quantity of water for which it is designed, caused the idea of using pumps to be abandoned in favour of employing air-lifts. The use of air-lifts has the further important advantage that smaller bore-holes are admissible as compared with the size of holes that would be required if turbine pumps were used.

In all probability the quantity of water to be lifted from the shaft bottom will not exceed 250 gallons per minute and, allowing for what is considered to be the most satisfactory type of air-lift for the conditions called for, an interior diameter for the cased bore-hole, to include sufficient clearance, would be 10 in. with an exterior diameter of $10\frac{3}{4}$ in. It must be remembered, in considering the size of these holes, that, in the initial drilling, allowance has to be made for casings. The first 150 to 200 ft. of average ground will require an outer casing of $13\frac{3}{8}$ in. exterior diameter and within this and to the full depth of the hole a casing of $10\frac{3}{4}$ in. (O.D.) as mentioned above will be used. These strings of casing will of course be perforated to allow the free ingress of water from the surrounding country. The inner casing is required even in hard country rock in order to provide a smooth channel for lowering or raising the air-lifts and also to prevent flakes and pieces from the sides of the bores falling to their bottoms and partially or wholly filling them. In most districts the two strings of casing referred to are all that will be necessary, but, when encountering soft and bad ground which does not allow of the satisfactory driving of the casing, it might be necessary to use a third string, in which circumstance the bore would have to be started with a still larger diameter. The data here quoted may be accepted for shafts of 1,000 ft. in depth. A shallower shaft will require less robust casings. Some remarks about conditions qualifying deeper shafts are made later on.

The Air-Lifts and their Operation.—In Fig. 4 will be seen the type of air-lift that will be found suitable. Any air-lift designed for working in a bore-hole will be satisfactory, but the type in which the air is conducted by an exterior pipe is regarded as being the more satisfactory. To describe the manner in which these air-lifts would operate it will be assumed that shaft sinking proper has commenced and that the same air power that is being used for the rock-drills will be available for the lifts and that the pressure of this is about 105 lb. per sq. in. If less pressure than this is available, the distances apart of the temporary auxiliary pumping stations, as described below, should be decreased to conform with satisfactory working conditions for the air-lifts at the pressure of the air supplied for their operation. An air-lift is lowered in one of the bore-holes, say A1, to a depth of some

300 ft. and set to work. Shaft sinking meantime proceeds until a depth of 150 ft. is reached, when a temporary auxiliary pumping station will be required. This is brought into being somewhat as follows :—The station is blasted in the side of the shaft to include the casing of both bore-holes, care being taken that they are not damaged, although damage to A2 at this stage would not be of such vital importance. A suitable type of centrifugal or other mine unwatering pump is here installed, capable of dealing with the water delivered to it as described in what follows, as well as that entering the shaft above this horizon, which should be taken up by means of a special curb. A section of the casing of A2 is now cut out and a second air-lift is lowered down A2 to a depth of some 300 ft. below this pump station. The second air-lift is then put to work delivering water, via the hole cut in the casing, to the sump at this auxiliary pumping station and the air-lift in A1 can now be withdrawn. Sinking is now proceeded with for a further 150 ft. when another auxiliary pumping station is installed but on this occasion, of course, it is the casing of A2 bore-hole which must not be damaged in blasting and that of A1 will be cut out for linking up to the pump as in the first instance. The procedure is continued for successive depths of 150 ft. until the bottom of the shaft is reached.

The air-lift, for satisfactory working, requires to be submerged by some 40 to 60% more than the desired lift and for this reason the author has suggested above that it should be lowered to a depth of 300 ft., a depth which makes allowance for raising a total of 200 ft. This permits of a drainage of 50 ft. in depth below the pump station, thus securing that the station be kept reasonably dry. The lowering of the air-lift to this depth at one stage might be regarded as bad practice during the early stages of the sinking, but such lowering may be done if desired in two or more stages. In view, however, of the elasticity, even if it is mechanically inefficient, of an air-lift system, and in order that no stoppages may occur during sinking to the first 150 ft. level, it is probably desirable to operate as described above.

THE CENTRAL BORE-HOLE.—Up to this stage we have considered the possible utility of only one system of bore-holes to aid in shaft sinking. Referring to Figs. 1,

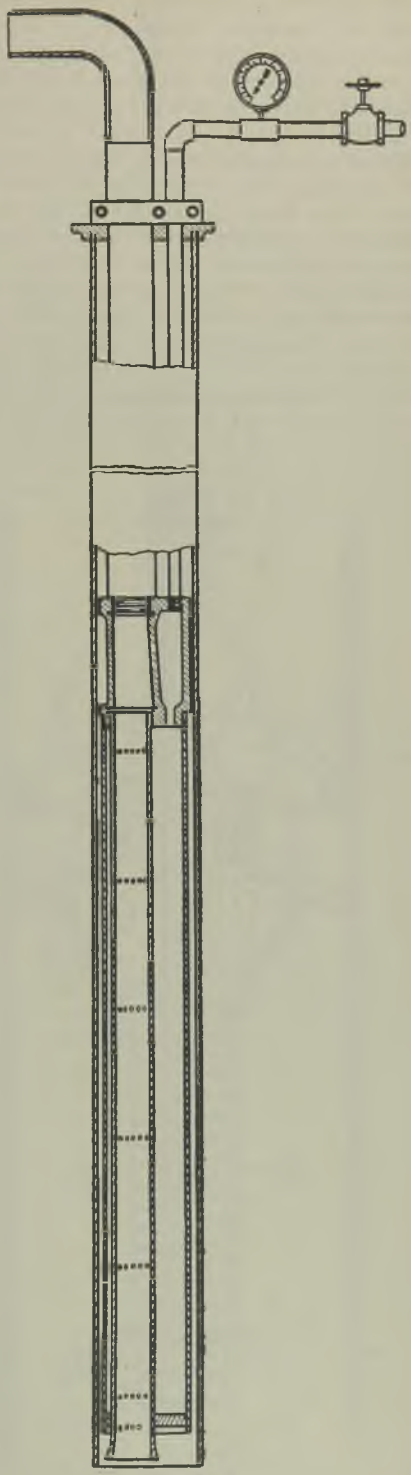

FIG. 4.

2, and 3, it will be seen that a third bore-hole of larger diameter, called B, is outlined. This is one member, and perhaps the only necessary member of the second set of holes referred to earlier in this article, the function of which would be to assist in providing a face or cut to blast to and also to facilitate the clearing of the shaft bottom after each blast. This bore should be of as large a diameter as possible and is only cased for that portion from surface to solid rock. For this section the hole is, if anything, a hindrance rather than a help as the casing has to be removed piece by piece as sinking proceeds and for this reason it should probably be made up in 5 ft. lengths. Once, however, solid rock is reached and all casing has been removed the suggested method of procedure is somewhat as follows:—A removable plug, a suitable design for which is given in Fig. 5, would have to be set at some 2 ft. below the depth which the blast would affect. After each blast the *débris* would have to be removed from the immediate vicinity of the bore and the super-incumbent broken rock above the plug itself cleared away. There are types of plugs used in oil-well drilling, but these would not be suitable for constant placing and removal and they would also require the use of stem, jars, etc.

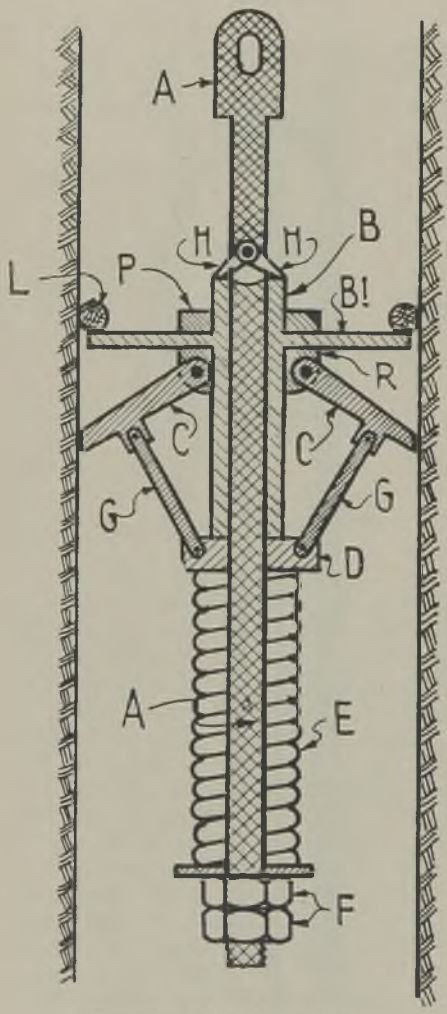

Fig. 5.—Bore-Hole Plug.

Description of Plug for Bore-Hole B.—This consists essentially of a central cylindrical rod A. Around this, and capable of sliding up and down it, is a sleeve or shell B, which has connected to it the circular plate B1 with its shoulders or collars P on the upper side and R on the lower. Four or more loose arms C, capable of movement in a vertical plane only, are pivoted, as shown in Fig. 5, at equal distances apart, in shoulder R. A substantial ring, D, is capable of sliding up and down over the outside of the sleeve B. Each arm C is connected to the ring D by stout spokes G in the manner indicated. Thus D, G, and C are capable of movement in a somewhat similar manner to the ribs and spokes of an umbrella. E is a strong coil spring, the upper face or end of which presses against the lower face of the ring, D. The lower portion of this spring presses against a washer (not lettered). This washer is seated on the lock nuts F, on the bottom end of the rod A, which is screw threaded at this section. The spring E is of such diameter that the sleeve B is entirely within it and is not affected by its motion.

The central rod A, in addition to the lock nuts and washer at its lower end, is provided with a hoisting eye at its upper end and the lower end of this is turned to make a shoulder so that A cannot descend too far through B. Also at a suitable point in A a slot is cut which contains pivoted stops HH, which will have their lower portions forced out of their slot by a small spring, when the rod A is uncovered by movement of the sleeve B. The stops are, however, kept in their slot when this is covered by the sleeve B.

As the plate B1 is of a rather smaller diameter than the bore-hole, a loose spliced ring of old, large diameter hemp hawser L is used to stop debris falling between the

edge of the plate and the walls of the bore-hole.

Use of Plug.—To set the plug in position it is suspended by the extension hook M (Fig. 6) from the hoist cable or lowering blocks and the distance piece O, which is shaped in the form of a pipe having a longitudinal section cut from its entire length wide enough to permit the hook M to pass through the aperture, surrounds

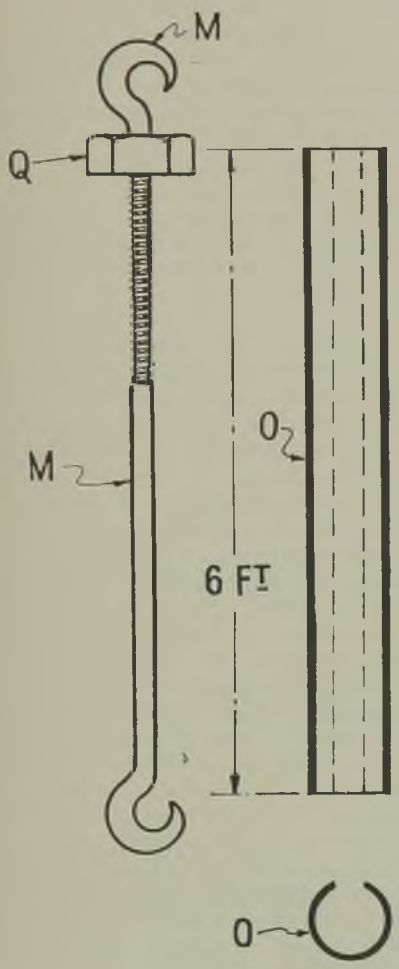

FIG. 6.

it such that the bottom end of O rests in the shoulder P. The hook M has a screw thread of large pitch at the top for about 2 ft. and has the large nut Q running on this. The large nut is screwed down and so causes the sleeve B to uncover the slot carrying the stops HH, which now open and prevent the sleeve B from sliding up the rod A, and this results in compression of the spring E against the ring D. This in turn forces the arms C against the sides of the bore-hole with sufficient strength to hold the plug firmly in position. The nut Q can now be slackened off and the distance piece and extension hook respectively removed. The loose protecting cone R, Fig. 7, is placed over the top of the plug and blasting can be proceeded with.

Removing Plug.—To remove the plug after a blast the *débris* is cleared away immediately round the bore and from the bore itself above the plug, the protecting cone R and the hawser ring L are removed and the plug can be lifted from the bore directly either by the hoist or by differential blocks.

Removal of Broken Ground.—A special kibble or skip of such diameter as will allow it to enter the bore-hole easily will be required. This should be provided with

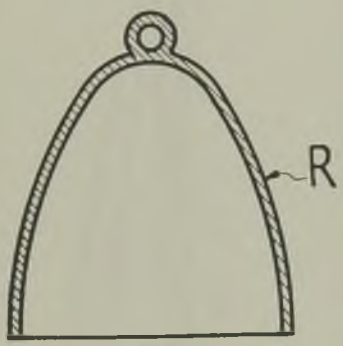

FIG. 7.

bottom discharge having a positive arrangement for opening and shutting, no part of which arrangement should project beyond the exterior circumference of the skip. Its top should be flared to a diameter some 6 in. greater than its general exterior diameter so that it would close and be supported by the lip of the bore when lowered in it. It would also be advisable to restrict its top opening slightly by means of a top plate so that jamming of large sized pieces, of the waste to be hoisted, could not occur. Clearing up and hoisting the broken rock would then proceed normally, the advantage of this method being that the *débris* does not need to be lifted as would be the case with ordinary sinking kibbles because it can be raked or dragged into the special kibble above described in virtue of the position thereof in the bore-hole.

Size of Central Bore-Hole.—The size of the bore-hole B while preferentially as big

as possible will of course be governed by the size of the standard casing available. This has an exterior diameter (not over couplings) of $24\frac{1}{2}$ in. and an interior diameter, for use to a depth of 200 ft. (with a safety factor of 2) of $23\frac{3}{4}$ in.

Verticality of Bore-Holes.—Having outlined the precise functions of bore-holes as an aid to faster and otherwise more efficient shaft sinking it may be as well to consider in some detail one or two

Fig. 8.—Portable Drilling Rig, capable of drilling to 2,500 ft. Shear-legs for handling casing are shown.

difficulties that might be expected to arise. In general, it may be doubted whether a practically vertical bore-hole, such as these three that have been proposed here, can be drilled. With ordinary homogeneous country to a depth of some 1,000 to 1,200 ft. there is no danger that a crooked hole would be bored. If, however, the ground to be drilled consists of steeply inclined strata containing alternations of hard and relatively softer material, either with or without jointing, it would be difficult to keep bore-holes absolutely vertical. If the dip of the strata were at right angles to the short axis of the shaft the amount of distortion in 1,000 ft. of depth would probably not be sufficient to throw the bottom of the bore outside of the side lines of the shaft. If however the dip were at right angles to the long axis of the shaft there would be a possibility of the bore being diverted sufficiently for it to leave the shaft area, but unless the divergence was sufficient to carry the bore-hole completely beyond the shaft's side-lines it would still be of service. With regard to bores A1 and A2, small amounts of divergence would not be of serious moment since they are only intended as small pumping shafts. Further, a crooked hole can always have its diverted portion filled with broken rock and be re-drilled. Generally this procedure once is sufficient to straighten the hole, though in extreme cases two or more fillings and re-borings may be required.

Depth of Central Bore-Hole.—With regard to the central bore-hole (B) it is impossible with even the greatest care to prevent some fines and smalls from passing the plug when it is removed. For this reason it is advisable to drill this hole some 200 ft. deeper per 1,000 ft. of shaft depth to form an adequate receptacle for such inadvertently admitted *débris*.

Shafts over 1,000 Feet.—If it is desired to sink more than 1,000 ft. there is no practical difficulty in drilling the bores for the air-lifts to 3,000 ft. or more but a string of casing of the diameter given above (suitable for an air-lift capable of handling 250 gallons per minute) would weigh some 90 short tons. A column of this length could probably not, on account of the friction between it and the wall of the bore, be "worked" and kept sufficiently free to allow of its being driven, consequently it would have to be "landed" at that depth, beyond which it could not be driven, and the extra depth required would have to be bored for and be cased with the next diameter casing. As will be recognized, with a smaller diameter casing a smaller capacity air-lift must be used. This would probably be quite satisfactory as it is exceptional for a shaft to make as much water below 1,000 ft. in depth as it does above that horizon.

The central bore-hole could also be continued to a considerably greater depth, but in order to permit of a satisfactory length of stroke while drilling, the weight of the string of tools used would have to be

lessened. This means that the diameter of the lower portions of a deep central bore would also have to be diminished.

Naturally, with any bore-hole, the deeper it is drilled the greater the danger of its deviation from the vertical and on this account it is possible that the methods so far put forward would not prove to be economical for sinking to depths greater than about 2,000 ft., but it may be possible to proceed to a considerable distance deeper by erecting a modified drilling rig near the shaft bottom (when the shaft had been sunk to say, 2,000 ft.) and to start from again with large diameter holes. The drilling engine would be actuated either by compressed air or electrically.

Possible Alternative Use of Unwatering Bore-Holes.—During shaft sinking, sections of the twin pumping bores (A1 and A2) might be used for ventilation purposes by simply covering those portions of the casing which have been cut (at various auxiliary pumping stations) with stiffened canvas tube or pipe and connecting the lowest open end with canvas pipe to near the shaft bottom and placing an exhaust fan at the top of A1 or A2 as the case may be.

Another possible use for these pumping bore-holes is provided by the following suggestion :—When the shaft is completed, and even before, if arrangements are made underground for the handling of the air-lifts and their rising columns, the twin pumping bores can be used as channels through which the permanent pump rising mains can be passed. This procedure might be objected to on the ground that pumping columns could not be inspected and leaks taken up. If, however, such columns are of oil-well casing with taper threads, and with joints properly made up, there is no danger of any leakages. The weight of such columns can be supported, at each temporary pumping station, by spiders and pipe "slips," or by clamps.

Conclusion.—It will be recognized that, until the procedure outlined above is tried out, no data permitting comparison as to costs and other variables are accessible, so that the approximate figures given hereunder as to the cost of the drilling plant and operations are of little value since it is not possible to show to what extent savings in time, in explosives used, and in other costs of shaft sinking have been effected by these means. As an opinion, the author ventures that from $\frac{1}{4}$ to $\frac{1}{3}$ will be saved in time of the actual shaft sinking which does not, however, include the time spent in the preliminary work of bore-hole drilling. He is also of the opinion that a saving in costs of a like amount would result, but this largely depends on whether there was an available market for the drilling rig and tools at the end of operations. Finally, before dismissing these somewhat revolutionary proposals, as the reader may be tempted to do at first sight, let him remember his own experiences when behind time and how he would have given anything for a dry shaft bottom and to have been able to clear up and hoist the broken ground more expeditiously.

Costs.—As has been remarked above it is only possible to give approximate costs for drilling the bore-holes referred to here, those given hereunder being somewhat conservative. These costs are divided, it will be seen, under two headings, those of capital and operating costs respectively, and they are based on the assumption that a shaft of 1,000 ft. in depth has to be sunk in a granite of medium hardness, in which ground an average drilling speed of $7\frac{1}{2}$ ft. per day of two "tours" (shifts) may be expected for the large bore B and 10 ft. per day for the A1 and A2 holes. The total time estimated for all three bore-holes is 15 months (400 working days) which allows time for erection and skidding of the rig, fishing and such-like delays.

Capital

	£
Portable Cable Tool Drilling Rig complete with mast and shear poles	1,090
12 in. by 12 in. Single Cylinder Steam Drilling Engine	175
Complete Set of Drilling and Fishing Tools	1,100
Wire Lines, Belting, Forge Tool, Portable Steam Hammer, and other accessories	900
	3,265

Operating

	£
150 ft. $24\frac{1}{2}$ in. O.D. casing	460
300 ft. $13\frac{3}{8}$ in. O.D. Casing	300
2,400 ft. $10\frac{3}{4}$ in. O.D. Casing	970
Drilling Wages Drillers (2)	2,700
Drilling Wages Rig Crew	1,500
Oil for Forge, Sundry Stores, etc.	750
Fuel for Power	2,000
	£8,680

Notes.—

(1) In addition to the foregoing the freight charges for the plant and casing from British or American ports to the drilling site would have to be added.

(2) The cost of casing has been included under operating costs, as, when the work was finished, this would have no value whereas the plant used should have a certan value after allowing for depreciation.

(3) It will be noted that the cost of a boiler has not been included under plant cost, the reason being that a suitable boiler will be required for shaft sinking in any case.

(4) The plant of which the cost is given above is capable of drilling to a greater depth than 1,200 ft. but the shear legs could not be used for supporting weights of casing of more than 50,000 lb., and in case of drilling below 1,200 ft. a derrick would have to be substituted for the shear legs.

THE ANALYSIS OF WOLFRAM AND SCHEELITE

By C. STANSFIELD HITCHEN, A.R.C.Sc., D.I.C., B.Sc., Ph.D.

The author gives an account of the impurities likely to occur with tungsten minerals and of methods for their determination.

During the course of some recent research work it became necessary to make a number of complete analyses of wolfram and scheelite. In endeavouring to carry out these analyses certain difficulties were encountered of which but little mention appears to have been made in many of the text-books and which arose chiefly by reason of the chemical peculiarities of tungsten and its influence upon the separation and estimation of other elements present. By a certain amount of experimentation and checking of the already existing methods, a scheme was devised which gave fairly satisfactory results although it should be borne in mind that in dealing with tungsten, tantalum, and columbium some of the most baffling problems in analytical chemistry are encountered and consequently results are perhaps not so accurate as when the commoner elements are being estimated. The lack of uniform opinion as to the best methods to adopt in the quantitative analysis of tungsten-bearing material but serves to indicate the difficulties met with in the course of such work and, needless to say, these are rendered more acute by the presence of tantalum, columbium, tin, and titanium. In this article, therefore, an attempt is made to set down the results of the author's experience in this matter in the hope that they may be of some interest and service to those assayers and analysts who are called upon to make examinations of this kind of material. Although the samples analysed in the present instance consisted of the pure mineral, freed as far as possible from adhering gangue, etc., the methods employed would doubtless prove equally satisfactory in dealing with concentrates.

Before describing the chemical methods for the separation and estimation of the various constituents, the mineralogical characters of wolfram and scheelite together with such relevant matters as their genesis and mineral associates may be briefly considered.

MINERALOGICAL CHARACTERS.—The impurities present in a mineral fall into two classes, namely, those which are chemically combined with the essential elements of the mineral and those which are due to heterogeneity of the material. The first class is well exemplified by isomorphous replacements, etc., whilst regarding the second class of impurity, it should be pointed out that the foreign matter is often very minute and greatly dispersed, in fact the "poikilitic texture" of the petrologist frequently affords an excellent example of such heterogeneity. Such considerations as these, although elementary, are of the greatest importance to the mining geologist, ore-dresser and assayer and they will be found to be well illustrated in the case of the two minerals now under discussion.

Turning first to chemically combined impurities, wolframite is an isomorphous mixture of the tungstates of iron and manganese, ferberite ($FeWO_4$) and hübnerite ($MnWO_4$) respectively. Admixtures of these molecules in all proportions are found in nature and Hess and Schaller therefore proposed the following arbitrary divisions :—

$MnWO_4$ less than 20% . .	Ferberite.
$MnWO_4$ between 20% and 80%	Wolframite.
$MnWO_4$ greater than 80% .	Hübnerite.

With the possible exception of tantalum and columbium, other elements do not

appear to replace the iron, manganese, and tungsten.

Isomorphic replacement is, however, more important in the case of scheelite since this mineral belongs to the " tetragonal tungstate and molybdate " group which also includes powellite ($CaMoO_4$), belonesite ($MgMoO_4$), stolzite ($PbWO_4$), and wulfenite ($PbMoO_4$). Traube [1] has shown that molybdenum is a frequent impurity in scheelite owing to the presence of the powellite molecule and the isomorphic replacements to which this group of minerals is liable is realized by the study of published analyses and also by the occurrence of such mixed members as chillagite $Pb(WMo)O_4$. Magnesium, molybdenum, and lead therefore, are liable to be present as combined impurities although the latter element is not common as such and is distinctly " alien " to scheelite ; copper and cerium have also been reported as impurities, but these are rare.

Impurities due to heterogeneity of the material are, of course, dependent to a great extent upon the particular type of paragenesis which occurs. In his memoir, " The Genesis of Tungsten Ores," [1] Rastall has summarized our knowledge of the occurrence and mineral associates of wolfram and scheelite in many parts of the world and his table shows the associates of cassiterite and wolfram (Table 1).

In other places wolfram and scheelite occur unaccompanied by cassiterite, but can, nevertheless, often be attributed to the influence of granitic intrusions, although in a few cases this is not altogether clear. Where their igneous origin is beyond doubt however, parageneses similar to those

[1] Traube. *Neues Jahrbuch für Mineralogie, u.s.w.* Beil. Bd. 7, 232, 1890.

[1] R. H. Rastall. The genesis of Tungsten Ores. *Geol. Mag.*, 1918, pp. 193, 241, 293, 367.

TABLE 1

	Cornwall.	Brittany (Tourmaline Granite.)	Erzgebirge.	Dakota (Etta Knob).	Greenland (Ivigtut).	Burma-Tavoy, etc.	Malay States (Perak, Selangor).	Alaska (Seward Peninsula).	North Queensland.	Tasmania (Mt. Bischoff).
Wolframite	×	×	×	×	×	×	×	×	×	×
Cassiterite	×	×	×	×	×	×	×	×	×	×
Molybdenite	—	×	—	×	×	×	—	—	×	×
Arsenopyrite	×	×	×	×	—	×	×	×	×	×
Chalcopyrite	×	×	×	—	×	×	×	×	×	×
Galena	×	—	×	×	×	×	—	×	×	—
Blende	×	×	×	—	×	—	—	×	×	—
Pyrite	×	—	—	—	×	—	—	×	—	×
Bismuth (Sulphides, etc.)	—	—	—	×	—	×	—	—	×	—
Uranium	×	—	×	—	—	—	—	—	—	—
Columbite	—	—	—	×	×	×*	—	—	—	—
Tourmaline	×	×	×	×	—	×*	×	×	×	×
Fluorite	×	×	—	—	×	—	×	×	×	×
Topaz	×	—	×	—	—	—	×	×	×	×

* This is incorrect. Neither columbite nor tourmaline occurs in Tavoy. See J. Coggin Brown and A. M. Heron, " The Distribution of Tungsten and Tin in Burma," *Rec. Geol. Surv. India*, Vol. 50, Part II, p. 120. (C.S.H.)

indicated in Table 1 are often found. Phosphorus in the form of apatite frequently accompanies the two minerals in all classes of deposits.

In the United States wolfram is sometimes found in association with telluride and pyritic gold veins as at Denver and Leadville, Colerado, and in Nevada, and in the Black Hills of Dakota there exists an association of wolfram, pyrite, fluorite, gypsum and barytes which appears to be a secondary deposit derived from primary deposits in the underlying strata. At Pitkäranta, in Finland, magnetite, copper ores, and tin-scheelite ores occur intergrown with a great variety of contact-metamorphic calcareous minerals. In the eastern Alps, tungsten is associated with titanium minerals together with molybdenite, beryl, felspar, and apatite whilst at Neudorf, in the Harz, wolfram, accompanied by fluorite, occurs in lead-silver lodes, but both these occurrences are exceptional. Although an account of such associations could be greatly extended, enough has been said to indicate the minerals which commonly accompany wolfram and scheelite and which may at times contaminate either as heterogeneous impurity. Jones [1] noted that wolfram from certain districts invariably carried small amounts of tin and has succeeded in showing that this was due to minute crystals of cassiterite which occurred embedded in the wolframite.

[1] W. R. Jones. "Tin and Tungsten deposits: the economic significance of relative temperatures of formation." *Trans.* Inst. Min. and Met., Vol. XXIX (1920), p. 340 *et seq.*

FIG. 1.—MAGNIFICATION × 50.

Under ordinary climatic conditions wolfram slowly disintegrates into its constituent oxides and recent research by the writer has further shown that this mineral readily reacts with hydrothermal solutions containing dissolved calcium as bicarbonate to form scheelite, iron and manganese being borne away in solution thus:—

$$\begin{matrix} \left\{\begin{matrix} FeWO_4 \\ MnWO_4 \end{matrix}\right. & + & \begin{matrix} CaH_2(CO_3)_2 \\ CaH_2(CO_3)_2 \end{matrix} & = & Ca_2WO_4 & + & \begin{matrix} FeH_2(CO_3)_2 \\ MnH_2(CO_3)_2 \end{matrix} \\ \text{Wolfram} & & & & \text{Scheelite} & & \text{in solution} \end{matrix}$$

Wolframite, occasionally accompanied by a little primary scheelite, formed at a late period in the pegmatitic (pneumatolytic)

TABLE 2

	Wolframite.	*Scheelite.*
Chemically combined impurity.	Columbium ? (Tantalum) ?	Molybdenum Magnesium (Lead) (Copper) (Cerium)
Minerals giving rise to heterogeneous impurity. Mineral associates.	Scheelite Cassiterite Molybdenite Arsenopyrite Chalcopyrite Sphalerite Pyrite Bismuth tellurides and sulphides Columbite (Tantalite) Rutile Tourmaline Topaz Apatite Muscovite Fluorite Quartz (Gangue minerals.)	Wolfram Same as for wolfram but both primary and secondary scheelite is usually fairly "clean" and often free from this type of impurity.

FIG. 2.—MAGNIFICATION × 40.

phase, and during the hydrothermal phases which followed there is evidence that solutions containing silica, calcium, and various sulphides together with dissolved carbon dioxide and hydrogen sulphide, acted upon it, forming scheelite by the metasomatic processes already described. The change first appears along a parting plane in the wolfram crystal, parallel to "*a*" (100) and in microscopic sections is represented by parallel rows of minute tooth-like crystals when the section is cut at right-angles to the parting planes (Fig. 1). As replacement progresses the rows of tooth-like crystals develop (Fig. 2) and so increase in number that finally the wolfram is broken up into a number of angular fragments (Fig. 3). It is also noticed that, in some cases, the scheelite forming these tooth-like crystals can be further replaced by arsenopyrite, pyrite, and chalcopyrite as shown in Fig. 4. These observations help to indicate how heterogeneous impurity originates and there is no doubt that, in general, metasomatism is a very important factor in this connexion. It is interesting to note that under certain conditions, as yet not thoroughly understood (but probably at lower temperature and pressure), a reversal of the above metasomatic process can take place and waters carrying iron and manganese in solution can replace the calcium from scheelite to form wolfram thus giving rise to pseudomorphs of wolfram after scheelite such as occurred at the Maudlin mine, Lanlivery, Cornwall, and which are also reported from Monroe and Trumbull, Connecticut, and other areas.

The impurities likely to occur in wolfram and scheelite are summarized in Table 2.

ANALYTICAL METHODS

WOLFRAM.—From the considerations set out above and from a study of published analyses the following elements may be regarded as common impurities in wolframite in addition to the essential iron, manganese, and tungsten :—

Arsenic, bismuth, calcium, columbium, copper, magnesium, molybdenum, phosphorus, sulphur, tin, zinc, and possibly titanium, together with elements contained in the gangue minerals such as silica, alumina, alkalis, fluorine, and boron.

Before commencing an analysis it is essential that the mineral be reduced to the finest possible powder otherwise incompletely attacked particles will result and thus hinder the work : "sliming" is recommended as a precaution against this.

Two methods of opening up have been advocated, namely, by means of acid and by means of fused alkali, but as each of these methods possesses its own peculiar advantages and disadvantages it will be advisable to consider briefly the various points of each.

The acid treatment consists of boiling the powdered mineral almost to dryness with conc. hydrochloric acid to which a few ccs. of nitric acid have been added, the process then being repeated using conc. hydrochloric acid alone. By this means a greater part of the tungsten (some 95% or more) separates

FIG. 3.—MAGNIFICATION × 25.

FIG. 4.—MAGNIFICATION × 40.

as a dense yellow powder whilst the remainder stays in solution as an acid tungstate,

$$R''WO_4 + 3WO_3 = R''W_4O_{13}$$

—which is hard to decompose by acids. By the addition of cinchonine hydrochloride however, the WO_3 remaining in solution may be quantitatively precipitated. The chlorides of iron, manganese, bismuth, calcium, copper, magnesium, molybdenum and zinc are present in the acid solution whilst columbium and tantalum, together with the gangue minerals, remain as a residue along with the precipitated tungstic oxide. Tin, which mostly occurs as cassiterite embedded in the wolfram, will for the most part remain undissolved, although should any pass into solution, there is danger of loss owing to the volatility of stannic chloride. Arsenic will also pass into solution and there is no possibility of loss provided that it remains in the *arsenic* condition, prolonged boiling with conc. hydrochloric acid alone should, however, be avoided as far as possible, since under these conditions there is danger of reduction with consequent loss of the element as volatile $AsCl_3$.

Alkaline attack entails the fusion of the mineral with sodium carbonate in a platinum crucible or with a mixture of sodium peroxide and sodium carbonate in a nickel crucible. It has been shown, however,[1] that two or three fusions are necessary in order to extract all the tungsten as sodium tungstate. In this treatment iron, manganese,[1] bismuth, calcium, copper, and magnesium remain as a residue whilst tungsten, molybdenum, arsenic, sulphur, phosphorus, and tin pass into solution as sodium salts together with silica derived from the gangue. Sodium columbate and tantalate are only slightly soluble so that, whilst small quantities will pass almost completely into solution, larger amounts will be found partly in solution and partly in the residue and the same is true of alumina derived from micaceous gangue, etc.

Experience shows that, although not without its demerits, the acid method is definitely superior to the alkali fusion. It is true that there is a possibility of losing some tin and arsenic under certain circumstances, but the elements remaining in solution are in the form of chlorides and ordinary analytical methods can be employed for their separation and estimation. Furthermore, gangue can often be estimated as such without breaking it down into silica, alumina, etc. The method of alkaline attack is slow, very laborious, and introduces large quantities of sodium salts into the solution. Moreover, estimation of the tungsten in the solution of sodium tungstate cannot be carried out by precipitation with mercurous nitrate owing to the presence of sulphate, phosphate, and other radicles.

The following detailed procedure is recommended for the acid treatment of wolfram :—

0·8–1·0 gm. of the finely powdered mineral is accurately weighed out into a round-bottomed flask of resistance glass (300–400 ccs. capacity) and about 1–2 ccs. of water added to wet the powder (this is important). A mixture, consisting of 50 ccs. of conc. HCl and 10 ccs. conc. HNO_3 is next added and after judicious shaking of the contents, the flask is clamped at an angle of 45° or so over a gauze and burner, boiling being continued until only 5–7 ccs. remain. During this latter operation "bumping" may occur so that the employment of a long-necked flask is advisable. Most of the acid having been thus expelled, the flask is removed and 20–30 ccs. of water added, followed by NH_4OH, drop by drop, until a slight excess is present. Digestion on a steam bath causes the yellow tungstic oxide to dissolve whilst the brown hydrated oxides and tungstates of iron and manganese are

[1] Vide "Analytical Chemistry." Treadwall and Hall, fifth edition, p. 858.

[1] Provided that alcohol is added to reduce manganate and permanganate.

precipitated. The object of this is to free any unattacked particles of ore from a protective coating of WO_3 and a close inspection serves to indicate if any such particles remain ; the operation also helps to remove some of the acid tungstates from solution, although it cannot do this completely as they are formed again by the further acid treatment. All yellow WO_3 having been thus dissolved, 50 ccs. of conc. HCl are added and the solution again boiled down to small bulk (5–10 ccs.). A further 50 ccs. of conc. HCl are next added and boiling again continued for 10 minutes after which the ore will have been completely attacked, provided that grinding has been sufficiently fine.

After diluting with 150–200 ccs. of water, the flask is placed on the steam bath (1–2 hours) and the precipitated WO_3 allowed to settle. The contents are afterwards filtered whilst hot through a close grained filter paper (Whatman 42 or similar paper) and thoroughly washed with hot dilute HCl (1 : 10) about eight times by decantation and a further two or three times after transferring to the paper. Tungstic acid adhering to the walls of the flask is easily dissolved by warming with a few ccs. of dilute NH_4OH.

By this procedure a preliminary separation is obtained thus :—

Precipitate.	*Filtrate.*
W, Sn, Cb, Ti, Ta, Gangue, together with possibly a trace of iron and molybdenum.	As, Bi, Ca, Cu, Fe, Mn, Mg, Mo, Zn, together with some W as acid tungstate. Also contains P and S.

In Tables 3 and 4 at the end of this article are set out procedures for dealing with the precipitate and filtrate respectively. The scheme is fairly orthodox and although somewhat tedious, it may be relied upon to give satisfactory results in the majority of cases in which tantalum, columbium, and titanium are present in small amount. If, however, these elements occur in quantities exceeding 0·5% great care should be exercised by the operator in dealing with the residue insoluble in ammonia and he should satisfy himself that each treatment has been satisfactory before proceeding to the next. Because of the difficulties which may possibly be encountered in dealing with this insoluble residue it is recommended that it be gently ignited and weighed before further analysis is undertaken and this procedure is essential where the gangue consists of material other than quartz because the percentage of such gangue is calculated by difference after the subtraction of tantalum, columbium, tin, etc., from total weight of the ignited residue. Regarding the filtrate, it should be borne in mind that addition of too much ammonium hydroxide will throw down cinchonine, which is undesirable.

If the quantities of columbium, tantalum, tin, and titanium are small, it is advisable to estimate these constituents on a larger portion of material (3–5 gms.) while the same is true for sulphur and phosphorus, the procedures for which are given below.

Sulphur.—About 2 gms. of the ore are boiled with *aqua regia*, care being taken always to have nitric acid present in some quantity as this hinders the attack on the wolfram yet at the same time reacts with the sulphides ; it is also advisable to add a crystal of potassium chlorate occasionally. After decomposition of the sulphides is complete the acid solution is diluted, filtered, washed with dilute nitric acid and evaporated twice to dryness with HCl to destroy HNO_3. After taking up the residue with dil. HCl and precipitating the iron by means of ammonia, sulphur may be estimated in the filtrate by acidification (HCl) and addition of barium chloride in the usual way.

Phosphorus.—About 2 gms. of the ore are decomposed by boiling first with aqua regia and then with HCl alone. The WO_3 is filtered off, washed with dilute HCl and H_2S passed through the filtrate to free it from arsenic, etc. After filtering off any precipitate, the solution is boiled to remove H_2S, evaporated twice to dryness with nitric acid to remove HCl and the final residue taken up in dil. HNO_3. Phosphorus is estimated in the usual way by addition of molybdate mixture.

Manganese and Iron.—The detection and estimation of small amounts of these elements in residues and precipitates is sometimes desirable during the course of an analysis and the following methods are recommended.

(*a*) Manganese : The residue or precipitate is brought into sulphuric acid solution either by dissolving in dil. H_2SO_4 or by fusion with $KHSO_4$ and subsequent digestion of the melt. Filter if necessary and add about 0·05–0·1 gm. of solid potassium periodate and boil. If manganese be present, even in minute amounts, it will be revealed by the pink colour of permanganate which develops on boiling and it may be estimated colorimetrically. Phosphoric acid may be added to

decolorize iron, but if hydrogen peroxide, or sulphur dioxide, have been employed to aid the solution of manganese these should be completely expelled by boiling before adding the periodate.

(*b*) Iron : This is best detected and estimated colorimetrically in the ferric state by means of thiocyanate in dil. HCl solution according to the usual method.

Tantalum, Columbium, Tin, and Titanium.—These four elements, which sometimes occur in small quantities in wolfram and scheelite, present most baffling problems for the analyst and their separation and estimation have in recent years received the attention of Schoeller and co-workers.[1] These analysts have shown that most of the older methods are unsatisfactory and cannot be relied upon to give even approximate results, they have, however, in a number of cases, been able to devise new and more satisfactory methods. In view of the fact that the old method for separating tin and tungsten from the earth acids by means of ammonia and ammonium sulphide or fusion with sodium carbonate and sulphur has been shown to be wholly unsatisfactory, it seems that the new method, discovered by Schoeller and Jahn,[2] for the separation of tungsten from tantalum and columbium will prove decidedly useful although they do not state that it also effects a separation from tin Unfortunately the writer has not had an opportunity of testing the method in presence of tin although he has used it successfully in separating the earth acids from tungsten. Briefly, the details are as follows :—

The mixed oxides are fused with NaOH in a nickel crucible, gently at first and finally at red heat which may only be continued for half a minute or so. The cold mass is taken up in the crucible with 10 ccs. of half-saturated NaCl solution by digestion on the water bath and the precipitate allowed to stand for a few hours at room temperature. A little filter pulp is stirred in and the precipitate collected on a small, tightly packed pad of filter pulp in a funnel ; it is washed with half-saturated NaCl solution (1 to 1·5 ccs. at a time) until washings scarcely blue litmus paper (8 to 10 times). The pulp containing the precipitate is transferred to a beaker and digested hot with dil. HCl for half an hour. After standing some time it is collected on a filter, washed with NH_4NO_3 solution and ignited and weighed as $(Ta, Cb)_2O_5$.

Tin, which will be in the alkaline filtrate after such a procedure can be determined by any of the usual methods : titanium if present will remain with the precipitate as insoluble sodium titanate which on treatment with HCl will in part dissolve whilst the remainder will be found with the ignited earth acids. Since the amount of the element is likely to be small it may be tested for colorimetrically in both the filtrate and ignited residue by H_2O_2 and deduction made in the latter case if necessary.

The above methods will be found useful in purifying the precipitate of earth acids, titanium, etc., which is thrown down after fusion with K_2CO_3 by HCl and tannin. If, however, larger quantities of these troublesome elements occur the analyst is advised to consult the various papers by Schoeller and others.

Scheelite.—This mineral contains only calcium and tungsten as its essential elements, but molybdenum and magnesium are frequently present in small amounts as combined impurity, whilst, more rarely, copper, lead, and possibly aluminium and rare-earth elements form the impurities. Elements arising from the presence of heterogeneous impurity might be supposed to be the same as in the case of wolfram, since the two minerals are frequently associated in the same paragenetic suite. Experience shows, however, that scheelite is often a fairly "clean" mineral and that when inclusions do occur, they are limited to minerals of hydrothermal origin (e.g. sulphides, carbonates, and certain oxides). This, of course, is not surprising, since scheelite has in many instances been produced from wolfram by hydrothermal metasomatism.

In view of the above facts and from a study of published analyses, the following elements may be regarded as liable to occur in scheelite in addition to calcium and tungsten :—

Molybdenum, magnesium, lead, copper, tin, iron, alumina, manganese, arsenic, bismuth, zinc, phosphorus, sulphur, and occasionally rare earths, together with elements contained in gangue (silica, etc.) and carbon dioxide in the form of carbonates.

The mineral is fairly soft and may be quickly reduced to a powder, sufficiently fine for analysis, by grinding in an agate mortar.

[1] A full list of papers by these chemists is given in a short bibliographical index to this article.

[2] W. R. Schoeller and C. Jahn. *The Analyst*, 1927, p. 504 *et seq.*

With regard to opening up, exactly the same method may be employed as that advocated for wolfram. On addition of ammonium hydroxide after the first acid treatment, the yellow tungstic oxide dissolves but at the same time white hydrated calcium tungstate is precipitated so that it is difficult to discover by inspection whether any unattacked scheelite remains, the addition of this reagent is still to be recommended, however, in view of the fact that it dissolves the tungstic oxide which frequently becomes caked at the bottom of the flask during the boiling with hydrochloric acid. Scheelite is more easily attacked than wolfram so that the treatment recommended for the latter is sufficient to assure complete attack when applied to the former. After filtering off the insoluble tungstic oxide and washing with dilute hydrochloric acid, as already described, a preliminary separation is effected.

Precipitate.	*Filtrate.*
W, possibly carrying a trace of Mo, together with gangue, tin, and possibly titanium. Rarely contains Ta or Cb.	As, Bi, Cu, Fe, Al, Mn, Mg, Ca, Mo, Zn, P, and S together with a little W in solution as acid tungstate.

The *Precipitate* may be treated according to the scheme laid down in Table 3, under wolfram, but its analysis is not likely to prove so tedious. If, on dissolving in ammonia, a perfectly clear solution [1] is obtained, it is an indication that neither columbium, tantalum, nor iron are present in any perceptible amounts and there is then no necessity to allow the solution to stand overnight with ammon. carbonate. Separation from any gangue is effected by filtering through the original filter paper and washing with dilute ammonia : the tungstic oxide in solution as ammonium tungstate can then be estimated by evaporation and ignition to WO_3 as already described.

If, on the other hand, a marked turbidity results after solution of the precipitate in dilute ammonia, this may be due to :—

(1) Suspension of gangue material in a peculiarly fine state of division (rare).

(2) Presence of determinable amounts of Cb and Ta.

(3) Presence of the form of tungstic oxide insoluble in ammonia.

[1] Except for a small quantity of gangue, etc. which usually sinks readily and feels gritty when rubbed with a stirring rod.

(4) Insufficient washing of the precipitated WO_3 with dilute HCl.

If cases (1), (2), and (3) obtain, it will be necessary to follow the full procedure in Table 3, but if case (4) is suspected it is better to start the analysis afresh.

The *Filtrate.*—The same scheme may be employed as in the case of wolfram (Table 4) but some slight modification is necessary because iron and manganese are usually present in much smaller quantities while the amount of calcium, on the other hand, is comparatively great. Phosphorus, if present in stoichiometric excess with regard to the combined amounts of iron and manganese, will tend to throw down a certain amount of calcium with the ammonia precipitate as calcium phosphate. Before proceeding with the analysis of the filtrate therefore, it is necessary to have some knowledge of the quantity of phosphorus present and this may be determined by the method already given. If phosphorus is in excess of iron plus manganese, it will be necessary to add one-and-a-half times the requisite amount of iron as ferric chloride to combine with the phosphorus before precipitating with ammonia. When, however, phosphorus is either absent or present in very small amount and from the colour of the solution iron is seen to be in excess, the addition of ferric chloride is, of course, unnecessary.

The quantitative examination of the filtrate may be carried out according to Table 5, where a suitable procedure is briefly indicated. Practical details of sundry separations and estimations which are of some use in connection with the analysis of scheelite are given below.

Separation of small amounts of Molybdenum from much Tungsten.—In practice the separation of small quantities of molybdenum from much tungsten provides a somewhat difficult analytical problem owing to their chemical similarity. Most text-books give three methods, namely,

(*a*) Method of W. Hommel (digestion with hot conc. H_2SO_4 and subsequent dilution, molybdenum being dissolved).

(*b*) Sublimation method of Péchard (dry HCl gas is passed over the mixed oxides heated at 250–270 C., molybdenum being volatilized as $MoO_3 2HCl$).

(*c*) Method of Rose (H_2S is passed through an acid solution (H_2SO_4) of the two metals, precipitation of WO_3 being prevented by excess of tartaric acid).

All three of these methods have been tested

by the author and from the results it would appear that Hommel's sulphuric acid method is best suited to the present requirements although none are particularly well adapted to the estimation of small quantities of molybdenum. In this and similar cases the spectrograph provides a valuable means of ascertaining the presence or absence of the minor constituent and by employing the newer methods of quantitative spectrography, it is possible to estimate with fair accuracy, the quantity present. In Fig. 5 are reproduced the photographs of spark spectra of solutions containing 1·00, 0·50, 0·10, 0·05, and 0·01% of molybdenum trioxide, 10·00% of tungstic oxide being present at the same time in each solution. The photographs were

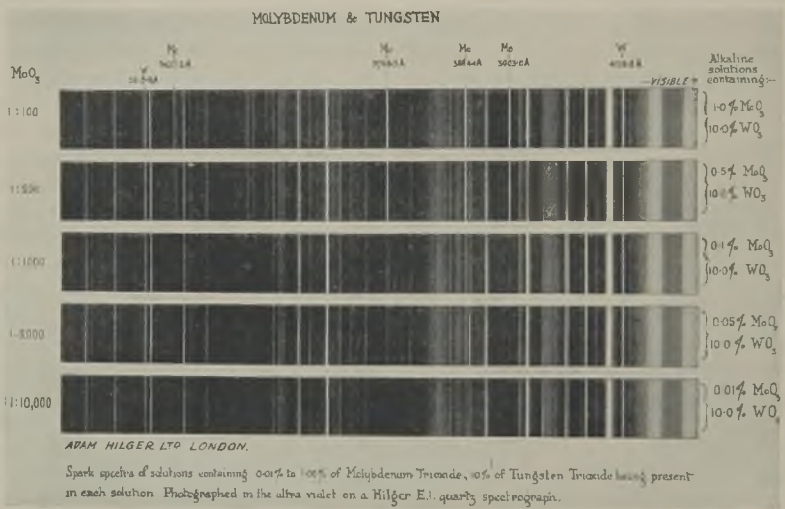

FIG. 5.

the sulphate. For experimental details the original paper should be consulted.

Carbon Dioxide.—This constituent is best determined on a separate portion of material by any of the accepted methods. One of the most satisfactory consists of heating the powdered mineral to boiling with syrupy phosphoric acid, the carbon dioxide evolved being passed first through a bubbler containing syrupy phosphoric acid and then through a calcium chloride tube. Absorption is effected by two tubes containing soda-lime (or "Sofnolite"), but it is advisable to attach another calcium chloride tube to the last soda-lime tube to act as a "trap."

Sulphur and Phosphorus may be determined by the methods given for wolfram.

taken on a "Hilger E 1" quartz spectrograph.

SEPARATION OF SMALL AMOUNTS OF ALUMINIUM (RARE EARTHS AND TITANIUM) FROM IRON.—This separation can be satisfactorily accomplished by phenyl hydrazine according to the method of E. T. Allen,[1] iron having first been reduced to the ferrous state. Under suitable conditions phenyl hydrazine precipitates titanium, zirconium, cerium, and thorium as well as trivalent iron and chromium and aluminium, it does not, however, precipitate the stronger bases such as calcium, magnesium, barium, strontium, and divalent iron and manganese. Beryllium is not precipitated except when present as

[1] E. T. Allen. "Precipitation and Separation by weak Organic Bases." *Journal* Am. Chem. Soc. Vol. 25 (1903), p. 421 *et seq.*

ESTIMATION OF TIN ON WOLFRAM AND SCHEELITE.—Tin is a frequent impurity in both minerals and is almost always present in the form of included specks of cassiterite although in a few cases some may occur as stannite. Cassiterite is practically unattacked by acid treatment and it therefore remains with the residue (consisting of gangue, etc.), after solution of the tungstic oxide in ammonia. Any tungstic oxide of the form insoluble in ammonia should be removed from the residue by gently warming it for a few minutes with 5% caustic soda and filtering, the paper being washed two or three times with hot water and then several times with hot dilute hydrochloric acid. The residue, containing the cassiterite is then dried, gently ignited in a nickel crucible, and finally fused with sodium peroxide for a few

minutes at dull red heat. After cooling, the melt is extracted with water and acidified with hydrochloric acid until there is one-fourth the volume of free acid present. The changes brought about by these operations are as follows :—

Fusion.—

$$SnO_2 + Na_2O_2 = Na_2SnO_3 + O$$

$$TiO_2 + Na_2O_2 = Na_2TiO_3 + O \text{ (or } Na_2Ti_2O_5)$$

$$3Cb(Ta)_2O_5 + Na_2O_2 = Na_8Cb(Ta)_6O_{19} + 2O_2$$
(Hexa-columbate or tantalate)

Acidification.—

$$Na_2SnO_3 + 6HCl = SnCl_4 + 2NaCl + 3H_2O$$
(soluble)

$$Na_2TiO_3 + 6HCl = TiCl_4 + 2NaCl + 3H_2O$$
(sol. in acid)

$$Na_8Cb(Ta)_6O_{19} + 8HCl = 3Cb(Ta)_2O_5 + 8NaCl + 4H_2O \text{ (insoluble)}$$

The solution so obtained contains tin and much of the titanium whilst the hydrated oxides of columbium and tantalum separate as a white gelatinous precipitate which always contains a certain amount of occluded titanium (if present). Allow any such precipitate to settle by standing on the water bath for a half to one hour and filter, washing with dilute hydrochloric acid. If it is known that titanium is absent, tin can be estimated directly on the filtrate by reduction and titration with iodine. If, on the other hand, titanium is present, it will be necessary to dilute the filtrate (until HCl 7–8%) and separate the tin as sulphide by passing hydrogen sulphide. If the solution contains too much acid, tin will, of course, be imperfectly precipitated, but if, on the other hand, the acid is too dilute, titanium may be thrown down. The tin sulphide thus obtained may be filtered off, washed with ammonium nitrate, and roasted to oxide in a porcelain crucible. Results by this direct ignition tend to be a little high owing to the difficulty of washing free from sodium salts but this is almost negligible in view of the small amounts likely to be encountered.

In conclusion, the author gratefully acknowledges his indebtedness to Dr. H. F. Harwood, who kindly read through the manuscript of this article and made a number of helpful suggestions.

References to some of the more recent papers on the analysis of tungsten, tin, molybdenum, niobium, and tantalum will be found in the short bibliography below.

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XVI. Observations on Tartaric Hydrolysis.

XVII. The quantitative precipitation of the Earth Acids and certain other Oxides from Tartrate solution. W. R. Schoeller and H. W. Webb. *Analyst.* 1929, 54, p. 705.

TABLE 3

WOLFRAMITE—Precipitate.

Wash into a beaker and dissolve the yellow WO_3 by warming with dil. NH_4OH—add the ammoniacal washings from the flask. Turbidity is due to impurities. To the solution occupying a volume of 150 c.cs. or so, add 2 gms. of $(NH_4)_2CO_3$ and allow to stand overnight. Filter through the original filter and wash with freshly prepared dil. $(NH_4)_2CO_3$ solution.

P

Ignite gently and weigh.
This residue may contain Cb, Ta, Sn, gangue, and possibly Ti also traces of Fe and W.[1]
If quartz is known to be the only gangue mineral present, SiO_2 may be estimated by evaporation with HF in presence of a few drops of H_2SO_4 and re-weighing after gentle ignition.
Fuse with a small quantity of K_2CO_3 containing a little KNO_3, digest with water on a steam bath and filter; wash with dil. K_2CO_3 solution.

P[2]

Fe usually negligible if washing has been thorough in the preliminary separation. The paper should be ignited and any residue fused up, acidified with H_2SO_4 and tested for Ti colorimetrically by H_2O_2.

F

Contains the bulk of the tungsten.
Evaporate down to dryness in a weighed Pt dish, dry well and ignite gently to decompose the ammonium tungstate and finally at 550–600° C. in the electric furnace. If molybdenum is suspected to be present, the ignition temperature should not exceed 500 C.

F

Add HCl till neutral and then enough of that acid to make a 10% solution. Add a few c.cs. tannin solution, allow to coagulate on the water bath. Wash with dil. NH_4Cl—tannin solution.

P

Principally Cb, Ta, and SiO_2 if not previously removed by evaporation with HF. Sn and Ti may also contaminate the ppt. The separation and estimation of these elements is dealt with in a special paragraph in the text.

F

Test for Sn and Ti.

[1] Unfortunately it so happens that there is a form of WO_3 insoluble in NH_4OH (see Hutchin, the *Analyst,* 1911, 36, p. 398) and a few tenths of a mg. of this sometimes appear as yellow specks in the residue after ignition. If it is thought necessary to estimate such WO_3, the weighed residue is warned for a few minutes with dil. NaOH until the yellow WO_3 dissolves and the solution filtered through a tiny filter paper and washed with dil. $(NH_4)_2CO_3$ solution until free from alkali and re-ignited. W is obtained by difference. NaOH should not be too strong and warming should not be continued too long, otherwise there is a danger of dissolving gangue, etc.

[2] If the gangue contains tourmaline or any other ferruginous mineral, a certain amount of Fe, Al, Ca, and Mg may be found in this residue after fusion with K_2CO_3. This should be rejected. Examination of gangue should be carried out on a separate portion, but such examination is rarely required. For the estimation, etc. of elements occurring in gangue consult " The Analysis of Silicate and Carbonate Rocks " by W. F. Hillebrand.

TABLE 4

WOLFRAMITE—Filtrate

Add 5 c.cs. of cinchonine hydrochloride solution (prepared by dissolving 12·5 gms. of cinchonine in 100 c.cs. 6*N*.HCl) and allow to stand overnight ; tungsten remaining in solution is thrown down as a yellow cinchonine complex. Filter cold by suction, washing 10 times with cold dilute cinchonine HCl solution 10 c.cs. of above cinchonine solution to 1000 c.cs.).

P

Contains remaining WO_3 with a few milligrams of Fe. Ignite, weigh. Dissolve WO_3 in the crucible by warming with a few c.cs. dil. NaOH sol. Dilute, filter, wash with hot water and re-ignite in the same crucible and thus estimate the small amount of Fe. Figure for WO_3 obtained by subtraction of wt. of Fe from total wt.

F

Tests have shown that the presence of cinchonine in solution does not affect the estimation of other elements. Therefore pass H_2S through the warm acid solution, filter—dilute filtrate—again pass H_2S to assure complete precipitation. Wash with hot boiled-out water containing a little NH_4Cl.

P

As, Bi, Cu, Mo [1] Separate and estimate by the usual methods.

dF

Boil off H_2S-oxidize with a few c.cs. HNO_3 and add *slight* excess of NH_4OH. Filter. Re-dissolve ppt. in excess HCl and reprecipitate a second and third time, adding successive filtrates to the first.[2]

P

Fe (free from Mn). Ignite and weigh as Fe_2O_3.

F

Mn, Zn, Ca, Mg. Evaporate to 300 c.cs. add slight excess $(NH_4)_2S$ freshly prepared from carbonate-free NH_4OH. Allow ppt. to settle in a stoppered conical flask overnight. Wash with dil. $(NH_4)_2S$.

P

Mn and Zn (if present). Separate and estimate by the usual methods.

F

Ammonium salts will, by this stage have become large in amount. Destroy them [3] and then proceed thus : to the acid solution occupying a volume of 200 c.cs. add 2 gms. $(NH_4)_2C_2O_4$ and then NH_4OH till alkaline. Filter—dissolve ppt. in dil. HCl and reprecipitate using 0·5–1·0 gm. $(NH_4)_2C_2O_4$. Wash ppt. with dil. (0·1 %) ammon. oxalate in each case.

P

Ignite and weigh Ca as CaO.

F

Combine filtrates acidify with excess HCl [4] and add about 1 gm. sodium phosphate. Neutralize with NH_4OH and then add $\frac{1}{3}$ of the volume of the solution of strong NH_4OH (0·880). Repeat the precipitation. Ignite carefully and weigh Mg as $Mg_2P_2O_7$.

[1] If quantity of Mo is large, precipitation with H_2S must be carried out in a pressure flask.

[2] Three precipitations with NH_4OH in presence of 5 gms. NH_4Cl serves for the perfect separation of Fe and Mn but it is well to dissolve the iron ppt. in fused $KHSO_4$ and test for Mn colorimetrically as described in the text.

[3] Evaporate almost to dryness in a beaker (600–800 c.cs. capacity)—add 100 c.cs. conc. HNO_3 and heat the covered beaker on the water bath until the main action has ceased, then allow to evaporate to dryness ; finally take up with dil. HCl and filter.

[4] NH_4Cl must be present for the proper precipitation of Mg as magnesium ammon. phosphate therefore addition of excess of HCl saves addition of NH_4Cl since the solution is afterwards neutralized by NH_4OH.

TABLE 5

SCHEELITE—Filtrate

Precipitate WO_3 remaining in solution by cinchonine in the cold as described in Table 4.

P — Residual WO_3. Ignite and weigh.

F — Warm the filtrate—pass H_2S—filter from any precipitate (Precipitate I) and collect filtrate in a pressure bottle—allow to cool and then saturate with H_2S—seal the bottle and heat in boiling water for one hour—allow to cool and finally filter from any precipitate, washing with dil. HCl (Precipitate II).

P — (Precipitates I and II united) Pb, Cu, Bi, As, and Mo. Separate and estimate by the usual methods.

F — Boil off H_2S—oxidize with 1–2 c.cs. conc· HNO_3—add $FeCl_3$ if necessary. Precipitate iron, etc. by means of NH_4OH in slight excess and afterwards add slowly 20–30 c.cs. of saturated bromine water together with a few drops of NH_4OH to preserve alkalinity. Filter—dissolve precipitate in HCl and re-precipitate with NH_4OH and bromine water.

P — Al, Fe, Mn, and P.

It is best to determine iron and phosphorus on separate portions of material so that it is only necessary to estimate Al and Mn here. Re-dissolve precipitate in 50–100 c.cs. dil. HCl and precipitate twice with NH_4OH in presence of NH_4Cl, allowing ppt. to settle out by standing on the water-bath.

F — Ca, Mg, etc.

Treat as described in Table 4. It will not usually be necessary to remove ammonium salts and treatment with $(NH_4)_2S$ will only be necessary if Zn is present. In all other cases estimate Ca by double precipitation with ammonium oxalate and Mg by sodium phosphate as described.

P — Estimate Al by pnehyl hydrazine or other suitable method.

Evaporate to fuming with H_2SO_4 and estimate Mn, which is usually small, with potass. periodate.

[1] The filtrate contains most of the cinchonine which will be thrown down as a white flocculent precipitate when excess of ammonia is added for the precipitation of calcium, etc. Since this may prove somewhat troublesome, it is best to reduce the volume of the filtrate to 250–300 ccs. and remove the akaloid before precipitating calcium with ammonium oxalate. This may be done either by, (1) adding ammonia drop by drop until flocculation is complete or, (2) adding tannin solution drop by drop, so as to avoid excess, to the neutral or very slightly acid filtrate. In each case the precipitate is filtered by suction and transferred, unwashed, to a platinum crucible. This is then dried in the oven and afterwards gently ignited. Any residue after ignition is dissolved in dil. HCl and added to the filtrate.

BOOK REVIEWS

Mine Atmospheres. By W. PAYMAN and I. C. F. STATHAM. Cloth, octavo, 327 pages, illustrated. Price 10s. 6d. London: Methuen and Co., Ltd.

The book is divided into two parts. Part I deals with the properties of the constituent gases of the atmosphere and of the air of mines. It then proceeds to discuss the causes and effects of heat and moisture in mines, paying particular attention in a separate chapter to their physiological effects. These chapters are very similar to chapters in the reviewer's own book "Gases, Dust and Heat in Mines," published by Charles Griffin and Co. in 1927. The chapters on the ignition of firedamp, firedamp explosions, and mine dust contain in a readable form information of value, but the reviewer thinks more attention ought to have been paid to the coal dust

explosion tests carried out at the U.S.A. Experimental Station near Pittsburgh. The chapter on respiratory protection is too short and is lacking in practical details to be of any great value.

Part II of the book deals with the detection and analysis of gases constituting mine air. The chapters on mine fires and mine dusts are a useful addition to the book, though the information given concerning the estimation of dust in the air is much too scrappy. The references to Tillard and Ransom on page 77 should read Tillard and Ranson, and on page 104, line 28, the words " per gallon of water " should follow the words " 10 grams." There seems not to be one original thought in the volume, but the authors are evidently quite frank as to their intentions, since they claim to summarize existing knowledge. Other authors have recently covered the ground in a similar manner and the reviewer, therefore, sees no real justification for the publication of the present volume.

K. NEVILLE MOSS.

Seismometer, Auswertung der Diagramme. By Dr. H. P. BERLAGE, Jr. **Geologie der Erdbeben.** By PROF. A. SIEBERG. Handbuch der Geophysik. Vol. iv, Part 2. Paper covers, 388 pages, illustrated. Price 30m. Berlin: Gebrüder Borntraeger.

Part I of this volume dealing with " Earthquake-waves, observations and ground unrest " was reviewed in the June issue of the MAGAZINE. The high standard set by Prof. Gutenberg in the previous part has been well maintained in Part II and it would be difficult to find a more comprehensive and interesting account of the various types of seismoscopes and seismographs. The author in Chapter I traces the development of the instruments from the early Chinese seismoscope introduced by Choko in the year A.D. 136, to the modern recording instruments which are now in continuous use at many observatories, and among other examples refers to the unusual case of the large gasometer of the Batavian gasworks which has occasionally acted as a seismoscope in recording earthquakes at a distance of several hundred kilometers, by suddenly throwing the water from the surrounding trough in high waves over the side. The following chapter is devoted to an excellent discussion of constructional details of instruments, in which various types of registering, astatic and damping devices are described and their essential features and advantages compared. Then follows a useful chapter of 69 pages on the " Theory of Seismographs " in which the general theory of these instruments as developed by Perry and Ayrton, Poincaré, Lippmann, Wiechert, Galitzin, Backlund, Schlüter, Rudzki and Reid is outlined. Under the heading " Description and Manipulation of Seismographs " the author gives information of a practical nature on the setting up of instruments and the determination of their constants, while a further chapter deals with the measurement of the records and the subsequent interpretation.

In the second portion of the book Dr. Sieberg discusses the geological aspect of the subject, and considers both the statics and dynamics of earthquakes, while he also outlines the geological processes to which they might conceivably be due. Detailed consideration is given to the local power of earthquakes, damage to buildings and its prevention, the energy of earthquakes and its source, and also to the different types of earthquakes and tremors.

This book should be read by those who are interested in seismology, whether as pure geophysicists or in connexion with the application of a fascinating science to more practical problems of immediate economic importance, to all of whom it will prove most interesting and informative.

H. SHAW.

☞ 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.

LETTERS TO THE EDITOR

The Education of the Engineer

SIR,—The correspondence to date on this subject when summarized gives three main reasons why the young English-trained mining engineer has been tried in the balance and found wanting, namely :—(1) Unsuitable training and/or personality before going to a school of mines. (2) Unsuitable curriculum at the school of mines. (3) Unadaptability to working conditions after graduation.

(1) Before deciding to take up a mining career the schoolboy should have a good grounding in science, enjoy a good physique, and possess to a certain degree a spirit of wanderlust. However, in all professions there are round pegs in square holes, thus a small proportion of " rejects " in the post-graduate period is inevitable.

(2) The mining school curriculum is probably one of the main factors. American or Dominion trained engineers have the advantage of having modern and large metal-mining concerns close at hand to work in and study whilst they are students, which gives a more practical tone to their technological training. In Great Britain this is available to a smaller degree in Cornwall. It may be said that the course at the Royal School of Mines is too theoretical, whilst that at the School of Metalliferous Mining (Cornwall) is too practical, thus it would appear to be logical that a fusion of the two schools would be advantageous—neither school would have anything to lose, whereas they would each gain by such an amalgamation. The practical side of such subjects as mining, geology, surveying, milling, etc., could be taken in Cornwall, where the school is in a mining centre with a mining atmosphere, and there are also a small mine and millplant belonging to the school, whilst the theoretical side of these subjects and others could be studied in the well-staffed and well-equipped buildings and laboratories of the Royal School. The difficulties in the way of this fusion may be great, but they should not prove insurmountable, so that every effort should be made to this end once it be admitted that it would tend to turn out a better-trained English-schooled graduate then at present available and one better equipped to hold his own with mining graduates from other countries.

(3) Unadaptability to working conditions after graduation is practically always either a question of personality or of bad luck, but the fact that a student on getting his first job often has to start in by a form of manual work, such as sampling, would be materially helped by the fact that a student in Cornwall has to do himself during the course hand and machine drilling, tramming, timbering, sampling, etc., which acts as a good "rough-age" to a diet of attending lectures.

Again, a graduate would be well-advised not to take his first position with exploration companies or on prospects in course of opening up, but first to work in an established up-to-date mining camp and to endeavour to work in its various departments, not staying sufficiently long to get into a rut, but passing to another large operating company. When he considers that he has gained sufficient practical experience and if he sees no openings in his company, then is the time to endeavour to join a company opening up a new field, when, with his training and experience and also a certain amount of ambition, he should make good.

Another point in the education of the engineer is the question of specializing. Mining training in its widest sense covers a host of subjects which are really professions in themselves, such as pure mining, milling, smelting, mechanical engineering, electrical engineering, geology, surveying, and so on, so that a mine school course may turn out a, "jack of all trades and master of none." It would appear advisable, after the first year's general course, that a student should be able to specialize if he so wishes; thus if he aims at mine administration he should specialize in such subjects as mining, geology, engineering, and surveying, but leave out metallurgy altogether beyond its preliminary study in the first year. Again, a metallurgical student should devote hardly any time to pure mining or geological subjects, whilst a student aiming at geology should only lightly skim over metallurgical, mechanical, and electrical engineering and allied subjects. Such specializing in an amalgamated English mining school would tend to turn out graduates better equipped to make their way and to hold their own with graduates from other countries and should be of benefit to the British mining profession in providing better material for making our mine managers, metallurgists, and economic geologists.

G. C. Barnard.

Northern Rhodesia.
August 23.

"Symposium"

Sir,—In a recent review in The Mining Magazine of our "Symposium on the Relation of Oil Accumulation to Structure" we have been roundly and soundly lectured on the meaning of the word "symposium" and our misuse of the word and indirectly the suggestion has been implied that we should consult the dictionary. We have consulted the dictionary and have found: (1) In the Encyclopedia Britannica—"Symposium . . . The term has been applied in modern usage, due to Plato's Symposium, to a collection of opinions of different writers on a given subject." (2) In Webster's New International Dictionary, which is the standard for American geologists—"Symposium 1 . . . 2. A collection of short essays by different authors on a common topic; so called from the appellation given to the philosophical

dialogue by the Greeks ; hence by extension a series of discussions or a more or less formal interchange of views among several treating a common topic."

We American geologists decline the proferred admonition. The reviewer sensed the lack of theory in Volumes I. and II. of this symposium. The plan of this symposium is first to get an extensive collection of descriptive papers giving the facts of the occurrence of oil uncoloured by theory and then to theorize on the facts which have been marshalled. The papers for the more theoretical Volume III. are now being written.

DONALD C. BARTON.

Houston, Texas.
September 15.

NEWS LETTERS

JOHANNESBURG

September 4.

Millions from Minerals.—Up to the close of 1928 the Union's mineral production was valued at nearly 1,411 millions sterling. Towards this huge sum gold contributed more than 1,005 millions, diamonds 284 millions, and coal 80¼ millions, copper coming next with 26 millions. Dr. Kupferburger, mineral technologist to the South African Board of Trade, has published a valuable monograph in which he shows that impressive as the figures mentioned above are, they do not indicate the remarkable possibilities attendant upon the mining of the base metals in which South Africa abounds and the immense benefits which must be derived from their exploitation if conducted on right lines. Dr. Kupferburger has carried out extensive investigations, not only in this country but also in America and Europe, and he leaves no doubt that, with further encouragement from the Government and combined efforts of the producers, the output and disposal of base metals should contribute most materially towards national stability and prosperity when the gold-mining industry begins to decline. Dr. Hans Pirow, Government Mining Engineer, has, in an introductory note, shown how deeply the State is interested. There is, he observes, a wide field for investigation of mineral occurrences, in which co-operative or State action is almost or quite necessary. It may well be considered, he says, whether the time has not come when the activities of the Geological Survey should be extended.

Big Drop in Diamond Output.—During the first half of the current year the mines and diggings of the Union produced 1,615,312 carats of diamonds valued at £4,144,175, and of this output 1,285,408 carats were sold during the period. Compared with the output figures for the first half of 1929 there is a decrease of 287,814 carats in weight and £1,509,914 in value. The average value per carat sold during the period under review was 66s. 1d. as against 79s. 6d. for the first half of 1929. Returns from twelve diamond mines (five in the Orange Free State, six in the Cape and one in the Transvaal) give a total production of 1,136,408 carats, valued at £2,752,864, for the first six months of this year as against 1,143,033 carats, valued at £2,834,232, for the corresponding period of 1929, while the average value per carat at 48s. 5d. was 7s. 10d. higher. The number of diamond mines operating in the first half of 1929 was also twelve. From the alluvial diamond fields of the Union a total of 477,434 carats (£1,389,059) was won during the first half of this year, showing a decrease of 281,282 carats (£429,290), while the value per carat declined from 74s. 3d. to 58s. 2d. Namaqualand's contribution was 55,191 carats (£407,359) as against 161,168 carats (£1,088,401) for the first half of last year. The value per carat of these diamonds, 147s. 7d., compares with 135s. 1d. Sales of Namaqualand stones during the period under review totalled £600,413 as against £2,195,040.

Deep Mining on the Rand.—Some interesting facts concerning deep mining on the Rand are given in the latest Union Year-Book. The continuity of the Witwatersrand as a gold producer, it is stated, depends upon the practicability of mining at great depth and on the extension of the reef in the eastern area, where great possibilities exist favourable to a large gold production. On account of the great strength of the formation and the low rate of increase of temperature with depth it should be possible to mine at greater depths than have been attained in any part of the world. The limits of deep mining are governed by many causes and have been variously estimated at from 6,000 ft. to 10,000 ft. It appears reasonably certain that owing mainly to the low temperature gradient of one degree Fahrenheit per 200 to 250 ft., mining can be carried on to a depth of at least 7,000 ft. where the grade of ore mined is sufficiently high to cover the high cost which must inevitably

prevail at such a depth. (In the Village Deep section of the Robinson Deep mine a depth of over 7,700 ft. has been reached.) The success in working large bodies of comparatively low-grade ore is assigned to the following factors: (*a*) the adaptability of the cyanide process to the Witwatersrand ores; (*b*) uniformity and character of the gold-bearing deposit; (*c*) cheap unskilled labour; (*d*) proximity of coal deposits; (*e*) absence of heavy pumping charges; and (*f*) a good water supply. Actual mining in the main gold-bearing area, says the Year-Book, is greatly assisted by a very strong roof, which supports all excavations made within reason, and which requires a minimum of timbering and other supports in the shallower workings. This excellent roof or hanging-wall has its limits, however, and the enormous amount of ore extracted during the past 30 years is beginning to have effect over large worked-out areas, causing large falls, earth tremors and subsidences, and necessitating extensive sand-filling and other precautions to save existing working and communication ways.

New Lease Areas.—Among the six companies and syndicates which have applied to the Government for lease areas on the farm Vogelfontein No. 62 is the Consolidated Main Reef Mines and Estate, Ltd. The ground offered by the Government on Vogelstruisfontein consists of three adjoining blocks of 933, 354, and 213 claims respectively. The first block comprises an area that was prevously held by the Bantjes Consolidated Mines, while the next occupies ground that belonged to the Vogelstruis Consolidated Deep. The third block, together with a large area in the southern portion of the 933 claims, comprises ground that was held at one time by the General Mining and Finance Corporation north of the joint boundary of Vogelstruisfontein No. 62 and Klipspruit No. 59. On the eastern side the new lease is bounded by the property of the Consolidated Main Reef Mines and Estate and old Aurora West, while on its western edge it adjoins various claim areas registered in the names of the New Steyn Estate, Roodepoort United Main Reef and others. The township of Florida, including the Florida Lake, lies to the north of the eastern portion and Mynpacht No. 549 to the north of the western portion. The mynpacht referred to was formerly the claim area of the old Vogelstruis Estate and G.M. Co., which was voluntarily liquidated in 1922.

Far West Rand in the Limelight.—Increasing attention is being attracted to the Far West Rand by the consistent advance in the monthly profit of the Randfontein Estates. In July this company returned a profit of £37,601, which has not been equalled since June, 1925. The company's report for the quarter ended June 30 last shows that development values have improved, but the most important feature is the flattening of the reef, which will have an important bearing on the life of the mine and future profits. Substantially increased profits are expected by the end of the year. Taking the return for July as a basis and making allowances for capital expenditure, debenture redemption, and interest the company's present earnings represent a return of 10% on its capital of £4,063,553, and it will probably re-enter the list of dividend payers next year. The "life" of the property is unofficially estimated at over 20 years.

Research Work on the Mines.—Dr. Hans Pirow, the Government Mining Engineer, remarks in his annual report that certain mining houses, engineers and managers have from time to time carried out research work in limited directions, but there does not appear to have been any combined effort to reduce, by the aid of scientific investigations and general study of conditions, the risks attendant upon underground working and particularly of accidents due to causes showing a tendency to become more prominent. He suggests that the mine owners might consider the appointment of a body of technical experts to make investigations and carry out experiments in connexion with mining problems involving, in the first place, questions of safety and health and also of economical working. So far as is known, there is nothing in the nature of a mine owners' research organization, representing the industry as a whole, which studies all the problems which arise as the workings extend, and it is believed that the creation of such a body would be amply justified by the results which would be obtained both from a humane as well as from an efficiency point of view.

Postmasburg Manganese.—Two shipments of manganese ore from the Postmasburg fields, totalling over 11,000 tons, have been made by the Manganese Corporation since the beginning of June. The first consignment was sent to Europe and the second, at the time of writing, was on its

way to Japan. Kloof Manganese, Ltd., has recently obtained options over four farms which are in a line north and south, covering the general run of the manganese outcrops discovered for a distance of ten miles. These outcrops are not continuous on the surface, and the first examination disclosed two groups, one in the north and the other in the south, separated by a distance of some eight miles. The first short hole to be drilled in the northern outcrop disclosed ore which on analysis was found to contain 53·6% Mn. The southern outcrops also appear to contain ore of equally high grade.

Interesting Finds in Natal.—It is reported that Rand mining men have acquired properties in the old Nondweni goldfields area in Natal, where interesting discoveries are said to have been made. Some 30 years ago in the old Nondweni mining area, a 40-stamp battery was worked on the Enterprise mine, and a 20-stamp battery on the New Sisters mine, and great hopes were centred in the field, but owing to the refractory nature of the ore and the primitive process of extraction then employed the fields yielded only non-payable results. With modern appliances and improved methods, however, it is anticipated that a larger percentage of gold will be recoverable. A message from Vryheid says that a Rand mining engineer has inspected the properties and in his report confirms the discovery of a lode 20 ft. wide carrying zinc, copper, gold and silver. It is stated that in the old days the zinc was mistaken for iron.

BRISBANE

August 18.

Mount Isa Activities.—In April last the sinking of the haulage and the man-and-supply shafts at the Mount Isa mines was suspended, pending the installation of more pumping power to cope with excessive water. Since then additional boilers and compressors, having a total capacity of 2,000 cu. ft. of free air per minute, have been provided at these shafts, and latest reports from the field indicate that the sinking of the shafts should have been resumed by this time. At the supply shaft the erection of a 750 h.p. Diesel-electric plant is in progress and when this is finished driving will be resumed at the 366 ft. level from this shaft. In the meantime, development work has been proceeding apace. Lawlor's shaft, on the Rio Grande lode, is being deepened; rises are being put up at Doherty's shaft, on the Black Rock lode; and levels are being pushed ahead on the Black Star, in Davidson's shaft. Likewise, on the surface construction is being carried on rapidly. It is expected that the first units of the power-house will be ready for operation in November, but that the first unit of the smelter will not be finished till the end of the year. In a four-weekly period, when 955 ft. of diamond drilling was done on the Black Star, core assays from 9B bore-hole showed the ore-body, which was cut at 822 ft., incline depth, continued to 992 ft. A field report states that the drill passed out of the Black Star lode at the latter depth, and was continued down to 1,156 ft. Assay cores showed—from 1,047 ft. to 1,057 ft., 7% lead, 12·5% zinc, and 2 oz. silver per ton; and from 1,117 ft. to 1,122 ft., 12·2% lead, 16% zinc, and 8·8 oz. silver. These veins correspond to the footwall veins met in previous bore-holes. In bore-hole 13A available assays to June 14 were—from 561 to 581 ft., 12·1% lead, and 17·2% zinc; and from 616 ft. to 621 ft., 17·2% lead, and 6·4% zinc.

Australian Mineral Output.—The following table, compiled from preliminary figures, shows the value of minerals produced in the different States of the Australian Commonwealth for the years 1928 and 1929 respectively:—

	1928.	1929.
New South Wales	£12,600,668	£10,114,000
Victoria	1,098,691	1,116,083
Queensland	1,386,016	1,707,179
South Australia	1,032,952	(*a*)
West Australia	2,128,109	2,082,110
Tasmania	1,335,571	1,433.303
Northern Territory	14,627	7,796
Total	£19,596,634	(*a*)

(*a*) Not yet available.

The Sardine Tin Mine.—The Sardine, for the past ten years the principal tin mine on the Kangaroo Hills field, North Queensland, has been compelled, for the second time, to close down—temporarily it is hoped—owing to the low market value of tin. Last year the mine was put out of commission in April, and resumed operations in September. The directors state that there are many parts of the mine that justify further prospecting, but, owing to the very low market for the metal now ruling, they have considered it advisable to cease work for six months, by the end of which term they expect to see

a fair rise in prices, and possibly a decrease in wages. The dividends paid by the company total 7s. 9d. for each 5s. share, but no distribution has been made for the past four years.

The New Mount Morgan.—Mount Morgan Ltd., the new company which now owns the Mount Morgan mine, so famous for many years as a producer of gold and copper, has finished the duplication of its complete oil plant, which makes a total of 400 h.p. for the Linda power-house, and which has been in commission for some time. There are, too, being erected new precipitating vats, which will be an improvement on the old ones, particularly in cleaning-up operations. The water in the mine is still about 5 ft. in the 650 ft. level. A Melbourne man has taken from the company a tribute for collecting ores from the various dumps on the lease. The new company since its inception has continuously carried on the work, previously in vogue, of recovering copper by precipitation from the mine waters. Under the new regime there has been obtained copper to the value, approximately, of £600, gold worth a like amount, and 44 oz. of silver.

The Mount Coolon Enterprise.—As was announced in the August issue of the MAGAZINE, Gold Mines of Australia, Ltd., has exercised its option over the Mount Coolon mine. The Mount Coolon field is inland south-westerly from the northern port of Bowen, 130 miles distant, and is 82 miles west of the nearest railhead—that at Collinsville (the Bowen River coalfield), which is 52 miles by rail south-west of Bowen. It is situated on a direct line between the old goldfields of Clermont in the Central district and Charters Towers in the north, being 120 miles from the former and 150 miles from the latter. The newly appointed general manager (Mr. J. C. Coldham) is now at Mount Coolon, and work has been commenced in the way of substituting new methods for the old in the shape of mining and crushing plants.

Shale Oil.—A company, called the Shale Oil Investigations, Pty. Ltd. has been registered in Melbourne. The object in view is thoroughly to investigate the production of fuel and lubricating oils from shale for the use, primarily, of the Broken Hill mines. The capital of the company is £100,000. A quarter share in the enterprise is held by each of four Barrier companies, which together have bought the long-idle distillation and oil refining plant at Newnes, in the Wolgan Valley, New South Wales, together with 32 miles of railway, and have taken an option over leases of 10,000 acres of oil-shale land in that district. Should the results of investigation prove commercially favourable, a big operative company is to be formed. This project is regarded as an important development in the Australian shale-oil industry that is expected to lead to its revival in a large way.

Broken Hill Mines.—Six of the Broken Hill mines have notified unions whose members are employed along the line of lode of the termination of existing agreements as from three months after August 1. The companies state that they regret that the critical position of the mining industry renders this action necessary. They hope that it will be possible at an early date to enter into negotiations with the different unions with a view to arrive at a working arrangement mutually satisfactory to all parties, and at the same time ensure the future of the industry. Agreements between the Barrier Industrial and Iron Trades Councils and the four big companies, which were signed in April, 1925, expired on December 31, 1927. Under the conditions of those agreements work has since been carried on smoothly, with an agreement that three months' notice of termination can be given by either side. The companies have now given such a notice, the date of termination being October 31. In view of the weakness of the metal market, chiefly as the result of over-production, those associated with the industry are hopeful that the parties will arrive at a satisfactory new arrangement. The production of zinc concentrates by the North Broken Hill, Ltd. ceased on July 19, and the zincy tailings are now being used for filling underground. This step is attributed to the low price of spelter. The company, with Broken Hill South, and the Zinc Corporation, recently entered into a contract to dispose of their zinc concentrates to the Electrolytic Zinc Company of Australasia and the Imperial Smelting Corporation. The contract, it was stated, would provide for closer association between the parties in the production and treatment of zinc concentrates.

New Guinea Gold Mining.—The Bulolo Gold Dredging, Ltd., incorporated in February last to operate in New Guinea, has forwarded to Salamoa a 10-ton crane, a caterpillar tractor, and other equipment. An immediate start is to be made in providing

transport facilities by means of barges between Salamoa and Lac, and a contract has been let for the construction of two dredges. An aerodrome is being prepared on the Bulolo field, suitable for use by large planes, which are expected to be delivered at Salamoa by the end of November.

IPOH

September 5.

The tin price having remained fairly stable during August, hopes have been expressed that the bottom of the depression had been reached and that some slight recovery might soon be evident. Unfortunately the consumption recorded for the month of August is only 9,900 tons, showing a decline of 1,600 tons from the high total of 11,500 tons in July. The F.M.S. output for July showed a decrease of 65 tons compared with the June output, and a decrease of 277 tons compared with the corresponding month last year, but such small differences can hardly influence the market, which cannot be expected to react permanently until stocks have been largely reduced. Sales of tin (metal) in Singapore show a material reduction as follows :—May 4,775 tons, June 4,350, July 4,525, and August 3,250. The last figure seems to indicate that restriction is affecting that market, and if other markets are similarly affected in the near future the effect on stocks will soon be considerable.

Restriction.—While there can be no doubt as to the economic folly of selling such a product as tin ore below a fair average price, especially since the ore reserves of most producers however large are distinctly limited, it is clear that the declared policies of stoppage for a time and restriction thereafter do not equally affect all concerned. A period of severe restriction must be contemplated, though its immediate effect may be to cause hardship in particular cases, for there must be some who cannot easily afford to renounce their present income from tin-producing companies in order to enjoy enhanced values in the future. The greatest good to the greatest number must be given due priority and hardship to a few must not be allowed to outweigh lasting benefit to many and to the industry as a whole. For conservation of tin resources the Siamese Government has suspended the issue of Exclusive Prospecting Licences, and in certain localities this decision has been interpreted to mean that existing E.P.L.s cannot be renewed, but existing E.P.L.s were taken out carrying certain rights of renewal under conditions over a period, and it would appear that there must be some local misinterpretation of the effect of the recent decision.

Effects of Slump Conditions.—There have already been several cases of locally owned and of other mines closed down in the Peninsula, and there is a considerable fall in the strength of labour employed since the beginning of the year ; but during July and August there has been only a small reduction in the labour force, and conditions at the moment appear to be fairly stable.

Electrification.—It is unfortunate that completion of the main undertakings of the Perak River Hydro-Electric Power Co. has coincided with such depressed conditions in the mining industry ; but on the other hand, by emphasising the need of economies and of more efficient methods, the present depression is likely to hasten modernization and improvements in many directions, and will tend to bring the resources and advantages of electrical equipment urgently to the notice of miners. The comparative efficiency of steam or oil engines and of electric motors for driving gravel- and sand-pumps is a detail of the subject of mine equipment worth close attention. It must be premised that pumps are uniformly fed to their full capacity with as high a proportion of solids as the conditions allow. If this is taken as fairly attained the comparison of performance will show that the motor-driven pump has kept more uniform speed, and constant speed means constant maximum yardage on the above premises. A useful check on comparative uniformity of running would be given by a revolution counter on the pump shaft. If the supply of material to the pump is not uniform, comparison of revolutions would not give evidence as to comparative yardage. The useful work done must be taken into account in any such comparisons. A new, closely graduated, revised tariff for electrical energy has been effective since May 1, and the Power Company have been giving technical advice and some much needed supervision to certain consumers whose methods were depriving themselves of advantages they had expected.

Mining Titles.—The very small portions into which the most active mining districts are subdivided are an inheritance from

former conditions and now affect operations adversely in a variety of ways. Consolidations of such small portions is often delayed and hindered by the number of parties holding interest in even one small block, each successive sublessor having right to a percentage of tribute. So long as the land is being worked within the provisions of the Mining Enactment, cancellation of what are really parasitic rights cannot be demanded. It might assist to clear the field of this obstruction if every holder of a title to mining land were under obligation either to work it himself or to be a subscriber of a definite minimum proportion of capital in the mining "Kongsi" or Company, or must surrender his title within a certain period to the actual miners. The existence of even two or three small holdings of this kind may seriously prejudice the economic working of important surrounding areas.

VANCOUVER

September 9.

Consolidated Mining and Smelting Company.—After the payment of the usual dividends and bonuses, aggregating $3,187,810, covering operations for the first half of this year, the Consolidated Mining and Smelting Company of Canada's half yearly statement that the gross earnings of the company totalled $3,598,089 and that, after deducting $470,377 which has been spent on exploration and development of new properties, and writing off $1,226,204 for depreciation, $357,638 for depletion, and $182,474 for taxes, the net earnings for the period totalled only $1,361,397 comes as rather a disappointment. In the corresponding period of 1929 the gross earnings were $7,433,331, and the net earnings $4,559,944. The directors attribute the sharp drop in earnings entirely to the depreciation of metals. During the first half of this year production was well maintained and operating costs were reduced. There was no unsold lead at the end of the period but there was a considerable accumulation of unsold zinc. This is being carried at cost, which is below current market prices. The directors hold out no hope of any appreciation in the price of silver, but, following meetings of world zinc producers at Ostend and London, which the company's president, Mr. J. J. Warren, attended, when an agreement was reached as to the principle to be applied to adjust world production to world consumption, they do expect an improvement in the price of zinc, though the full effect of the agreement must not be expected until the accumulated stocks of the metal have been absorbed. Considering the resources of the company and the large contingent reserve that has been accumulated during years of prosperity to tide over such periods as the world now is passing through, which the directors consider to be only temporary, they recommend the continuation of the usual dividends and bonuses, unless, of course, metal prices should become completely demoralized, a condition that they think unlikely. Moreover, they remind the shareholders, the sums written off for depreciation and depletion do not affect the cash position of the company.

Good progress is being made with the construction of the new fertilizer plant, and the production of triple superphosphate will begin early in 1931. Excellent results are being obtained from the large scale experiments with the fertilizer in the western prairies. Exploration is being carried on vigorously, with promising results. A pilot mill of 100 tons daily capacity is being erected at the Big Missouri mine; the ore bins will have a capacity of 600 tons. New ore is being opened up at the Coast Copper property, but, owing to the drop in copper prices, a mill will not be erected there this year. Development continues favourably at the Northern Lead Zinc Company's property, in which Consolidated holds a large interest, at Great Slave Lake. Ore reserves at the Sullivan mine have been materially increased. The company has acquired a substantial interest in the Sherritt Gordon Company, and Mr. W. M. Archibald, vice-president in charge of mines for Consolidated, will go on the board of that company. The Ontario Refinery Company's plant has started to refine copper, and blister copper from Anyox, which for some time has been refined at Tadanac, is now being sent to Ontario.

Several years of research, first in the laboratory and latterly in pilot plants at Tadanac, has culminated in the putting into operation on August 29 of a plant to recover 100 tons of zinc daily from lead-furnace slag. The slag is carried in nine-ton pots by a travelling crane from the lead furnaces to a rectangular, water-jacketed converter, situated on the bank of the Columbia River. The charge consists of 40 tons. Air carrying pulverized coal is blown into the molten slag, rapidly raises the

temperature, reduces zinc and lead to metal, volatilizes them, and the excess of air oxidizes them in the upper part of the converter. The fume is drawn by a duplex fan out of the converter and through settling chambers, tubular boilers, and boiler-feed heaters to a Draco baghouse. Provision is made for collecting fume that falls out along the line of route in hoppers. The oxides are automatically shaken from the bags and are carried in a screw conveyor to a 40-ton bin, whence they are loaded into railway hopper-cars that carry them to the new leaching plant, where the zinc is removed as sulphate and the residue is returned to the lead furnaces for the recovery of lead and silver. The zinc sulphate is purified by treatment with atomized zinc and is pumped to the storage tanks at the electrolytic zinc plant. The plant has been designed not only to recover the 15 to 20% of zinc and small amount of lead in the slag, which up to now has been a waste product, but to utilize as much as possible of the heat generated in the operation. The boilers through which the fume passes generate 1570 h.p. Besides recovering metal from the freshly made slag, the plant will be used to treat a large quantity of old slag that has been accumulated. The complete plant is said to have cost $2,500,000.

The Consolidated company is dismantling some of the machinery in the St. Eugene mill, at Moyie, and is shipping it to the Big Missouri mine, in the Portland Canal district. The St. Eugene mill was built several years ago to treat a large accumulation of tailing from the old St. Eugene mill, which was burnt in 1916. The tailing, which was stored in Moyie Lake, has been cleaned up and a large tonnage of low-grade dump ore from the Sullivan mine also has been treated. The mill has been idle for several months.

The Kootenays.—The annual report of Galena Farm Consolidated Mines, in which the Victoria Syndicate, of London, is interested, shows that work was started on April 1, 1929, and up to February 28, 1930, when work was suspended on account of low metal prices, 5,575 ft. of driving, 506 ft. of crosscutting, 663 ft. of rising, 87 ft. sinking, and 1,387 ft. of diamond drilling was done. The chief item on the programme was the driving of No. 10 tunnel 6,000 ft., to give an outlet from the Hewitt mine to the Galena Farm mill, on Slocan Lake, and to prospect the shear zone along the route. This work was not completed. The Cunningham high-grade ore-body, which had been worked on No. 9 level, was cut by the tunnel and followed for 200 ft., but no productive mining was done on the shoot, as until the tunnel was finished ore could not be taken to the mill. The remodelling of the mill was completed in October, 1929, and, pending the completion of the tunnel, was used to treat tailing from the old mill. Concentrates derived from the treatment of 9,800 tons of tailing brought a smelter return of $12,950. A 9,000 ft. aerial tramway was erected and a 250 h.p. Petter engine installed. Pending improvement in metal prices, part of the upper workings of the mine have been let to tributers.

True Fissure Mining and Milling Company is erecting a 100-ton concentrator on the shore of Trout Lake to treat silver-lead-zinc ore from its mine near Ferguson. A power plant recently has been completed and a saw mill installed to cut lumber for mill and camp buildings. The property has been under seasonal development by hand drilling for about 10 years.

Calgary and Kootenay capitalists have formed a company to take over and operate the California mine near Nelson and development has been started The consideration given for the property was $50,000, of which $20,000 was in shares in the new company. A considerable amount of shallow exploration has been done on four of the nine claims that make up the group, and some 2,000 tons of ore that has been shipped is reported to have brought an average smelter return of $34 in gold and 3 oz. of silver per ton.

Base Metals Mining Corporation, which is operating the Monarch and Kicking Horse mines, near Field, on the Canadian Pacific Railway, reports that during June it milled 7,875 tons of ore averaging 3 oz. silver per ton, 8·3% lead, and 12·7% zinc, and made a gross operating profit of $39,643, and a net profit of $17,219. The ore deposits in the Monarch mine are large and can be mined cheaply.

The Provincial Water Board has granted all rights on the Pend d'Oreille River in British Columbia territory to the West Kootenay Power and Light Company, Consolidated Mining and Smelting Co.'s power subsidiary. The company expects to develop 275,000 to 325,000 h.p. on the river, but, as this will take three or four years to complete and power is urgently needed at the smelter, construction work is being concentrated on the new 30,000 h.p. plant at the Kootenay River, two miles above the

Upper Bonnington Falls station. It is expected that this plant will be brought into service by the low water period of the winter of 1931–32.

Copper Producers' Profits.—Granby Consolidated Mining, Smelting and Power Company made a profit of $1,106,485 during the first half of this year, as compared with a profit of $2,105,177 during the first half of 1929. The two periods are not strictly comparable, however, as in co-operation with other copper producers the company appreciably curtailed output during the first part of this year. The Howe Sound Company, which operates the Britannia copper mine in British Columbia and two silver-lead-zinc mines in Mexico, made a profit of $1,182,290 in the first half of this year, as compared with one of $2,018,967 in the first half of last. The company increased output at the Britannia mine, but decreased it at the Mexican mines. The Granby's figures are after all expenses and local taxes have been deducted, but before allowance for depreciation, depletion, and Federal taxes. Howe Sound's figures are after allowing for all expenses and all taxes and depreciation but before depletion allowance.

TORONTO

September 19.

Porcupine.—The production of bullion during August from seven mines of the Porcupine area amounted to $1,260,860, as compared with $1,467,220 for July. Hollinger Consolidated maintains its position as head of the list. The mill has for some time been handling an average of 4,500 tons daily, the grade of ore handled this year having averaged between $6·50 and $6·60 per ton, with a recovery of approximately $6·25. The cost of operation has recently been somewhat reduced. Construction of the Dome mill has been advanced and it is expected to be ready to go into operation by November 1. The mill is designed to handle 1,500 tons of ore per day, and to secure a particularly high percentage of recovery. Underground development has increased the ore reserves sufficiently to give the mill a four years' supply of ore. A winze is now being put down on a vein which has been opened up on the 1,200 ft. level. McIntyre Porcupine has encountered an unusually wide mineralized body on the 3,800 ft. level. The gold occurs across a width of from 50 to 75 ft., some of the ore being remarkably rich, carrying upwards of $40 to the ton, with indications of a large tonnage of normal grade. An uncommon feature is that the new development is in massive porphyry, somewhat different from the regular occurrence of ore in the greenstone formation. A preliminary estimate of the production of the Vipond Consolidated for the first eight months of the year gives the total at approximately $622,000 from the treatment of 76,000 tons of ore. Underground development on the veins coming in from the Hollinger on the 400 and 500 ft. levels continues to yield good results. The mill is operating at a rate of about 9,500 tons monthly. At the Canusa, development work has been making steady progress, and the vein on which the shaft is being put down shows good values. A vein opened on the surface shows free gold and a crosscut is being run towards its downward continuation on the 300 ft. level. The Bennett-Pecaud has purchased the Hughes property and a shaft has been sunk, two levels established, and driving is being carried out on a vein showing good gold content.

Kirkland Lake.—The Kirkland Lake gold mines produced in August bullion to the value of $1,397,780, as compared with the July output of $1,365,743. The Lake Shore has made provisions for back filling on a very extensive scale, as the programme of expansion now being carried out will in a short time increase the volume of ore taken out to 700,000 tons annually. Production during the company's fiscal year terminating June 30 last amounted to $6,576,781 from 467,648 tons of ore, an average grade of $14·06 per ton for the year. The Teck-Hughes is making good progress with the construction of the addition to its mill which is expected to be completed by November 1 and which will bring the total milling capacity up to 1,250 tons per day. The new shaft has nearly reached its objective of 3,600 ft. When the shaft is completed lateral work will be started on several levels to supply ore for the mill. At the Wright Hargreaves the recent mill addition is operating efficiently and the management is preparing to instal additional equipment including a crusher and air compressor. During the first six months of the current year the output was valued at $1,117,386 from the treatment of 100,730 tons of ore of an average grade of $11·09 per ton. Important ore-bodies are being

opened up at depth. Exploration by diamond drilling at the Tough Oakes, now under option to the Bunker Hill Extension, is meeting with encouraging results, the drill having cut 50 in. of high grade ore. Other drill holes have proved the extension of the deposit. The new equipment recently installed in the mill at the Kirkland Lake gold mine is resulting in better recovery. While production is being held at about 150 tons daily, difficulty is anticipated in holding mill head at around $12. Development has been carried below the 4,000 ft. level, with rich ore indicated on the lower horizons. The mill of the Barry Hollinger, in the Boston Creek section of the camp is handling over 80 tons of ore daily, the output for the first eight months of the year amounting to over $138,000. The vein, where cut on the 1,750 ft. level, carried commercial ore across drive widths and lateral work is under way to determine the size and value of the shoot. A winze will be put down to the 2,000 ft. level with a view to deep development.

Sudbury District.—The first half of the new concentrating plant of the International company has gone into operation. This plant, which is the largest mining mill in Canada, has a capacity of 8,000 tons daily, and is built in two sections of 8 Marcy rod-mills each, with classifiers, filters, and flotation units. Some of the higher grade copper ore will be separated by flotation and sent direct to the smelter. The second section is expected to be completed in December. The company has contracted for the erection of a new refinery unit for Copper Cliff, at a cost of approximately $2,000,000, at which the first stages of the refinery process now conducted at Port Colbourne will be carried out. This step is in pursuance of the policy of gradually concentrating all operations in the vicinity of the smelter. At the Errington Mine of the Treadwell Yukon, a cross-cut has been driven for 900 ft. on the 1,500 ft. level to reach the mineralized zone indicated by diamond drilling. Should the result equal expectations the company plans considerably to increase their metallurgical equipment, in order to bring its capacity up to 2,000 tons per day. The Travers Copper Syndicate, a new company, will develop a copper property in Porter township, where exploration has disclosed a mineralized zone yielding high assays of copper. The Consolidated Mining and Smelting Company has closed an option on a group of 30 claims in Montgomery township known as the Beaver Mountain property, on which some showings of massive copper have been revealed. A crew of men is engaged in exploration work preparatory to a diamond drilling campaign.

Patricia District.—The Howey gold mine is steadily maintaining production, the mill treating about 500 tons of ore per day, but the grade of the ore is disappointingly low. The output for August is given as approximately $55,000, with a recovery averaging about $3·80 per ton. The Central Patricia has completed the programme of work laid out last autumn, and the mine has closed down temporarily. A new goldfield at Makokibatau Lake on the Albany River is attracting many prospectors.

Manitoba.—The concentrating plant of the Flin Flon mine of the Hudson Bay Mining and Smelting Company has gone into operation and at present treating 500 tons of ore per day which will be gradually increased. The concentrates are being stored pending the completion of the smelter which is expected to be ready for operation by about the middle of October. When all the units are working, the company plans to handle a tonnage of 3,000 tons a day. Most of the ore now treated is being taken from open pits. Construction of the mill of the Sherritt-Gordon is going forward according to schedule, and if this rate is maintained it will be ready for operation by the middle of January. Mining operations are being actively conducted and additional ore is being blocked out. At the San Antonia in Central Manitoba good gold values have been encountered on the three lower levels and the erection of a 100 ton mill is under consideration. A discovery of rare minerals, including beryl, amblygonite, spodumene, and lepidolite, has been made at Herb Lake.

Mineral Production of Canada.—The mineral production of Canada for the first six months of the year was valued at $116,360,409 as compared with $123,702,334 for the corresponding period of 1929. Lessened coal production, lower output of asbestos, and the falling off of metal prices, were the principal cause of the decline. The metallic output was valued at $75,031,606, as compared with $75,476,321, but, in quantity, nearly all the metals exceeded the output for the first months of 1929.

CAMBORNE

October 6.

Results of Low Prices of Tin.—The continuous further fall in the price of tin during the last few weeks, to £124 per ton at the time of writing, naturally makes the position of the Cornish tin industry more serious. Since prices first began to give way seven producing mines have ceased to work, viz., Tresavean, Dolcoath, Wheal Reeth, Parc-an-Chy, Wheal Kitty, Polhigey and Levant. With tin metal at £200 to £250 per ton, at least five of these mines could yield satisfactory profits, and there is no doubt that a resumption of work would take place in Dolcoath, Wheal Kitty, Polhigey and Levant, if a recovery of trade brought the price of tin once more within the limits indicated, provided that the existing financial encumbrances in these mines could be removed.

Recovery of the Industry since 1922.—During the last serious depression, of 1922, operations were suspended in all Cornish tin mines. The steady recovery of the industry since that date may be illustrated by the following figures of Cornish production of black tin :—

1923	1,758 tons
1924	3,523 ,,
1925	4,004 ,,
1926	3,846 ,,
1927	4,148 ,,
1928	4,844 ,,
1929	5,640 ,,

Notwithstanding the cessation of operations in the mines enumerated above, the Cornish output of black tin for the first eight months of the current year is fully 2,600 tons. Assuming that the mines which are still producing maintain their present rate of production for the remaining four months of the year, the total output for 1930 will be very little, if anything, short of 4,000 tons. East Pool and Agar, South Crofty, Geevor, and Jantar are the chief producing mines remaining at work.

Levant.—The suspension of operations at Levant, the latest mine to join the suspension list, leaves Geevor the only active mine in the western parishes. Levant has a marvellous history. Following early operations, of which records do not exist, the original cost-book company was formed in 1820, in 20 shares of £20 each. A second cost-book company followed later, the two companies in the course of 103 years of uninterrupted operations having divided large profits, and produced :—

Copper ores	136,562 tons	realizing	£859,303
Black tin	21,989 ,,	,,	1,531,977
Crude arsenic	3,800 ,,	,,	32,657
		Up to 1923 total value	£2,423,937

At the end of a century's work the existing limited liability company took over from the cost-book company on January 1, 1920, the nominal capital being £160,000 in 320,000 shares of 10s. each, of which 162,285 are issued and fully paid. The chief mine buildings are perched on the cliffs, and the workings extend more than 1½ miles underneath the sea. In spite of this submarine position of the principal workings, the mine is one of the driest in Cornwall, and pumping charges have always been unusually light. The man-engine at Levant was the last of its kind in Cornwall. Its end was a sad one. An accidental breakage, caused the "rod" to separate at surface, resulting in the deaths of 31 men, in October, 1919.

Wolfram.—For 20 years ending 1922, the Cornish output of wolfram averaged 222 tons a year, and much of it realized during the war from £150 to £175 per ton. For the last seven years, to 1929, the Cornish output has averaged 22 tons per year only. In 1916–17 there were 14 producers of wolfram, but only three of them produced any considerable quantity, viz., East Pool, South Crofty and Carn Brea (since closed). At present East Pool and South Crofty produce only negligible quantities of wolfram. Indeed, apart from the produce of the only wolfram mine in Cornwall, Great Western Ores, Ltd., at Castle-an-Dinas, near St. Columb, owned by South Crofty, scarcely any wolfram is being raised at the present time.

Visit of British Association.—The geological section of the British Association, which this year held its annual meeting at Bristol, paid a visit to Cornwall on September 10 for several days. Mr. E. H. Davison, Lecturer in Geology at the Camborne School of Mines, was in charge of the party, which included a number of eminent geologists from this country, its colonies, and from foreign countries. The first day, September 11, was devoted to a visit to the Polhigey mine and visits were also paid to quarries at Long Downs and Ponsanooth. In the evening the company dined in Camborne as guests of the Cornish Institute of Engineers, when speeches were made by Mr. William Hosking, Mr. H. B. Maufe, Director of the

Geological Survey of Southern Rhodesia, and Professor Barber of Pekin University. Mr. Thomas Berryman presided and Mr. William Thomas, one of the secretaries, was also prevailed upon to speak. Mr. Maurice Gregory, in the course of the evening, read a few notes on his recent visit to Abyssinia. The next day East Pool and Agar was visited, several going underground, and in the afternoon, having been guests of the firm to lunch, a tour of Messrs. Holman Bros'. works was made. On Saturday and Sunday open-air excursions to the Lands End granite area and to Wheal Fortune, Porthleven and Godolphin areas respectively were much appreciated. Monday was devoted to a visit to St. Michaels Mount, where Lord St. Levan welcomed the party with his customary courtesy, and lunch was taken as the hosts of the Royal Geological Society of Cornwall under his chairmanship. In the afternoon Penlee quarry and the Geological Museum were the alternative attractions. On Tuesday the South Terras Mine and the Herdon china-stone quarry and Carclage china-clay pit were visited. The last day was spent in seeing the Castle-an-Dinas mine and Roche and Tresayes felspar works. It is announced that the Council of the British Association has appointed a research committee to investigate the structure and tectonics of the Palaeozoic rocks of West Cornwall. The committee consists of: Mr. H. Dewey, chairman, Mr. E. H. Davison, secretary, Mr. H. G. Dines, Dr. S. Wooldridge, Mr. S. Hall, and Miss Lind Hendricks.

PERSONAL

R. A. Archbold has left for Bulgaria.
A. E. Bidlake has left for Nigeria.
Cyril Bond has left for Spanish Morocco.
Stanley C. Bullock has left for East Africa.
H. A. Cochran has left for Nigeria.
A. W. H. Dean is returning to India.
J. M. Fair has left for Nigeria.
J. G. Foley has left for Nigeria.
M. A. Francis is leaving for Malaya.
W. H. Geikie has left for Sumatra.
Sydney Higham is leaving for Northern Rhodesia.
T. Hirst is leaving for Nigeria.
Kenneth J. Holman has returned from South Africa.
F. H. Lathbury has left for Kenya.
B. G. Luff has left India for Panama.
A. D. Lumb has left for West Africa.
R. S. Mackilligin has left for the Argentine.
R. Murray-Hughes is home from Yugoslavia.
C. Pengilly is returning from India.
Frank B. Powell has left for West Africa.
J. Reed has returned to Colombia.
James Roberts has left for Italy.
A. B. Rowe is home from Spain.
H. Simon has returned to South Africa.
W. E. Sinclair has left for West Africa.
Blamey Stevens has returned to Mexico and resumed the management of the Lane-Rincon Mines.
F. B. Wade is returning to Tanganyika.
H. H. Watson has left for Panama.
H. J. Winch is returning to India.
Harley B. Wright is home from West Africa.
H. H. Yuill has been here from British Columbia.

Sir John Norton-Griffiths, who died in tragic circumstances on September 27 at the age of 59, had had a varied career. His early engineering experience was gained in Africa, where by 1905 he had sufficiently advanced in his profession to carry out much of the construction of the first 100 miles of the Benguela Railway. By 1910 he had become senior partner in the firm of Norton-Griffiths, Bruce Marriott, and Co. He was a member of the Institution of Mining and Metallurgy from 1900 to 1926 and a Fellow of the Geological Society. In 1910 he entered Parliament as Unionist member for Wednesbury. In 1914 he raised at his own expense the 2nd King Edward's Horse and later organized the tunnelling companies in which many mining engineers served in France. He is, perhaps, best known, however, for his exploit in Roumania, where he was entrusted with the task of destroying great stores of oil and corn which were liable to fall into the hands of the enemy following the retirement of the Roumanian forces. In recent years he had confined himself to civil engineering and was so engaged in Egypt at the time of his death.

TRADE PARAGRAPHS

Sullivan Machinery Co., of Salisbury House, London Wall, E.C. 2, announce that Mr. Austin Y. Hoy is no longer connected with their business and that Mr. A. F. Belding, who has been a senior member of the London branch for the past nineteen years, has been appointed manager.

Harker and Cable, of Milford Haven, East End Road, London, N. 3, issue an illustrated booklet describing their diamond core drills, well boring, and prospecting machinery. This includes a section devoted to their rotary shot drill especially suitable for boring large vertical holes which are constructed for all depths and for holes of 4 in. to 20 in. diameter for any form of drive.

G. A. Harvey and Co. (London), Ltd., of Woolwich Road, London, S.E. 7, issue a 185 page catalogue of their perforated metals for all screen, grading, and filtering requirements. These include plates with round hole perforations, square holes (parallel), square holes (alternate), round-end slots (alternate and parallel), square-end slots similarly spaced, diamond squares, and a variety of others for special purposes.

Kinetic Elutriators, Ltd., of 11, Southampton Row, London, W.C. 1, have published a catalogue describing in some detail and including all recent modifications and improvements in the Andrews hydraulic classifier, to which reference has more than once been made in these columns. The catalogue contains interesting photographs and cross sectional elevations to demonstrate the working and efficiency of this interesting system.

International Combustion, Ltd., of Africa House, London, W.C. 2, inform us that the Combustion Engineering Corporation of New York have received an order from the Solvay Process Co. for a boiler having a heating surface of 15,671 sq. ft.

fired by two unit mills with tangential burners. This order brings the number of combustion steam generators up to 40, a remarkable figure considering the short time since the first unit was constructed.

Edgar Allen and Co., Ltd., of Imperial Steelworks, Sheffield, issue a catalogue devoted to Stag ore-crushers and stone-breakers, which is fully illustrated with photographs and sectional drawings, together with particulars of granulators, complete portable crushing and screening plants and renewable wearing parts for these. They also send us the September issue of their *Edgar Allen News*, which is interesting as being the centenary number of this publication. It contains the usual variety of interesting articles.

Westinghouse Electric International Co., of 2, Norfolk Street, London, W.C. 2 (Head Office: New York) issue a number of leaflets devoted to the following: Primary fuse cutouts, condensate pumps, type CS squirrel-cage induction motors, direct current magnetic brakes, type CW wound-rotor induction motors, electrical equipment for cable tool drilling (both twin motor and single motor equipment), electrical equipment for rotary drilling, the Westinghouse-Nuttall gear for electrical pumping, electrical pumping of oil wells, reversing limestarters, timestarters, and reversing drum controllers.

Denver Equipment Co., of Denver, Colorado, send us their bulletin 2901 which covers 103 pages and is well illustrated with photographs and sectional and other drawings. It gives details of results in modern flotation obtained with the Denver "Sub-A" (Fahrenwald) flotation machine. Part I consists of a series of articles on such subjects as flotation history, reagents used, testing ores by flotation, fundamental conceptions of flotation, flotation theory, and goes on to discuss results and factors affecting flotation. Part II contains details of the machine already referred to and this is the section which is so well illustrated.

The Nordberg Manufacturing Co., of Bush House, London, W.C. 2, issue a booklet giving particulars of the Nordberg-Butler shovel, which is a mechanically operated excavator for underground shovelling of broken and blasted material. While it is particularly adapted for tunnelling and mine driving, its full revolving characteristic and wide clean up make it equally valuable in stopes and sill floors. It is operated by a direct thrust cylinder. The new model known as No. 110 has many new features over machines of this kind previously built, and it has 20% more power which gives it greater speed and ability to lift heavy material.

Sentinel Waggon Works, Ltd., of Shrewsbury, in their monthly house journal for August–September make editorial reference to the firm's latest product known as the D.G. 8, which is an eight-wheeled steam wagon the first of its kind to be manufactured. Over heavy transport for long distances this wagon is expected to be extremely useful, especially in countries and places where coal is cheap and easily available. The special feature of the wagon is that the four front wheels are carried on rocking bogie frames similar to those of the rear bogie, the only essential difference in the two bogies being that each wheel of the front one is under steering control.

Metropolitan-Vickers Electrical Co., Ltd., of Trafford Park, Manchester, in their *Gazette* for August have a lengthy article describing the firm's development in motor control gear. There is also reference to an order placed with the company by the Anglo-American Corporation of South Africa for the Bwana M'Kubwa copper mines for eleven 400 h.p. synchronous induction motors. The motors are required to drive ball-mills. They are to operate at 3,300 volts, 3 phase, 50 cycles, 300 r.p.m. and at any required power factor between 98·4% leading and unity and they are designed to have a temperature rise not exceeding 40° C. in continuous operation at an altitude of 4,100 ft. above sea level. Ten similar machines were recently supplied to Roan Antelope copper mines.

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 5-roller Raymond mill for chalk; one 4 ft. by 5 ft. 1-surface type 39, Hum-mer screen for gypsum; one 3 ft. by 5 ft. 1-surface, type 39, Hum-mer screen for gypsum; and one No. 0000 Raymond pulverizer for precipitate colours. For France: One 6 ft. by 60 in. Hardinge mill for graphite; one 3-roller Raymond mill for graphite; one No. 00 Raymond pulverizer for wood charcoal; one No. 00 Raymond pulverizer for unstated duty; and two 4 ft. 1-surface type 37, Hum-mer screens for cement slurry. For South Africa: One 4 ft. by 16 in. Hardinge mill for unstated duty.

Geophysical Company, Ltd., of 62, London Wall, London, E.C. 2, inform us that at the recent fourth general assembly of the International Union of Geodesy and Geophysics held at Stockholm an exhibition was held at the Museum of the Swedish Geological Survey, of maps, sketches and apparatus illustrating the vast amount of geophysical work which has been carried out by the Swedish Electrical Prospecting Co., Seismos G.m.b.H., Exploration B.U.U.V. G.m.b.H., the Geophysical Company, Ltd., of London and other associated companies. The exhibition included:—(1) A summary of seismographical investigations carried out since 1921 in Texas, Louisiana, Mexico, Egypt, Iraq, Persia, Spain, England, Holland, Sweden, Poland, Germany, Austria and elsewhere, showing that 100,219 seismograms had been recorded; that the total length of profiles observed was 152,566 miles and that the total area covered by such investigations was 73,834 square miles. (2) A summary of gravimetric investigations in Texas, Louisiana, Oklahoma, New Mexico, Kansas. Pennsylvania, Missouri, Egypt, Mexico, Italy, Spain, Poland, Sweden, Germany, Austria and elsewhere, showing that over 31,095 observations had been made covering an area of more than 20,988 square miles, and also that 438 pendulum observations had been made in Germany, Egypt, Oklahoma and Kansas, covering an area of 4,635 square miles. (3) Maps showing results of seismic and gravimetric investigations on salt-domes near Celle (Germany). These maps showed seismic observation lines, torsion-balance stations with gradients and curvature values, pendulum stations with the observed relative values of gravity and the boundaries of salt-domes located and outlined by such investigations. (4) Maps of Texas and Louisiana showing 119 salt-domes, discovered by geophysical methods since 1924, in the Gulf Coast area. (5) A list of all salt-domes discovered by geophysical methods in Texas and Louisiana since 1924, showing method of discovery, year discovered, and details of development. (6) Map showing that in the Gulf Coast area of Texas and Louisiana 51,900 square miles had been investigated by the seismic method and 8,226

square miles by the gravimetric method. (7) Map showing the results of a gravimetric survey of the salt-dome of Blue Ridge, Texas. (A shallow dome at a depth of 400 to 500 ft. with a thick cap-rock of anhydrite and gypsum.) (8) Map giving results of a gravimetric survey on the salt-dome "Sugar-land," Texas. (This dome has a depth of 4,200 ft.) (9) Map of the results of a seismic investigation in the coal district of South Holland. (10) Map of the results of a gravimetric survey in the ore district of Menstrask, Sweden. (11) Map showing the results of a gravimetric survey carried out near Rickling, Holstein (Germany).

METAL MARKETS

COPPER.—The tendency of prices throughout the month was markedly easy, but the weakness was especially accentuated towards the close of the month when Standard values lost heavily in a few days. In New York the export quotation of Copper Exporters Inc. receded from 10·87½ cents per lb. f.a.s. to 10 cents, and the further increase in the unwieldy surplus stocks of copper in the United States, recorded during the month, was probably responsible for this to some extent by further undermining sentiment. The position of European consuming industries has not been improved by the uncertain political situation in Germany which has naturally tended to retard commercial enterprise of all kinds for the time being. The recent decline in copper prices—and indeed in all non-ferrous metal quotations—has been almost unprecedented. Standard Copper has not been so cheap as it is at present since 1896 when it fell at one time to £40 10s.

Average price of Cash Standard Copper: September, 1930, £46 6s.; August, 1930, £47 11s. 4d.; September, 1929, £75 6s. 9d.; August, 1929, £73 16s. 8d.

TIN.—After keeping fairly steady till towards the close of September, tin shared in the fresh slump which then afflicted all the non-ferrous metal markets and prices fell substantially. Confidence is kept in check by the known existence of large surplus supplies, and doubts as to whether the present measures which are being taken by producers to curtail output will prove adequate to restore equilibrium between supply and demand. That these measures are having some effect at last, however, is indicated by the fact that during September the world's "visible supply" of tin is estimated to have been reduced by over 3,000 tons. It remains to be seen whether this development will infuse more confidence into the market.

Average price of Cash Standard Tin: September, 1930, £132 14s.; August, 1930, £135 1s. 2d.; September, 1929, £204 18s. 9d.; August, 1929, £209 17s. 11d.

LEAD.—The price of lead had for some time looked dear in comparison with other metals, prices having been artificially maintained by the Lead Producers' Association. During September, however, the latter relaxed their control and prices immediately fell heavily and it would not be surprising if the fall were carried still further during October. Demand from consumers was dull during the month, there were ample supplies and the general situation was not improved by the political developments in Germany. The price of lead, however, like that of other metals is now getting near a level which can only be regarded as a "bargain" quotation, and sooner or later we ought to see a vigorous buying movement set in. The inception of this will of course be dependent to a large extent on outside financial and commercial developments.

Average mean price of soft foreign lead: September, 1930, £17 17s.; August, 1930, £18 4s. 8d.; September, 1929, £23 11s. 5d.; August, 1929, £23 4s. 5d.

SPELTER.—Quotations receded afresh during September. Demand from consumers remained dull, supplies being superabundant despite the curtailment which has taken place in production and no fresh developments were announced with regard to the projected International Zinc Cartel. The outlook remains rather discouraging, particularly in view of the depressed state of certain consuming industries, but of course prices are now remarkably cheap, being indeed lower than they have ever been since 1896 when prompt values touched £14 2s. 6d. Incidentally, the highest price attained during the past fifty years was £115 in 1915!

Average mean price of spelter: September, 1930, £15 18s. 5d.; August, 1930, £16 4s. 2d.; September, 1929, £24 8s. 11d.; August, 1929, £25 0s. 7d.

IRON AND STEEL.—Conditions in the British iron and steel market have not been favourable of late. There has so far been no autumn revival, and the tendency has been for plants to slacken operations rather than increase them. The number of active blast-furnaces has been further reduced, but the position of pig-iron producers seems to be a little sounder as they are now apparently working off their stocks in some instances. Cleveland No. 3 foundry pig-iron remained at 63s. 6d. and East Coast Hematite Mixed Numbers were steady to firm at 71s. per ton. The British rolling mills are complaining of a dearth of fresh business both for home and foreign account. On the Continent the market has remained very weak and this fact has not been a favourable one from the point of view of British producers. Except in France, the position of European steelmasters can only be described as critical at the present time.

IRON ORE.—This market could not very well be in a much worse state. Buyers everywhere are overstocked and cannot take delivery of the quantities due under old contracts, and in some cases 1930 contracts have been put forward as far as 1932. With freights low and the Spanish exchange depreciating quotations have declined, the nominal value of best Bilbao rubio being about 17s. per ton c.i.f.

ANTIMONY.—At the close of the month of September English regulus was quoted at £38 to £46 10s. per ton. Chinese regulus was an irregular market, with spot ranging between £26 10s. to £27 10s. ex warehouse, whilst metal for shipment from China was quoted around £26 2s. 6d. c.i.f.

ARSENIC.—Supplies of Cornish arsenic are none too plentiful at the moment, and sellers are rather firmer in their ideas at £16 15s. per ton f.o.r. mines.

BISMUTH.—A fairly good demand is maintained at 4s. per lb. for 5 cwt. lots and over.

CADMIUM.—Severe Continental competition on a market none too plentifully supplied with orders has caused easy conditions in this market, current quotations being about 2s. 6d. to 2s. 7d. per lb.

COBALT METAL.—The official price remains at 10s. per lb., but less is accepted for good contracts.

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.	
Sept.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	d.	d.	s. d.
11	47 6 10½	47 10 7½	51 0 0	—	134 11 3	136 8 9	16 0 0	18 5 0	19 10 0	16⅝	16⅝	84 11½
12	47 9 4½	47 9 4½	51 0 0	50 0 0	134 8 9	136 3 9	15 18 9	18 3 9	19 10 0	16⅞	16⅞	85 0½
15	47 0 7½	46 18 1½	50 15 0	—	133 18 9	135 8 9	15 18 9	18 3 9	19 10 0	16 1/16	16 1/16	85 0½
16	46 5 7½	46 6 10½	50 0 0	49 0 0	134 6 3	135 18 9	15 18 9	18 1 3	19 10 0	16 1/16	16 1/16	85 0½
17	46 3 1½	46 3 1½	50 0 0	—	134 1 3	135 13 9	15 18 9	17 16 3	19 5 0	16⅛	16⅛	85 0½
18	46 3 1½	46 4 4½	50 0 0	—	134 1 3	135 13 9	15 18 9	17 12 6	19 0 0	17	17	85 0½
19	45 14 4½	45 14 4½	49 10 0	48 5 0	133 11 3	135 1 3	15 18 9	17 12 6	19 0 0	16 15/16	17	85 0½
22	45 11 10½	45 13 1½	49 10 0	—	132 1 3	133 13 9	15 16 3	17 16 3	19 5 0	17	17	85 0½
23	45 6 3	45 8 1½	49 10 0	48 0 0	131 17 6	133 11 3	15 10 0	17 15 0	19 5 0	17	17	85 0½
24	45 5 7½	45 4 4½	49 10 0	—	132 17 6	134 6 3	15 10 0	17 17 6	19 5 0	16⅞	16⅞	85 0½
25	45 1 10½	45 1 10½	49 0 0	—	131 8 9	132 18 9	15 7 6	17 17 6	19 5 0	16⅞	16⅞	85 0½
26	44 10 7½	44 11 10½	49 0 0	47 10 0	130 18 9	132 11 3	15 5 0	17 13 9	19 0 0	16⅞	16⅞	85 0½
29	43 8 9	43 8 9	48 0 0	—	127 18 9	129 11 3	15 0 0	16 15 0	18 5 0	16⅝	16⅝	85 11½
30	43 10 7½	43 9 4½	47 0 0	46 0 0	125 7 6	126 17 6	14 15 0	16 15 0	18 5 0	16⅜	16⅜	84 11½
Oct.												
1	43 18 1½	43 15 7½	47 0 0	—	125 2 6	126 8 9	14 10 0	16 8 9	18 0 0	16⅞	16⅜	84 11½
2	44 13 9	44 11 3	47 0 0	—	124 2 6	125 13 9	14 12 6	16 8 9	18 0 0	16 7/16	16 7/16	84 11½
3	44 0 0	43 18 1½	47 0 0	46 0 0	123 16 3	125 6 3	14 13 9	16 11 3	18 0 0	16⅝	16½	84 11½
6	44 11 10½	44 11 10½	47 0 0	—	124 15 6	126 2 6	14 13 9	16 6 3	17 15 0	16 7/16	16 7/16	84 11½
7	43 18 9	43 18 9	47 0 0	46 0 0	122 2 6	123 12 6	14 10 0	16 2 6	17 10 0	16 7/16	16 7/16	84 11½
8	43 11 10½	43 11 10½	47 0 0	—	119 7 6	120 17 6	14 1 3	15 15 0	17 5 0	16⅛	16⅛	84 11½
9	43 5 7½	43 5 7½	47 0 0	—	115 15 0	117 7 6	13 18 9	15 5 0	16 15 0	16⅝	16⅝	84 11½
10	42 11 10½	42 11 10½	47 0 0	46 0 0	109 7 6	110 17 6	14 0 0	14 18 9	16 10 0	16 1/16	16 1/16	84 11½

Cobalt Oxides.—Quotations are still pegged officially at 8s. per lb. for black and 8s. 10d. for grey.

Chromium Metal.—A moderate enquiry persists, mainly from the plating trade, and the price keeps steady at 2s. 6d. per lb.

Tantalum.—With the falling from favour of this metal in the wireless world demand has practically ceased, but the nominal quotation remains at £40 to £50 per lb.

Platinum.—Further weakness was seen in this market in September, down to £6 per oz. being accepted for refined metal. Subsequently, however, negotiations were resumed among leading producers for a sales agreement and a rather harder tone developed. The current official price is £7 per oz., although about £6 10s. might be accepted for good lots.

Palladium.—There is only a limited interest displayed at the unaltered price of £3 15s. to £4 per oz.

Iridium.—Quotations have eased somewhat in sympathy with the break in platinum, sponge and powder being priced at around £37 to £39 per oz.

Osmium.—This metal keeps very steady at £15 10s. to £16 per oz.

Tellurium.—Sales are so scanty as to be almost negligible and quotations are wholly nominal in the region of 12s. 6d. to 15s. per lb.

Selenium.—There is no change to report, high grade black powder remaining in fairly good demand at 7s. 8d. to 7s. 9d. per lb. ex warehouse.

Manganese Ore.—The only feature of interest in this market is the very low price the Soviet are willing to accept for their ore, about 11¾d. to 1s. per unit c.i.f. being the current quotation for washed Caucasian. Best Indian is held for about 1s. ½d. to 1s. 1d. per unit c.i.f., but there is practically no demand and a number of mines have had to close down.

Aluminium.—The undertone of this market has been rather firmer since production was curtailed, but the agitation in Germany for a reduction in prices, although it is hardly likely to succeed for the time being, is rather an unsettling factor. For the present quotations remain at £95 per ton, less 2% delivered, for ingots and bars.

Sulphate of Copper.—A moderate demand has been in evidence, but quotations are rather easier in sympathy with copper, English material being quoted at £22 to £22 10s. per ton, less 5%.

Nickel.—Demand is only fair, but production is fully maintained and stocks are accumulating. However, prices are upheld at £170 to £175 per ton for both home and export.

Chrome Ore.—The position of this market does not vary much, for although supplies are plentiful prices are upheld at £4 to £4 5s. per ton c.i.f. for good average 48% material, and about £5 5s. for New Caledonian.

Quicksilver.—Only a skeleton demand has been in evidence recently, but prices are still £22 12s. 6d. to £22 15s. per bottle, full terms, for spot material.

Tungsten Ore.—This market has been very irregular and the volume of business passing has been trifling. Buyers' and sellers' ideas have remained rather wide apart, but at the moment shippers are rather firm at 20s. 6d. to 21s. 6d. per unit c.i.f. for October-November shipment from China, with buyers bidding around 19s.

Molybdenum Ore.—Some odd parcels of 80 to 85% concentrates are offering at 33s. per unit c.i.f., but for contract quantities about 35s. 6d. is asked.

Graphite.—There is no change to report, 85 to 90% raw Madagascar flake being held for £25 to £27 per ton c.i.f. and 90% Ceylon lumps for about £24 to £26 c.i.f.

Silver.—During the early part of September the market was firm, spot bars being 16 7/16d. on September 1 and 16 13/16d. on September 15, rising to 17d. on September 18. Subsequently China sold rather more freely, and with rumours that the Indian Government intended to dispose of a substantial parcel to a private buyer at slightly under the London price, quotations eased off somewhat spot bars closing at 16⅜d. on September 30.

STATISTICS

PRODUCTION OF GOLD IN THE TRANSVAAL.

	Rand.	Elsewhere.	Total.
	Oz.	Oz.	Oz.
September, 1929	814,707	34,846	849,553
October	853,609	35,081	888,690
November	827,952	33,641	861,593
December	813,574	37,560	851,134
January, 1930	848,245	34,556	882,801
February	783,086	35,102	818,188
March	852,089	37,281	889,370
April	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

TRANSVAAL GOLD OUTPUTS.

	August.		September.	
	Treated Tons.	Yield Oz.	Treated Tons.	Yield Oz.
Brakpan	88,800	£141,516	87,500	£139,068
City Deep	99,000	26,628	96,500	26,426
Cons. Main Reef	62,000	21,454	59,500	21,242
Crown Mines	255,000	80,752	248,000	78,198
D'rb'n Roodepoort Deep	46,000	14,923	44,600	15,095
East Rand P.M.	157,000	42,461	153,000	41,296
Geduld	86,000	27,513	83,500	26,704
Geldenhuis Deep	70,000	15,557	68,500	15,665
Glynn's Lydenburg	6,600	2,034	6,200	1,879
Government G.M. Areas	207,000	£396,534	205,000	£396,385
Kleinfontein	52,300	11,293	50,900	10,884
Langlaagte Estate	80,000	£115,781	80,000	£115,661
Luipaard's Vlei	30,000	7,653	29,900	7,700
Meyer and Charlton	18,400	£18,358	17,800	£17,957
Modderfontein New	159,000	71,784	158,000	71,253
Modderfontein B	71,500	25,166	69,000	24,317
Modderfontein Deep	44,200	23,034	44,200	22,880
Modderfontein East	71,000	20,525	71,000	20,245
New State Areas	78,000	£162,538	78,000	£161,693
Nourse	67,000	18,926	66,500	19,381
Randfontein	223,000	£235,370	220,000	£240,842
Robinson Deep	97,000	28,288	95,500	27,589
Rose Deep	64,500	13,528	62,000	13,351
Simmer and Jack	77,800	20,967	78,300	20,943
Springs	72,000	£145,690	71,000	£142,007
Sub Nigel	30,800	27,329	30,900	27,557
Transvaal G.M. Estates	15,000	5,401	14,450	5,338
Van Ryn	42,500	£41,870	41,000	£40,884
Van Ryn Deep	62,000	£103,514	67,000	£106,106
West Rand Consolidated	93,000	£105,852	91,500	£102,698
West Springs	68,000	£75,735	68,800	£76,544
Witw'tersr'nd (Knights)	55,500	£51,577	55,000	£50,514
Witwatersrand Deep	43,200	13,580	40,200	12,626

COST AND PROFIT ON THE RAND, Etc.

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

	Tons milled.	Yield per ton.	Work'g cost per ton.	Work'g profit per ton.	Total working profit.
		s. d.	s. d.	s. d.	£
June, 1929	2,543,550	28 3	19 10	8 5	1,065,191
July	2,649,560	28 1	19 8	8 5	1,112,246
August	2,661,800	28 1	19 9	8 4	1,111,834
September	2,530,370	28 2	19 10	8 4	1,056,839
October	2,658,100	28 1	19 8	8 5	1,115,744
November	2,559,450	28 3	19 11	8 4	1,071,199
December	2,528,000	28 3	19 11	8 4	1,058,231
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	—	—	—	—	1,174,828

NATIVES EMPLOYED IN THE TRANSVAAL MINES.

	Gold Mines.	Coal Mines.	Diamond Mines.	Total.
September 30, 1930	190,567	15,733	4,814	211,114
October 31	189,739	15,533	4,555	209,827
November 30	186,941	15,320	4,561	206,822
December 31	184,280	15,326	4,811	204,417
January 31, 1930	190,663	15,288	5,889	211,840
February 28	196,752	15,495	6,584	218,831
March 31	200,134	15,350	7,002	222,316
April 30	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

PRODUCTION OF GOLD IN RHODESIA.

	1927	1928	1929	1930
	oz.	oz.	oz.	oz.
January	48,731	51,356	46,231	46,121
February	46,461	46,286	44,551	43,385
March	50,407	48,017	47,388	45,511
April	48,290	48,549	48,210	45,806
May	48,992	47,323	48,189	47,645
June	52,910	51,762	48,406	45,208
July	49,116	48,960	46,369	45,810
August	47,288	50,611	46,473	46,152
September	45,838	47,716	45,025	—
October	46,752	43,056	46,923	—
November	47,435	47,705	46,219	—
December	49,208	44,772	46,829	—

RHODESIAN GOLD OUTPUTS.

	August.		September.	
	Tons.	Oz.	Tons.	Oz.
Cam and Motor	24,600	10,647	24,200	10,692
Globe and Phœnix	6,065	5,330	6,060	5,116
Lonely Reef	6,300	3,831	5,900	3,766
Luiri Gold	1,517	£2,028	—	—
Rezende	6,400	2,709	6,400	2,709
Sherwood Star	5,000	£12,855	5,000	£12,776
Wanderer Consolidated	15,900	4,081	15,151	3,876

WEST AFRICAN GOLD OUTPUTS.

	August.		September.	
	Tons.	Oz.	Tons.	Oz.
Ariston Gold Mines	—	—	—	—
Ashanti Goldfields	10,711	13,437	10,816	12,959
Taquah and Abosso	9,950	£15,934	9,870	£15,907

AUSTRALIAN GOLD OUTPUTS BY STATES.

	Western Australia.	Victoria.	Queensland.
	Oz.	Oz.	Oz.
September, 1929	32,751	1,739	381
October	35,445	—	789
November	28,460	—	473
December	33,650	1,459	1,636
January, 1930	25,472	952	209
February	31,307	1,354	350
March	27,946	2,552	382
April	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	—	—
September	32,034	—	—

AUSTRALASIAN GOLD OUTPUTS.

	August.		September.	
	Tons	Value £	Tons.	Value £
Associated G.M. (W.A.)	5,229	7,656	5,351	7,683
Blackwater (N.Z.)	3,800	6,237	3,700	6,068
Boulder Persev'ce (W.A.)	6,696	13,054	6,908	17,229
Grt. Boulder Pro. (W.A.)	9,414	25,031	8,823	22,740
Lake View & Star (W.A.)	7,799	16,519	—	—
Sons of Gwalia (W.A.)	13,656	14,737	13,488	14,281
South Kalgurli (W.A.)	8,501	15,305	8,364	14,817
Waihi (N.Z.)	18,541‡	{ 6,226* / 35,984†	18,462§	{ 6,492* / 40,902†

* Oz. gold. † Oz. silver. ‡ To August 23. § To Sept. 20.

GOLD OUTPUTS, KOLAR DISTRICT, INDIA.

	August.		September.	
	Tons Ore	Total Oz.	Tons Ore	Total Oz.
Balaghat	3,700	1,957	3,950	1,950
Champion Reef	8,340	5,640	8,460	5,872
Mysore	17,959	9,596	17,397	8,752
Nundydroog	11,568	7,027	11,500	7,021
Ooregum	13,500	5,729	13,500	5,704

MISCELLANEOUS GOLD, SILVER, AND PLATINUM OUTPUTS.

	August.		September.	
	Tons	Value £	Tons	Value £
Chosen Corp. (Korea)	9,760	12,380	9,870	14,650
Frontino & Bolivia (C'lbia)	2,280	10,146	2,400	10,577
Lena (Siberia)	—	—	—	14,650
Lydenburg Plat. (Trans.)	4,100	928*p*	4,150	1,112*p*
Marmajito (Colombia)	940	4,535	900	5,135
Fresnillo	83,174	29,549*d*	—	—
Onverwacht Platinum	—	—	—	—
Oriental Cons. (Korea)	17,484	82,792*d*	17,073	81,165*d*
St. John del Rey (Brazil)	—	46,000	—	44,500
Santa Gertrudis (Mexico)	45,856	83,632*d*	—	—

d Dollars. *p* Oz. platinoids.

PRODUCTION OF TIN IN FEDERATED MALAY STATES.

Estimated at 70% of Concentrate shipped to Smelters. Long Tons.

January, 1930	6,128	July	5,525
February	4,768	August	4,153
March	5,763	September	—
April	5,407	October	—
May	6,043	November	—
June	5,590	December	—

OUTPUTS OF MALAYAN TIN COMPANIES.

In Long Tons of Concentrate.

	July.	August.	Sept.
Ayer Hitam	65½	—	—
Batu Caves	—	—	27
Changkat	30	—	—
Chenderiang	—	—	—
Gopeng	66	67	71½
Hongkong Tin	44½	23⅝	110
Idris Hydraulic	31	—	23⅝
Ipoh	43⅝	—	—
Jelapang	29½	29¾	—
Kampar Malava	—	—	—
Kampong Lanjut	70	—	86
Kamunting	111	99	98½
Kent (F.M.S.)	27	30	36
Kepong	33	—	—
Kinta	20	13	21
Kinta Kellas	22½	—	—
Kuala Kampar	60	—	40
Kundang	38	—	—
Lahat	17	18	—
Larut Tinfields	—	—	—
Malaya Consolidated	76¾	69¼	72½
Malayan Tin	131	—	—
Meru	12	18	12
Pahang	225	225½	225⅜
Penawat	48½	78½	75¾
Pengkalen	65½	71½	71½
Petaling	149	149	131
Rahman	59½	65½	59½
Rambutan	9	9	9
Rantau	—	—	—
Rawang	35	—	48
Rawang Concessions	65	27	30
Renong	80	—	—
Selayang	13	—	—
Southern Malayan	154⅜	—	—
Southern Perak	83½	—	—
Southern Tronoh	51	—	—
Sungei Besi	37	—	—
Sungei Kinta	12	15½	—
Sungei Way	65½	—	—
Taiping	—	—	—
Tanjong	38½	30	46
Teja Malaya	26½	30	23
Tekka	33	32	32
Tekka-Taiping	57	45	40½
Temoh	29⅜	—	—
Tronoh	60	—	—

OUTPUTS OF NIGERIAN TIN MINING COMPANIES.

In Long Tons of Concentrate.

	July.	August.	Sept.
Amari	—	—	—
Anglo-Nigerian	65	51	46
Associated Tin Mines	130	80	80
Baba River	10	3	3
Batura Monguna	1½	3½	2½
Bisichi	65	65	40
Daffo	10½	10	—
Ex-Lands	55	—	—
Filani	4½	7½	10½
Jantar	15	15	15
Jos	28½	20½	19½
Juga Valley	18	6	6
Junction	2	—	—
Kaduna Syndicate	20	13	—
Kaduna Prospectors	16	13	—
Kassa	39	20½	20½
London Tin	85	75	80
Lower Bisichi	8½	11	10½
Naraguta	—	—	—
Naraguta Durumi	—	—	—
Naraguta Extended	—	—	—
Naraguta Karama	—	—	—
Naraguta Korot	—	—	—
Nigerian Consolidated	14	14	14
Offin River	6⅜	7½	3
Ribon Valley	21½	16½	15½
South Bukeru Areas	—	—	—
Tin Fields	—	—	—
Tin Properties	6	6	6
United Tin Areas	33½	27	28
Yarde Kerri	10	9	12

OUTPUTS OF OTHER TIN MINING COMPANIES.

In Long Tons of Concentrate.

	July.	August.	Sept.
Anglo-Burma (Burma)	40	39½	37
Aramayo Mines (Bolivia)	199	203	208
Bangrin (Siam)	70½	84	107
Berenguela (Bolivia)	—	—	—
Consolidated Tin Mines (Burma)	210	200	176
East Pool (Cornwall)	83	83	—
Fabulosa (Bolivia)	110	137	130
Geevor (Cornwall)	49	41	—
Jantar (Cornwall)	23	22½	—
Kagera (Uganda)	28	28	28
Northern Tavoy	—	—	—
Patino	1,329	1,329	—
Polhigey (Cornwall)	31	30	25
San Finx (Spain)	33½*	30½*	—
Siamese Tin (Siam)	159½	149	—
South Croftv (Cornwall)	66¾	65⅛	63¾
Tavoy Tin (Burma)	—	—	—
Theindaw (Burma)	—	—	—
Tongkah Harbour (Siam)	115	89	90
Toyo (Japan)	48½	46	59½
Wheal Kitty (Cornwall)	40	40	38
Zaaiplaats	35	—	—

* Tin and Wolfram.

COPPER, LEAD, AND ZINC OUTPUTS.

		August.	Sept.
Broken Hill South	Tons lead conc.	6,192	5,958
	Tons zinc conc.	—	—
Burma Corporation	Tons refined lead	6,420	6,420
	Oz. refined silver	580,000	540,000
Bwana M'Kubwa	Tons copper oxide	669	690
Electrolytic Zinc	Tons zinc	4,216§	4,135†
Indian Copper	Tons copper	223	234
Messina	Tons copper	656	736
Mount Lyell	Tons concentrates	3,904*	—
Namaqua	Tons copper	—	—
North Broken Hill	Tons lead conc.	5,420	—
	Tons zinc conc.	—	—
Poderosa	Tons copper ore	588	588
Rhodesia Broken Hill	Tons lead	—	—
	Tons slab zinc	1,500	1,438
San Francisco Mexico	Tons lead conc.	4,295	3,874
	Tons zinc conc.	—	2,669
Sulphide Corporation	Tons lead conc.	2,065	2,127
	Tons zinc conc.	2,834	2,841
Tetiuhe	Tons lead conc.	1,280	1,094
	Tons zinc conc.	3,209	2,646
Union Minière	Tons copper	—	—
Zinc Corporation	Tons lead conc.	5,686†	—
	Tons zinc conc.	3,919†	—

§ Four weeks to Aug. 20. † Four weeks to Sept. 6.
* Four weeks to Sept. 10. ‡ Four weeks to Sept. 17.

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

		July.	August.
Iron Ore	Tons	284,775	227,070
Manganese Ore	Tons	10,315	22,976
Iron and Steel	Tons	198,788	195,404
Copper and Iron Pyrites	Tons	31,844	18,483
Copper Ore, Matte, and Prec.	Tons	4,426	3,217
Copper Metal	Tons	17,491	15,040
Tin Concentrate	Tons	5,522	6,185
Tin Metal	Tons	1,655	723
Lead Pig and Sheet	Tons	20,642	22,574
Zinc (Spelter)	Tons	13,524	11,776
Zinc Sheets, etc.	Tons	2,073	2,257
Aluminium	Tons	1,375	1,518
Mercury	Lb.	183,455	116,221
Zinc Oxide	Tons	961	672
White Lead	Cwt.	15,280	11,928
Red and Orange Lead	Cwt.	7,965	3,626
Barytes, ground	Cwt.	55,077	45,854
Asbestos	Tons	2,280	2,388
Boron Minerals	Tons	267	194
Borax	Cwt.	17,200	22,956
Basic Slag	Tons	587	995
Superphosphates	Tons	890	2,318
Phosphate of Lime	Tons	45,560	33,082
Mica	Tons	264	289
Sulphur	Tons	6,339	5,593
Nitrate of Soda	Cwt.	41,220	24,403
Potash Salts	Cwt.	140,234	456,965
Petroleum: Crude	Gallons	43,867,683	37,595,990
Lamp Oil	Gallons	26,310,257	18,632,997
Motor Spirit	Gallons	95,135,678	76,415,615
Lubricating Oil	Gallons	7,122,490	8,428,060
Gas Oil	Gallons	23,198,376	10,531,274
Fuel Oil	Gallons	68,657,283	32,471,441
Asphalt and Bitumen	Tons	14,237	15,389
Paraffin Wax	Cwt.	93,491	147,206
Turpentine	Cwt.	49,879	73,639

OUTPUTS REPORTED BY OIL-PRODUCING COMPANIES.

In Tons.

	July.	August.	September.
Anglo-Ecuardorian	16,818	17,017	15,752
Apex Trinidad	40,240	39,500	40,430
Attock	2,227	2,286	1,936
British Burmah	5,054	4,986	4,589
British Controlled	34,111	33,121	—
Kern Mex	724	752	784
Kern River (Cal.)	1,990	2,503	2,696
Kern Romana	2,421	2,420	2,467
Kern Trinidad	5,020	4,824	4,152
Lobitos	30,771	29,214	28,501
Phœnix	65,597	40,445	51,890
St. Helen's Petroleum	6,346	5,968	5,696
Steaua Romana	79,380	64,060	60,100
Tampico	3,011	3,053	3,041
Trinidad Leaseholds	25,600	28,400	28,500
Venezuelan Consolidated	1,384	—	—

QUOTATIONS OF OIL COMPANIES' SHARES.

Denomination of Shares £1 unless otherwise noted.

	Sep. 10, 1930.	Oct. 10, 1930.
	£ s. d.	£ s. d.
Anglo-Ecuadorian	13 10½	12 3
Anglo-Egyptian B.	2 3 9	2 1 3
Anglo-Persian 1st Pref.	1 7 6	1 7 6
,, ,, Ord.	3 13 9	3 3 0
Apex Trinidad (5s.)	18 0	13 9
Attock	1 5 6	1 3 0
British Burmah (8s.)	4 0	4 0
British Controlled ($5)	2 0	1 6
Burmah Oil	4 2 6	3 18 0
Kern River Cal. (10s.)	3 6	2 9
Lobitos, Peru	1 11 3	1 8 0
Mexican Eagle, Ord. (4 pesos)	11 0	9 0
,, ,, 8% Pref. (4 pesos)	10 9	8 9
Phœnix, Roumanian	9 3	7 9
Royal Dutch (100 fl.)	30 5 0	27 12 6
Shell Transport, Ord.	4 8 9	4 1 3
,, ,, 5% Pref. (£10)	10 0 0	9 17 6
Steaua Romana	7 0	6 0
Trinidad Leaseholds	2 1 9	1 1 3
United British of Trinidad (6s. 8d.)	5 3	4 6
V.O.C. Holding	1 17 6	1 13 0

PRICES OF CHEMICALS. Oct. 10.

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

		£ s. d.
Acetic Acid, 40%	per cwt.	16 6
,, 80%	,,	1 16 3
,, Glacial	per ton	58 0 0
Alum	,,	8 10 0
Alumina, Sulphate, 17 to 18%	,,	6 15 0
Ammonia, Anhydrous	per lb.	10
,, 0·880 solution	per ton	15 10 0
,, Carbonate	,,	27 10 0
,, Nitrate	,,	16 0 0
,, Phosphate	,,	40 0 0
,, Sulphate, 20·6% N.	,,	9 1 0
Antimony, Tartar Emetic	per lb.	11
,, Sulphide, Golden	,,	7
Arsenic, White	per ton	17 5 0
Barium, Carbonate, 94%	,,	4 10 0
,, Chloride	,,	10 0 0
,, Sulphate, 94%	,,	5 0 0
Benzol, standard motor	per gal.	1 4½
Bleaching Powder, 35% Cl.	per ton	6 15 0
Borax	,,	13 10 0
Boric Acid	,,	22 0 0
Calcium Chloride	,,	5 5 0
Carbolic Acid, crude 60%	per gal.	1 8
,, ,, crystallized, 40°	per lb.	6½
Carbon Disulphide	per ton	24 0 0
Citric Acid	per lb.	1 6
Copper Sulphate	per ton	21 0 0
Cresylic Acid, 97–99%	per gal.	1 10
Creosote Oil (f.o.b. in Bulk)	,,	4½
Hydrofluoric Acid	per lb.	6
Iodine	per oz.	1 0
Iron, Nitrate 80° Tw.	per ton	6 0 0
,, Sulphate	,,	1 17 6
Lead, Acetate, white	,,	36 0 0
,, Nitrate	,,	29 10 0
,, Oxide, Litharge	,,	33 10 0
,, White	,,	42 0 0
Lime, Acetate, brown	,,	7 5 0
,, ,, grey, 80%	,,	14 0 0
Magnesite, Calcined	,,	9 10 0
Magnesium, Chloride	,,	6 15 0
,, Sulphate, comml.	,,	3 15 0
Methylated Spirit 64° Industrial	per gal.	1 9
Nitric Acid, 80° Tw.	per ton	21 0 0
Oxalic Acid	per cwt.	1 12 0
Phosphoric Acid	per ton	29 15 0
Pine Oil	,,	42 10 0
Potassium Bichromate	per lb.	4½
,, Carbonate	per ton	24 10 0
,, Chlorate	,,	24 10 0
,, Chloride 80%	,,	9 15 0
,, Ethyl Xanthate	per 1,016 kilos	55 15 0
,, Hydrate (Caustic) 90%	per ton	28 10 0
,, Nitrate, refined	,,	21 0 0
,, Permanganate	per lb.	5½
,, Prussiate, Yellow	,,	6½
,, ,, Red	,,	1 8
,, Sulphate, 90%	per ton	11 0 0
Sodium Acetate	,,	18 10 0
,, Arsenate, 45%	,,	26 0 0
,, Bicarbonate	,,	10 10 0
,, Bichromate	per lb.	3¾
,, Carbonate (Soda Ash)	per ton	6 0 0
,, ,, (Crystals)	,,	5 5 0
,, Chlorate	,,	23 0 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	,,	9 0 0
,, Nitrate (ordinary)	,,	9 9 0
,, Phosphate, comml.	per cwt.	10 0
,, Prussiate	per lb.	4½
,, Silicate	per ton	9 10 0
,, ,, (liquid, 140° Tw.)	,,	8 10 0
,, Sulphate (Glauber's Salt)	,,	2 12 6
,, ,, (Salt-Cake)	,,	2 15 0
,, Sulphide Conc., 60/65%	,,	8 10 0
,, Sulphite, pure	per cwt.	14 0
Sulphur, Flowers	per ton	11 0 0
,, Roll	,,	9 10 0
Sulphuric Acid, 168° Tw.	,,	4 16 6
,, ,, free from Arsenic, 144° Tw.	,,	4 0 0
Superphosphate of Lime, 33%	,,	3 9 0
Tartaric Acid	per lb.	1 0
Turpentine	per ton	39 0 0
Tin Crystals	per lb.	11½
Titanous Chloride	,,	10
Zinc Chloride	per ton	9 10 0
Zinc Dust	,,	20 0 0
Zinc Oxide	,,	39 0 0
Zinc Sulphate	,,	9 0 0

SHARE QUOTATIONS

Shares are £1 par value except where otherwise noted.

GOLD AND SILVER:	Sept. 10, 1930. £ s. d.	Oct. 10, 1930. £ s. d.
SOUTH AFRICA:		
Brakpan	2 14 6	2 12 6
City Deep	7 0	6 0
Consolidated Main Reef	16 6	15 6
Crown Mines (10s.)	3 12 6	3 12 6
Daggafontein	1 6 3	1 5 0
Durban Roodepoort Deep (10s.)	13 3	12 9
East Geduld	2 5 6	2 3 0
East Rand Proprietary (10s.)	10 9	9 3
Geduld	3 13 9	3 10 0
Geldhenhuis Deep	7 3	7 9
Glynn's Lydenburg	2 6	2 6
Government Gold Mining Areas (5s.)	1 12 0	1 10 0
Langlaagte Estate	1 3 6	1 2 9
Meyer & Charlton	13 9	14 3
Modderfontein New (10s.)	3 11 3	3 3 9
Modderfontein B (5s.)	12 3	11 9
Modderfontein Deep (5s.)	1 1 3	1 1 3
Modderfontein East	1 3 0	1 2 6
New State Areas	1 17 0	1 16 3
Nourse	10 3	11 0
Randfontein	13 3	11 9
Robinson Deep A (1s.)	15 0	15 0
,, ,, B (7s. 6d.)	9 9	8 3
Rose Deep	5 3	5 9
Simmer & Jack (2s. 6d.)	2 9	2 9
Springs	3 2 0	2 18 0
Sub Nigel (10s.)	2 17 0	2 15 0
Van Ryn	7 6	8 6
Van Ryn Deep	1 7 0	1 6 3
Village Deep (14s.)	3 6	4 9
West Rand Consolidated (10s.)	8 0	7 3
West Springs	15 3	13 9
Witwatersrand (Knight's)	10 0	10 0
Witwatersrand Deep	4 3	4 0
RHODESIA:		
Cam and Motor	15 9	13 9
Gaika	3 9	4 3
Globe and Phœnix (5s.)	13 6	13 6
Lonely Reef	19 0	18 9
Mayfair	9 9	10 0
Rezende	1 1 9	1 1 3
Shamva	1 0	1 0
Sherwood Starr (5s.)	16 3	15 0
GOLD COAST:		
Ashanti (4s.)	1 9 9	1 10 3
Taquah and Abosso (5s.)	2 9	2 6
AUSTRALASIA:		
Golden Horseshoe (4s.) W.A.	2 3	1 9
Great Boulder Propriet'y (2s.), W.A.	1 3	1 0
Lake View and Star (4s.), W.A.	10 3	7 3
Sons of Gwalia, W.A.	1 3	1 3
South Kalgurli (10s.), W.A.	12 6	12 6
Waihi (5s.), N.Z.	14 3	14 6
Wiluna Gold, W.A.	17 9	15 0
INDIA:		
Balaghat (10s.)	2 6	2 6
Champion Reef (10s.)	8 6	7 9
Mysore (10s.)	10 6	10 9
Nundydroog (10s.)	16 6	15 6
Ooregum (10s.)	4 9	3 6
AMERICA:		
Camp Bird (2s.), Colorado	6	6
Exploration (10s.)	4 3	4 0
Frontino and Bolivia, Colombia	11 6	11 6
Mexican Corporation, Mexico (10s.)	5 0	4 6
Mexico Mines of El Oro, Mexico	3 0	3 0
Panama Corporation	15 6	13 3
St. John del Rey, Brazil	17 3	16 6
Santa Gertrudis, Mexico	8 6	7 9
Selukwe (2s. 6d.), British Columbia	3 3	3 0
MISCELLANEOUS:		
Chosen, Korea	5 0	5 0
Lena Goldfields, Russia	6	6
COPPER:		
Bwana M'Kubwa (5s.) Rhodesia	13 0	8 9
Esperanza Copper, Spain	1 1 6	1 1 6
Indian (2s.)	1 6	1 3
Loangwa (5s.), Rhodesia	3 3	2 3
Luiri (5s.), Rhodesia	4 3	3 6
Messina (5s.), Transvaal	9 6	7 6
Mount Lyell, Tasmania	1 10 0	16 3
Namaqua (£2), Cape Province	7 6	7 6
N'Changa, Rhodesia	2 10 0	2 7 6
Rhodesia-Katanga	1 3 9	18 9
Rio Tinto (£5), Spain	36 2 6	30 5 0
Roan Antelope (5s.), Rhodesia	1 0 9	16 3
Tanganyika, Congo and Rhodesia	1 13 0	1 8 9
Tharsis (£2), Spain	4 0 0	3 11 3

LEAD-ZINC:	Sept. 10, 1930. £ s. d.	Oct. 10, 1930. £ s. d.
Amalgamated Zinc (8s.), N.S.W.	8 0	7 9
Broken Hill Proprietary, N.S.W.	12 3	11 6
Broken Hill, North, N.S.W.	1 17 6	1 8 9
Broken Hill South, N.S.W.	1 8 9	1 2 6
Burma Corporation (10 rupees)	11 9	9 3
Electrolytic Zinc Pref., Tasmania	1 0 0	16 3
Mount Isa, Queensland	18 9	16 3
Rhodesia Broken Hill (5s.)	2 3	1 6
San Francisco (10s.), Mexico	17 0	13 9
Sulphide Corporation (15s.), N.S.W	8 6	6 9
ditto, Pref.	14 6	13 0
Zinc Corporation (10s.), N.S.W.	18 3	17 6
ditto, Pref.	2 16 3	2 13 9
TIN:		
Aramayo Mines (25 fr.), Bolivia	1 3 9	1 3 0
Associated Tin (5s.), Nigeria	4 3	3 3
Ayer Hitam (5s.)	9 6	8 9
Bangrin, Siam	13 3	11 9
Bisichi (10s.), Nigeria	5 3	5 0
Chenderiang, Malay	1 6	1 6
Consolidated Tin Mines of Burma	3 6	3 6
East Pool (5s.), Cornwall	9	9
Ex-Lands Nigeria (2s.), Nigeria	1 6	1 3
Geevor (10s.), Cornwall	3 0	3 0
Gopeng, Malaya	1 17 6	1 12 6
Hongkong (5s.)	14 0	13 6
Idris (5s.), Malaya	6 6	6 0
Ipoh Dredging (16s.), Malay	16 3	14 6
Kaduna Prospectors (5s.), Nigeria	5 0	5 0
Kaduna Syndicate (5s.), Nigeria	12 0	10 0
Kamunting (5s.), Malay	6 0	4 0
Kepong, Malay	12 6	10 0
Kinta, Malay (5s.)	7 0	6 6
Kinta Kellas, Malay (5s.)	6 0	5 0
Kramat Pulai, Malay	19 6	17 0
Lahat, Malay	6 9	6 0
Malayan Tin Dredging (5s.)	17 0	14 6
Naraguta, Nigeria	8 0	5 0
Nigerian Base Metals (5s.)	9	9
Pahang Consolidated (5s.), Malay	6 9	7 0
Penawat ($1), Malay	1 0	9
Pengkalen (5s.), Malay	10 9	9 6
Petaling (2s. 4d.), Malay	10 0	7 9
Rambutan, Malay	7 6	6 3
Renong Dredging, Malay	19 6	18 0
Siamese Tin (5s.), Siam	7 6	6 9
South Crofty (5s.), Cornwall	2 3	2 0
Southern Malayan (5s.)	10 9	8 9
Southern Perak, Malay	1 10 0	1 7 6
Southern Tronoh (5s.), Malay	5 6	5 3
Sungei Besi (5s.), Malay	6 6	6 6
Sungei Kinta, Malay	11 0	9 9
Tanjong (5s.), Malay	6 9	6 0
Tavoy (4s.), Burma	3 9	3 6
Tekka, Malay	14 6	13 9
Tekka Taiping, Malay	12 6	12 0
Temengor, Malay	2 0	1 6
Toyo (10s.), Japan	2 6	2 6
Tronoh (5s.), Malay	14 6	13 6
DIAMONDS:		
Consol. African Selection Trust (5s.)	1 2 6	1 1 3
Consolidated of S.W.A. (10s.)	6 6	6 0
De Beers Deferred (£2 10s.)	7 1 3	6 12 6
Jaggersfontein	1 8 9	1 6 3
Premier Preferred (5s.)	3 15 0	3 15 0
FINANCE, ETC.:		
Anglo-American Corporation (10s.)	19 6	16 3
Anglo-French Exploration	15 0	13 9
Anglo-Continental (10s.)	6 3	6 3
Anglo-Oriental (Ord., 5s.)	8 0	7 6
ditto, Pref.	12 6	8 6
British South Africa (15s.)	1 13 3	1 10 0
Central Mining (£8)	16 0 0	12 0 0
Consolidated Gold Fields	1 11 3	1 2 6
Consolidated Mines Selection (10s.)	13 0	11 0
Fanti Consols (8s.)	10 9	9 6
General Mining and Finance	16 9	13 9
Gold Fields Rhodesian (10s.)	8 0	7 3
Johannesburg Consolidated	1 18 6	1 13 0
London Tin Corporation (10s.)	11 9	18 3
Minerals Separation	6 5 0	5 7 6
National Mining (8s.)	6	6
Rand Mines (5s.)	2 19 0	2 13 9
Rand Selection (5s.)	8 6	7 6
Rhodesian Anglo-American (10s.)	1 0 0	13 9
Rhodesian Congo Border	14 0 0	11 0 0
Rhodesian Selection Trust (5s.)	1 10 0	1 1 3
South Rhodesia Base Metals	6 3	4 0
Tigon (5s.)	12 6	10 0
Union Corporation (12s. 6d.)	3 4 6	2 15 0
Venture Trust (10s.)	5 0	4 9

THE MINING DIGEST

A RECORD OF PROGRESS IN MINING, METALLURGY, AND GEOLOGY

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

THE FLIN FLON PILOT MILL

Concentration and cyanidation at the Flin Flon pilot mill are described by S. P. Lowe in a paper appearing in the *Canadian Mining and Metallurgical Bulletin* for September. The author says that flotation testing of Flin Flon ore was started in the Denver laboratory of Complex Ores Recoveries Co. in March, 1926. There had been a considerable amount of flotation testing previously which had shown possibilities of success, and it was felt that, with the increased knowledge of flotation and the comparatively new reagents then available, flotation held out the best prospects for a successful commercial treatment of this ore. There remained available for this experimental work a small amount of the rejects from a thorough sampling of the mine and some ore from the mine dump.

DESCRIPTION OF ORE.—The Flin Flon ore-body contains two distinct types of ore: heavy sulphide, and disseminated. Average assays of these are as follows:—

	Heavy Sulphide Ore	*Disseminated Ore*
	%	%
Cu	1·57	2·05
Pb	0·5	0·0
Zn	4·4	1·12
SiO_2	4·0	29·1
S	37·0	12·9
Fe	35·0	19·3
MgO	1·0	8·0
Au	0·095 oz. / ton	0·018 oz. / ton
Ag	1·4 "	0·29 "

The copper mineral is principally chalcopyrite; the zinc is present in sphalerite, of which there are three varieties: dark, high-iron marmatite, normal sphalerite, and a low-iron type which contains 53% Zn and 8% Fe. The iron is mostly contained in pyrite, but there is some pyrrhotite and a little magnetite in the ore. The lead mineral, which is spotty, is galena. In the disseminated ore there is a large amount of talc and occasionally some quartz.

EXPERIMENTAL TWO-TON PLANT.—After preliminary laboratory tests a continuous two-ton-a-day plant was installed at the Denver laboratory. To supply this pilot plant with ore it was necessary to ship several carloads of ore from the dump at the mine. Fresh ore could not be obtained as the mine was under water. The ore was crushed to ¼ in. at a local sampling plant.

The two-ton test-plant was started, treating ore from a mine at Telluride and gave quite good results, and on July 1, 1926, Flin Flon ore was treated. Trouble immediately developed, due to the high specific gravity of the ore, but, after various changes, good results were obtained, tailings assaying 0·25% Cu and 0·6% Zn, copper concentrates assaying 18·0% Cu, 5·0% Zn, and zinc concentrates assaying 1·2% Cu, 44·0% Zn, being quite regular, except on a small lot of ore which contained a considerable amount of disseminated ore, which contains a large amount of talc. The plant was run until September 25, 1926, when it was shut down until November 26. It was then started again on another shipment of ore, and good results were obtained.

In all the flotation work, it had been apparent that there would be a material loss of gold and silver in the tailings. Cyanide tests were run with the object of reducing this loss, and it was found that most of the extraction took place in the first four hours and that a considerable amount of cyanide could be saved by stopping the agitation at this point. The following results show this effect quite clearly:—

Time of Agitation	*NaCN consumed per ton of tails*		*Assay of tails*	
	Gross	*Net*	*Au*	*Ag*
Hrs.	*lb.*	*lb.*	*oz.*	*oz.*
2	2·8	1·9	0·024	0·60
3	3·0	2·0	0·024	0·53
4	3·0	1·9	0·017	0·52
6	3·3	2·1	0·02	0·43
16	4·2	3·3	0·02	0·21
24	4·8	3·7	0·02	0·26
48	5·3	4·0	0·02	0·20

As the amounts of cyanide consumed were all nearly prohibitive, and the solution fouled rapidly, losing about 30% of its dissolving efficiency each time it was used over, even though strengthened with NaCN each time, a considerable amount of work was done on cyanide regeneration. It was found that the Mills-Crowe process gave the best results. In this process, the barren solution, after precipitation with zinc dust, is acidified with sulphuric acid or SO_2 gas. Air is then blown through the acidified solution, carrying off liberated HCN, and is subsequently passed through an alkaline solution, where the HCN is absorbed as $Ca(CN)_2$ or NaCN ready for use again. All free cyanide is transferred, and the complex copper and zinc cyanides are broken up, releasing part of their cyanide content and precipitating the copper. With the available solutions, a saving of 0·6 lb. of copper per ton of tailings was obtained by filtering the precipitate from the acidified solution. After this filtration the solution is thrown away.

Bottle tests using 500-gram charges were run on tailings from tests on the laboratory flotation machine and a small plant was installed to treat the two-ton mill tailings. The work in the two-ton cyanide plant checked the bottle tests and indicated a possibility of direct cyanide treatment in filter presses.

It was decided to instal a 25-ton flotation plant at the mine, with a 10-ton cyanide plant for treating the flotation tailings. The plant, when completed, started up with few mechanical difficulties and by

March 15, 1926, was running smoothly. It has given very steady operation ever since.

A stope was started in the solid sulphide ore to supply the mill feed. Results from March 22 to March 31, 1927, were :

Sample	Assay Au	Assay Ag	Assay Cu	Assay Zn	% Weight	% Recovery or loss Au	Ag	Cu	Zn
Cu concentrate	0·42	14·02	6·31	5·3	3·88	59·6	28·9	42·7	2·5
Zn	0·29	3·20	1·01	41·3	16·87	17·9	28·7	29·7	83·7
Tails	0·078	1·01	0·20	1·45	79·25	22·5	42·4	27·6	13·8
Feed	0·27	1·88	0·57	8·3	100·00				

Although this shows a lower extraction of copper and grade of copper concentrates than was expected, the results were considered fair in view of the small amount of copper in the feed. As the stope went higher, some talc appeared in the ore and began to give trouble in the flotation. It became more and more difficult to obtain either a good grade copper concentrate or a good recovery of copper. The zinc section was not affected much.

At this time, mine development indicated that a close separation could not be made between the disseminated talcy ore and sulphide ore, and flotation work showed that even a comparatively small amount of the " talc " would seriously interfere with the treatment of the sulphide ore. This talc is magnesium silicate containing 55% SiO_2, 27% MgO, and 10% Fe. It has the property of absorbing a certain part of the oils and reagents in considerable amounts, so that the promotor effect of the xanthate is largely overcome, unless a large amount is used, and there is little selective action between the chalcopyrite and the pyrite. Accordingly, test work was again undertaken both in the laboratory and in the mill, in an endeavour to either overcome the effect of the talc or remove it before the regular flotation treatment. Starch, used in a neutral or acid circuit, or starch solution acidified before use and added to an alkaline circuit, was found to both depress and overcome the absorbing effect of the talc to a considerable extent, but it had to be used in exactly the right amount and with exactly the right alkalinity or results suffered. As it is nearly impossible to maintain exact conditions in a mill where the character of feed is variable, the use of starch was discontinued, and a talc flotation substituted. It had been found that a large percentage of the talc could be removed in a low-grade product by adding pine oil to the alkaline ball-mill discharge and floating. Accordingly, a set of Fagergren flotation machines was installed ahead of the regular flotation circuits to remove the talc. It had also been found by this time that aerofloat was less affected by the talc than xanthate, and that zinc sulphate was an aid in keeping zinc from floating with the copper.

Clean concentrates are removed from the first two rougher cells in each circuit. This is a considerable aid to extraction, as the coarse mineral that floated in these cells was reluctant to float again when sent to a cleaner, and it was found that the concentrates from these roughers were of better grade than the concentrates formerly produced when all froth was cleaned. It was also found to be an aid, in obtaining high-grade zinc concentrates, to return the middling froth and cleaner tails to the third zinc rougher instead of to the original feed to the zinc circuit. The addition of the regrind mill, grinding the zinc middlings, lowered the tailings about 0·2% zinc.

Later a mixture of disseminated and sulphide ores was fed to the mill, and the following results were obtained for a considerable period :

Sample	Assay Au	Assay Ag	Assay Cu	Assay Zn	% Weight	% Recovery or loss Au	Ag	Cu	Zn
Cu concentrate	0·32	3·70	14·28	4·1	8·68	49·6	35·5	72·5	6·8
Zn	0·055	1·78	2·05	43·2	9·83	9·7	19·4	11·8	81·6
Tailings (includes talc froth)	0·028	0·50	0·33	0·74	81·49	40·7	45·1	15·7	11·6
Heads	0·56	0·90	1·71	5·2	100·00				

The reagents used to obtain these results were :

To Ball-mill	*To Copper Cells*
2·02 lb. CaO	0·09 lb. aerofloat
2·00 lb. $ZnSO_4.7H_2O$	2·81 lb. NaCl
	0·04 lb. xanthate
To Talc Cells	*To Zinc Rougher*
0·063 lb. pine oil	0·74 lb. $CuSO_4.5H_2O$
	2·00 lb. CaO
	0·15 lb. cresylic acid
	0·12 lb. xanthate
	To Zinc Cleaners
	0·18 lb. $CuSO_4.5H_2O$
	0·55 lb. CaO

Disseminated ore treated alone gave the results shown below.

The mill was operated until March 10, 1928, treating ore from various parts of the mine and trying various changes in flow sheet, other reagents, etc., but it was found that the reagents and modified

Sample	Assay Au	Assay Ag	Assay Cu	Assay Zn	% Weight	% Recovery or loss Au	Ag	Cu	Zn
Cu concentrate	0·12	1·57	18·0	3·95	10·46	70·66	56·27	91·2	33·90
Talc Froth	0·005	0·20	0·4	0·76	16·00	4·50	10·97	3·1	9·98
Tailings	0·006	0·13	0·16	0·93	73·54	4·84	32·76	3·7	56·12
Heads	0·018	0·29	2·06	1·22	100·00				

flow sheet gave the best results on both classes of ore, except that Mineral Separation talc cells were substituted for the Fagergren machine, due to lower maintenance cost and the advantage of having all cells of one type.

As a result of working out the proper flow sheet and reagents, the main points that ensure good results are shown to be :—

Requirement	*Practice*
(1) Fine grinding with avoidance of excessive sliming.	85% — 200 mesh, 65% — 300 mesh.
(2) Removal of sufficient talc.	The amount depending on the feed.
(3) Careful control of alkalinity throughout the circuit.	PH 9·0 to 9·4 in copper circuit; PH 11·6 in zinc rougher circuit; 0·6 lb. CaO per ton of water in zinc cleaner circuit.
(4) Proper pulp density in the flotation circuit and adding as little fresh water as possible to the circuit after the pulp leaves the classifier.	1·3 sp. gr., or 30% solids.
(5) Proper time of conditioning after adding reagents.	From 3·5 to 4 minutes at least ahead of the zinc float.

The cyanide plant was operated during the entire time that the flotation plant was run.

Considerable trouble was experienced with the regeneration process, partly mechanical, due to the large amount of calcium sulphite ($CaSO_3$) formed in the absorbing solution when SO_2 was used for acidification, and partly chemical, due to a 5% SO_2 gas not giving the yield of cyanide that sulphuric acid or liquid SO_2 gives. When sulphuric acid or concentrated SO_2 gas was used, the recovery of cyanide was better than had been anticipated, but as these are both expensive reagents, it would be preferable, if possible, to use roaster gas, which would be available from the smelter at slight cost. It was finally found that water could be used to absorb the dilute gas, forming a 0·5% acid solution, and then added to the solution to be acidified, with results equal to those obtained with sulphuric acid. The net cyanide consumption has been reduced to 1 lb. per ton of tailings, and recent work indicates a further saving of cyanide by treating the precipitates from the acid solution.

The pilot plant was started again in July, 1928, and operated until February, 1929, when it was permanently shut down. During this period, the mill water was obtained severally from Flin Flon, Ross, and Trout lakes, for comparison of metallurgical results. Very little difference was observed. Various modifications of treatment were also tried, with negative results. These consisted of grinding in a comparatively thin pulp, feeding the crude ore to the classifier instead of to the ball mill, thickening the classifier overflow before flotation, separate flotation treatment of the middlings, separate flotation circuit of the rougher concentrates, and thickening the copper flotation tails before the zinc flotation. The use of a comparatively thin pulp in the ball mill, and a separate flotation circuit of the rougher froth, have still considerable possibilities. Various other reagents, such as sodium aerofloat, carbolic acid, amyl xanthate, cyanide, etc., were tried, but no improvement in results was obtained. An attempt was made to refloat the zinc tails in an acid circuit, and obtain a concentration of gold which would eliminate the cyanide plant, but this was unsuccessful.

The 3,000-Ton Mill.—A description of the present 3,000-ton capacity mill follows :

Both the ore from the open-pit and the ore from the mine are delivered to the same coarse crusher, located beside the main shaft and at the extreme southern end of the coarse crushing plant. This coarse crusher is a 42 in. heavy-duty Traylor gyratory crusher. It is belt-driven and crushes the ore from whatever size is delivered to it (up to 42 in.) down to 6 in. The 6 in. discharge of this crusher is delivered to a 42 in. belt conveyor cushioned by special rubber-covered idlers and is carried from there to one small surge bin having a capacity of 200 tons. From this bin it is fed by two 42 in. pan feeders to two 4 ft. by 6 ft. Hum-mer screens, the undersize from which goes to a 36 in. belt conveyor and the oversize to two fine-type 7 ft. Nordberg-Symons cone crushers, where it is reduced from 6 in. to ¾ in. size. After passing through the Symons cones, the ore strikes the same 36 in. belt conveyor as the undersize of the screens. It is taken first to the south and then back to the north again on another belt conveyor and delivered into one small surge bin of 200 ton capacity, from which it is drawn out on four 36 in. belt feeders. These deliver it to four 4 ft. by 5 ft. Hum-mer vibrating screens. The undersize of these screens drops directly to a 42 in. conveyor, which carries the ore over to the mill. The oversize is sent to two sets of 72 in. by 24 in. Traylor Ajo-type rolls, which crush the ore to approximately ¼ in. size. Thus, the undersize of the screens ahead of the rolls and the discharge of the rolls both join and are carried by the 42 in. belt conveyor from the coarse crushing plant to the head of the concentrator building, where it is sampled by a Geary-Jennings sampler. Then it is distributed by a mechanical belt tripper to seven steel fine-ore bins, in such a manner as to bed the ore in each bin to the maximum possible under these conditions. This tripper is a Stephens-Adamson motor-driven tripper and will fill the bins to a maximum capacity of 1,150 tons each. Each bin has four openings in the bottom in order to draw the ore out evenly and leave as small an amount as possible which cannot be drawn out by the feeders. There is a 24 in. belt feeder under each opening, so arranged that the ore may be drawn from either of two bins and fed on a belt which feeds one ball-mill. There are six of these 24 in. belt conveyors. They deliver the ore, now reduced to ¼ in., to six 10 ft. diameter by 66 in. Hardinge conical ball-mills. Each ball-mill will be charged with 28 tons of balls of a maximum size of 3 in. diameter. It is the intention to use four mills to grind solid sulphide ore and two mills to grind disseminated ore. It is expected that these mills will have a capacity of 500 tons per twenty-four hours, reducing the ore from ¼ in. size to approximately 90% through a 200 mesh to the inch screen. The ball-mill discharge in the sulphide section will be pumped by four 8 in. Wilfley sand pumps to four 16 ft. wide by 23 ft. 4 in. long quadruplex standard Dorr classifiers. There are, in addition, two 8 in. Wilfley sand pumps identical with the others, for use as spares. The sands from the classifiers will be returned by gravity

to the ball-mills for further grinding, and the overflow will also flow by gravity to a 10 ft. by 10 ft. surge tank, and from this tank to a mechanical distributor, which will separate the pulp into five parts for feeding five sets of flotation cells.

In the disseminated section, the discharge of the ball-mills will be pumped by three 8 in. Wilfley sand pumps—one of which is a spare—to two 16 ft. by 23 ft. 4 in. quadruplex standard Dorr classifiers and one 8 ft. by 31 ft. 8 in. by 16 ft. Dorr bowl classifier, the sands from these classifiers returning by gravity to the ball-mills, and the overflow passing to a 10 ft. by 10 ft. surge tank and then to a mechanical distributor which divides it into four parts for flotation treatment. Lime and zinc sulphate are added to all the ball-mills.

There are a total of 466 24-in. Mineral Separation Sub-A flotation cells in the mill, and 37 5-ft. square conditioner cells. Each pair of flotation and conditioner cells is driven by one 7½ h.p. motor and each flotation cell is supplied with 40 cu. ft. of free air per minute at 3 lb. pressure by two 22,000 cu. ft. Ingersoll-Rand centrifugal blowers, one of which is a spare.

The pulp coming from the distributors is fed to nine units of 14 24-in. flotation cells each, five units for sulphide ore and four for disseminated ore. Pine oil is added to these cells, which are used to remove the talc from the ore. The concentrate froth, which contains the talc, is removed from these cells and treated again in nine units of seven flotation cells each, designated as "talc cleaners." The concentrate froth from these cells is removed and flows by gravity to the tailings pumps. Aero-float is added to the mineral-bearing tailings from both of these operations. These tailings thus in reality become the heads to the actual flotation operation. This product, from which the largest amount of talc possible has been removed, feeds 5 units of 14 flotation cells for sulphide ore, and 4 units of 13 flotation cells for disseminated ore, from which a copper-bearing froth is removed and re-treated in 5 units of 4 and 4 units of 3 flotation cells each. These cells produce a finished copper concentrate which flows by gravity to a 75 ft. Dorr thickener for copper concentrates; but a small portion of these concentrates is separated and pumped by a 2 in. Wilfley pump over a half-size Wilfley pilot table and then rejoins the main concentrates. The tailings from the re-treatment of the copper-bearing froth in the sulphide section are pumped by two 6 in. Wilfley pumps, one of which is a spare, to an 8 ft. by 31 ft. 8 in. by 16 ft. bowl classifier, the sands from which flow by gravity to a 10 ft. by 66 in. Hardinge mill for regrinding and are pumped back to the bowl classifier by a 3½ in. Wilfley sand pump. The overflow of this bowl classifier also runs by gravity to a distributor and then to the original copper cells.

In the case of the disseminated-ore section the tailings from the re-treatment of the copper froth are pumped back to the first copper cells by a 3½ in. Wilfley pump.

In the sulphide-ore section, the tailings from the first copper units run by gravity to 5 units of 4 conditioner cells, from which they flow to 5 units of 14 flotation cells each, for zinc flotation. Lime, copper, sulphate, xanthate, and cresylic acid are added to the conditioner cells. These flotation cells produce a zinc concentrate froth which is re-treated in 5 units of 1 conditioner cell and 4 flotation cells. These flotation cells produce a zinc concentrate, a portion of which is pumped by a 2 in. Wilfley pump to a half-size Wilfley pilot table, and this portion then rejoins the main zinc concentrates, which flow by gravity to a 60 ft. by 10 ft. zinc concentrate thickener. The tailings from the re-treatment cells are pumped by a 6 in. Wilfley pump to an 8 ft. by 31 ft. 8 in. by 16 ft. Dorr bowl classifier, the sands from which flow by gravity to a 10 ft. by 66 in. Hardinge ball-mill, whose discharge is returned to the bowl classifier by a 3½ in. Wilfley pump. There is also a spare 3½ in. Wilfley pump for the two regrind mills. The overflow from this classifier goes by gravity to a distributor and then to the zinc conditioner cells. The tailings from the first zinc units flow by gravity to a 90 ft. by 10 ft. tailings thickener. In the disseminated-ore section, the tailings from the copper units flow to 2 units of zinc cells, one of which consists of 6 conditioner and 12 flotation cells and the other of 4 conditioner and 14 flotation cells. Both units produce a froth which is cleaned by a 1 conditioner, 4 flotation-cell unit, and a 1 conditioner, 3 flotation-cell, set. Lime, copper sulphate, xanthate, and cresylic acid are added to the conditioner cells. The tailings from the re-treatment units are pumped by a 4 in. Wilfley pump to the zinc conditioner cells. The tailings from the first zinc units flow by gravity to the tailings pumps.

The copper concentrates, as before mentioned, are thickened in a 75 ft. by 10 ft. Dorr traction-type thickener, the overflow of which passes to the tailings pumps by gravity and the thickened product is drawn out of the thickener by two 4 in. duplex Dorrco diaphragm pumps, which discharge into a 3½ in. Wilfley sand pump. This pumps the concentrates to the filter plant, which is located about 1,700 ft. away in a separate building. The zinc concentrates are thickened in a 60 ft. by 10 ft. Dorr traction-type thickener, the overflow of which goes to the tailings pumps by gravity and the underflow is drawn out by one 4 in. duplex Dorrco diaphragm pump, discharging to a 3½ in. Wilfley sand pump, which pumps the zinc concentrates to the filter plant.

The tailings from the sulphide-ore section are thickened in a 90 ft. by 10 ft. Dorr traction-type thickener, the overflow of which goes to the tailings pumps while the underflow is drawn out by four 4 in. triplex Dorrco diaphragm pressure pumps, which deliver the tailings to the cyanide plant.

The heavy sulphide flotation tailings, after being thickened to a 1 to 1¼ density, are thus pumped to the first of five 18 in. diameter by 18 ft. high Devereaux agitators, each with a 4 ft. impeller. Sufficient cyanide solution is added to these agitators to make the dissolving solution about 4 lb. of cyanide per ton of solution. The pulp flows through these five agitators in series, being constantly agitated, and thence by gravity to two 14 ft. diameter by 18 ft. long Dorrco filters. In these filters the tailings are separated from the cyanide solution and washed with water, the filtrate being pumped to a 28 ft. diameter by 16 ft. long unclarified solution storage tank in which there is placed a Dorr thickener mechanism for occasionally removing the solids. The cake from these filters is re-pulped or mixed with water by a pug mill inside of each filter and flows by gravity to two additional 14 ft. by 18 ft. filters, where it is re-washed and the filtrate pumped to the absorber solution tank. The cake from these secondary

filters is re-pulped in a pug mill and flows by gravity to the tailings pumps, where it joins the other products, i.e., tailings from the disseminated-ore flotation section, talc flotation concentrates, and thickener overflows. All these products combined are pumped by three 8 in. Wilfley sand pumps, one of which is a spare, through a 16 in. pipe-line to the lake at a point on the northwest side of Killarney island. The Dorrco filters referred to in the above paragraph are equipped with four vacuum receivers, from which the solution is drawn by four 4 in. centrifugal pumps and delivered to either the unclarified solution tank or the Devereaux agitators, and the vacuum is maintained on the filters by two Type XRB1 30 in. by 14 in. Ingersoll-Rand vacuum pumps.

The unclarified solution is drawn from the tank by a 5 in. centrifugal pump and pumped through two 42 in., 30 frame, Merrill clarifying presses, where the last trace of slime is removed from the solution. The slime is returned to the agitators, and the solution flows by gravity to a 26 ft. diameter by 16 ft. clarified solution tank. The solution is drawn from this tank by a two-stage 4 in. centrifugal pump and zinc dust is added to it by a zinc-dust feeder and $1\frac{1}{2}$ in. triplex pump. The solution, mixed with zinc dust, then goes through two 52 in., 30 frame, Merrill precipitate presses, which remove the gold-silver-zinc-dust precipitate and deliver the solution by gravity to one 26 ft. by 16 ft. barren-solution tank. The gold-silver precipitate will be treated with acid to dissolve the excess zinc dust, then dried and melted in a small furnace to obtain the gold and silver in the form of bullion, which will be shipped to a refinery.

The barren solution, after the zinc-dust precipitation, will be pumped by a 5 in. centrifugal pump to two units of the cyanide regeneration equipment in series, where it will be mixed with acid or water containing SO_2 and copper sulphate, and the cyanide removed by air and absorbed in lime solution. These units are absolutely tight equipment. The acidified solution from which the cyanide has been removed will be pumped by one 5 in. bronze centrifugal pump through four 42 in., 48 frame, Shriver plate-and-frame filter presses, which will remove a copper sulphocyanide precipitate. The filtrate will flow by gravity to the tailings pumps.

The cyanide regeneration equipment consists of two units, each of which has a tower 8 ft. by 12 ft. in cross-section and 28 ft. high, filled with a checker-work of 2 in. by 4 in. wooden grids, through which the acidified solution passes. This is called a disperser. In addition there is a passage 4 ft. wide by 6 ft. high and 40 ft. long in which eight Hardinge rotor sprays, 12 in. diameter by 4 ft. long, are installed. This is called the absorber. There will be a fan capable of delivering 40,000 cu. ft. of air at 3 lb. water pressure, which will circulate air through the tower and through the rotor sprays and back through the tower again. The lime solution for absorbing the freed cyanide will be pumped from a 28 ft. diameter by 16 ft. absorber solution tank by two 6 in. centrifugal pumps to the absorbers described above, thus flowing through the chamber in which the rotor sprays are placed, absorbing the cyanide from the circulating air, and will then be pumped back to the absorber tank by two additional 6 in. centrifugal pumps.

The copper sulphocyanide precipitate removed from the Shriver presses will be roasted by a small furnace, the design of which is not yet completed, where a certain additional amount of cyanide will be removed as a gas and passed into the absorber units before mentioned. A copper sulphide cinder will be obtained from this roast, and will be transported by car or truck to the copper-smelter bedding bins.

The copper concentrates, as already stated, are drawn from the copper concentrate thickener by the diaphragm pumps and are delivered to the $3\frac{1}{2}$ in. Wilfley sand pumps. They will then be pumped through a pipe-line 1,700 ft. long to an 18 ft. diameter by 8 ft. high mechanical agitator in the filter plant. The zinc concentrates will also be pumped in the same manner to another tank in the filter plant, and a third tank will be provided as a spare for the use of either concentrates. These tanks will be provided with mechanical agitators. The copper concentrates will be drawn from their tank by a 2 in. Krogh sand pump and pumped to one 10 ft. diameter by 14 ft. long Dorrco filter, where they will be de-watered and delivered to a conveyor belt, which will transport them to the bedding bins at the copper smelter. The zinc concentrates will likewise be drawn from their tank by a 2 in. Krogh pump and pumped to an 8 ft. diameter by 10 ft. long Dorrco filter, which will deliver the de-watered concentrates to a belt conveyor which transports them to the 25 ton hoppers over the zinc roasters. These filters are served by two filtrate receivers and two filtrate pumps, which pump the water back to the respective thickeners. The necessary vacuum is maintained by two 26 in. by 11 in. Ingersoll-Rand vacuum pumps, one of which is a spare.

In case low-grade zinc concentrates are made in the disseminated-ore section, these will be thickened in a 16 ft. by 10 ft. Dorr thickener, drawn out by a 2 in. Dorrco diaphragm pump and delivered to a $3\frac{1}{2}$ in. Wilfley sand pump, which will pump them to the Moore filter in the zinc leaching plant, where they will be combined with the zinc leaching residue for further treatment.

SWEDISH GEO-ELECTRICAL PROSPECTING METHODS

A pamphlet published by the Geological Survey of Sweden for the Fourth General Assembly of the International Union of Geodesy and Geophysics comprises a summarized survey of Swedish geoelectrical methods by K. Sundberg, H. Lundberg and J. Eklund. Since these authors published in the Year Book of the Swedish Geological Survey for 1925 a paper entitled "Electrical Prospecting in Sweden" there have been important developments of these methods in other countries, one of the most notable being their application to electrical investigations of structure for oil prospecting purposes. The present paper contains a résumé of the theory of the various methods and then proceeds to possibilities of their application, finally summarizing results obtained.

Electrical Properties of the Earth's Crust.—Electrical conductivity is the most important property for the application of geo-electrical methods, as the underlying principle is to locate

bodies with conductivity differing from that of the surrounding material. There are three factors which mainly determine the electrical conductivity of ores and rocks, (1) the conductivity of the dry sample, (2) the conductivity, and (3) the content of, impregnated waters.

The conductivity of most dry minerals except certain ore-minerals is practically zero and factor (1) is therefore of importance only for certain ores. many ore-minerals having a very good conductivity. With the exception of material made up of such minerals the conductivity of the rest of the earth's crust, i.e. of most soils and rocks, is determined by the conductivity and content of impregnated waters. The conductivity of such waters can be determined either directly, if samples are available, or indirectly from the analysis. The most important chemical constituent in waters for judging their electrical conductivity is chlorine, it being possible to roughly determine the specific resistance of waters—except the purest ones—from their chlorine content alone. The specific resistance of waters in nature varies from a few ohms per cm.^{3} to several hundred thousands.

The maximum amount of water possible in a soil or rock equals the pore volume. The pores of rocks beneath the ground water level are generally considered completely filled with water (or partly or completely with gas or oil in exceptional cases). Pores of soils and rocks above the ground water level are only partly filled with water, the water content generally being very low at the surface, increasing with depth to a maximum at a certain distance above the ground water level and then decreasing. The pore volume of different soils and rocks differs considerably, from over 90% for the most porous soils to a fraction of 1% for igneous rocks. Unconsolidated sediments have, next to soils, the greatest pore volume, the pore volume for sediments generally decreasing with their metamorphism.

The relation between a resistivity factor p and the water content v of rocks or any porous material is such that the specific electrical resistance of a rock containing v_x% water, of specific electrical resistance ρ, is $pv_x \cdot \rho$. The resistivity factor can, for practical purposes, be considered to depend upon the water content only and thus does not seem to change much with the different configuration of the pores. The resistivity factor is of the magnitude 100 for igneous rocks and crystalline schists, 50 to 100 for dense lime- and sandstone, 20 to 40 for clays and sands, and 2 to 20 for porous clays, sands, limes, sandstones and soils.

The specific electrical resistance of igneous rocks and dense insoluble rocks is generally very high, due to the small pore volume and the pure water in the pores. The magnitude of the specific resistance for such rocks is 10^5 ohms/cm.^{3}. The specific electrical resistance of young sediments varies tremendously and is generally low, due to high porosity and salt waters in the pores; values as low as 100 ohms/cm.^{3} and less occur.

Classification of Geo-electrical Methods.—Geo-electrical methods are characterized by supplying current to the ground and investigating the current-distribution via the electric or magnetic field of the currents. The current may be supplied galvanically by grounded electrodes, or inductively by a primary current sent through closed loops. Consequently the methods may be classified in the following way:

I. Galvanic Methods, using electrodes.

Electric field investigated.	Magnetic field investigated.
Potential Methods.	*Electromagnetic Methods.*

II. Inductive Methods, no electrodes.

Electric field investigated.	Magnetic field investigated.
Inductive Potential Methods, (seldom used).	*Inductive Methods.*

The Swedish geo-electrical methods are alternating current potential-methods, with linear electrodes as a speciality, and electromagnetic and inductive methods, with special arrangements to investigate the magnetic field (" two frame " and " amplitude and phase "-methods).

Potential Methods.—The following theoretical cases have been treated: (1) Sphere in infinite medium traversed by current in a certain direction, (2) sphere in infinite medium, containing a linear electrode, (3) lenticular bodies, mainly referring to small scale-investigations, (4) horizontal layers of small horizontal extension, referring to small scale-investigations, and (5) horizontal layers with infinite extension. The cases 1–4 refer to ore-problems and case 5 to structural problems.

The theoretical considerations are mainly based upon Lord Kelvin's theory of images, which is strictly valid for direct current only. In ore prospecting the direct current-theory is generally sufficient, even when using medium frequent current, and the conducting bodies are located below the largest potential-anomaly, the bodies being outlined by observing the potential-gradient.

The horizontal-layer-theory results in methods to determine depth and conductivity of the different layers.

Electromagnetic Methods.—These methods may be said to lie between potential and inductive methods and the more elaborate theories given for each of these two groups of methods apply in combination. Generally speaking there results a concentration of the current in the best conductors, by which these are located. In case the conductor dips steeply and has lenticular form, as many ore-bodies have, the horizontal component of the secondary electro-magnetic-field will have its maximum and the vertical component its inflexion-point right above the conductor.

Inductive Methods.—The following cases have been treated: (1) Cylindrical conductors in a homogeneous field, the axis of the cylinder paralleling the field, (2) lenticular bodies, referring to small-scale investigations, (3) horizontal layers of small horizontal extension, referring to small-scale investigations, and (4) horizontal layers with infinite horizontal extension.

Good-conducting vertical bodies or horizontal bodies with small extension may be located by assuming the secondary currents concentrated along the border-lines of the conductors. The conductors will, therefore, generally be located by the maximum horizontal component and inflexion-point of the vertical component. The

theory for horizontal conductors is the application of a theory given by Levi-Civita for "thin" and by Pollaczek for "thick" conductors. These theoretical considerations are the fundamental basis for the present application of Swedish geo-electrical methods to structural investigations.

Influence of Magnetic Permeability.—Magnetic, as well as conducting material gives indications when investigating with alternating current.

Investigating Electric and Magnetic Fields.—The most simple way to investigate the electric field is by tracing so-called equipotential lines. For a complete investigation of the field two principles are used: (*a*) Amplitude and phase of potential-difference between any two points is determined, and, (*b*) ratio and phase difference between two potential-differences is observed.

The magnetic fields encountered in electrical prospecting are often elliptic, due to phase differences between the components of which the resultant elliptic field is composed. To investigate the field completely it is also necessary to know amplitude and phase of two field-components, for instance the vertical and the horizontal in the plane of the field-ellipse. To determine these or any other field-components two principles are used, as in electrical field-investigations: (*a*) Amplitude and phase of the field-component is observed, and (*b*) ratio and phase-difference between two components is measured.

Possibilities of Application.—It is at the present time possible to use geoelectrical methods:

(1) For indentification of geological formations (stratigraphical investigations), of importance to help the geologist to correlate beds on the surface and in drill-holes.

(2) To determine depth to water-tables, of importance for water-searching.

(3) To ascertain depth to bed-rock, for instance, in locating foundations for heavy structures.

(4) To find ore-bodies.

(5) For structural studies, especially in connexion with prospecting for oil.

Of these applications the two last-mentioned are at present by far the most important.

Investigation of Ore-deposits by Geo-electrical Methods.—The possibilities of geo-electrical methods in rendering services for the exploration of ore-deposits are limited by the conductivity of the ore, the shape and size of the ore-bodies, the depth to the conductive part of the ore-bodies, the barren conductors accompanying the ore-bodies etc. Swedish and foreign experience regarding geophysical prospecting on different types of ore-deposits may be summarized as follows:

(*A*) *Ore-deposits related to magmatic activity:*

(1) *Deposits of titano-magnetite.*—Will give distinct indications when investigating by means of magnetic, electric and gravimetric methods.

(2) *Deposits of chromite.*—Hard to discover by geo-electrical methods. Only some types of chromite are conductive.

(3) *Platinum deposits.*—Some primary deposits, especially of the norite type, with the platinum associated with sulphides may be traced by geo-electrical methods.

(4) *Deposits of nickeliferous pyrrhotite.*—This type is very easy to prospect by geo-electrical methods. Low grade disseminations causing electrical indications may be distinguished from the ore-bodies by gravimetric methods.

(5) *Deposits of magmatic bornite etc.*—This type has been successfully investigated by geo-electrical methods. Interfering indications are caused by titano-magnetite.

(6) *Deposits of intrusive pyritic ore.*—On this type of ore some of the most successful geo-electrical surveys have been made. Interfering indications are caused by disseminated pyrite and graphitic slate. The solid ore-bodies may be distinguished by a gravimetric survey of the electrical indications obtained.

(7) *Deposits of magmatic non-titaniferous iron-ore.*—This type is usually highly magnetic, but parts of the ore-bodies may consist of conductive, but slightly magnetic, specularite, distinguishable from the barren, slightly magnetic, wall-rock, only by electrical or gravimetric methods.

(8) *Gold-quartz veins and quartzose silver veins.*—The content of conductive minerals (pyrite etc.) is usually not high enough to obtain electrical indications on the ore-bodies. Nevertheless the geo-electrical methods may often render good service in investigating the structure of the districts of the deep-seated type. The gold-quartz deposits are often confined to folding zones with graphitic layers or shear-zones with pyrite.

(9) *Copper veins.*—This large group may be divided into deposits with strong veins and those with clusters of veinlets, worked as a unit. The former type is easy to investigate by geo-electrical methods, especially when pyritic. The other type seems to be harder to prospect, owing to the general low sulphide content of the deposits, and the usually great depth of the oxidized and leached zone. Experience in geo-electrical surveying of this group of ore-deposits is scanty and needs to be enlarged.

(10) *Veins with zinc and lead ore.*—These veins are usually strong and of a simple form. Their suitability for electrical methods depends on the content of galena and pyrite and if these minerals are lacking, or occur as insulated grains, patches or crystals, they are difficult to locate by geo-electrical methods. Indications are sometimes to be expected only on minor rich parts of the ore-bodies.

(11) *Molybdenum veins.*—Deposits of molybdenum ore most resemble copper veins. The better ore is conductive and suitable for electrical prospecting.

(12) *Tin and tungsten veins.*—This type of ore is only conductive when accompanied by enough sulphides, which often is the case. On such veins geo-electrical methods have proved successful.

(13) *Iron and manganese veins.*—Veins with iron and manganese are conductive when the ore minerals are oxides as specularite, manganite etc. Hydrates and carbonates are not conductive.

(14) *Metasomatic magnetite and sulphide deposits in silicate rocks.*—In these types of ores the ore-bodies have been formed by replacement at high or intermediate temperature of silicate and carbonate rocks, at the same time forming new silicates. The ore-bodies are mostly lenticular or irregular and their conductivity high. Barren indications may be obtained from graphitic zones, lean magnetite and unworkable sulphide disseminations. Magnetic and gravimetric investigations of the electrical indications may render good services.

(15) *Metasomatic low-temperature carbonate and sulphide deposits in limestone.*—The successful prospecting of this type of ore depends upon the amount of conductive sulphides and their arrange-

ment. The most important types are iron carbonate, galena, and blende deposits. Of these only the galena deposits are favourable, and only when the galena occurs in continuous bands, veins etc. Great trouble is caused by the conductive sulphate waters generated by the oxidation of the sulphides, and which remain stagnant in solution cavities or pores in the limestone, or which have been absorbed by clay layers.

(16) *Ore deposits with gold, silver, mercury etc., formed by impregnating porous rocks.*—To these types belong certain slightly sulphide-bearing gold-silver deposits in volcanic breccias etc. and most mercury deposits. They are all formed at shallow depth and at low temperature. The shape of the ore-bodies is mostly irregular, in some cases vertical pipes. The content of conducttive minerals is also irregular and the possibilities of a successful use of geo-electrical methods must be investigated in each case.

(*B*) *Ore Deposits related to surface processes.*

(1) *Sedimentary deposits of iron ore.*—The non-metamorphic deposits are not conductive. As these exist as extended horizons in porous sedimentary strata, their position can be determined from a general geo-electrical structural survey. When subject to thermal metamorphism, the earthy iron minerals are changed into conductive specularite and magnetite and may easily be located by geo-electrical methods.

(2) *Sedimentary manganese deposits.*—These deposits are in a geo-electrical respect different to the foregoing in that most of the primary manganese minerals are conductive, but some of the metamorphic non-conductive.

(3) *Placer deposits.*—This type is not conductive. In cases of heavy accumulation of "black sand" the deposits may be outlined by magnetic methods.

(4) *Deposits formed by residual weathering.*—Such deposits contain no conductive minerals. When hidden under a cover they may be porous enough to be located from their water-content.

Stratigraphical and Structural Problems.—The solution of stratigraphical problems by geo-electrical methods consists in identifying certain geological horizons by their electrical conductivity. As the electrical properties of rocks are determined by content and chemical composition of the impregnated waters, it is natural, that the identification electrically of young marine deposits, as compared with fresh and brack water-deposits, is most simple, because the difference in conductivity is generally very pronounced in this case. The conductivity of the marine deposits is of course highest and the fresh-water-deposits show the lowest conductivity. It is well known that structural information is of the utmost importance for the location of new oil-pools and for predicting the extension of known ones. By geo-electrical methods the structural information is obtained by mapping the configuration of a bed with a conductivity differing from the adjoining beds. Before starting an electrical structural survey, as much information as possible should be gathered regarding the pore-volume and composition of the waters in the area to be investigated, by which may be predicted, which geological horizon can be mapped electrically.

(*To be continued.*)

PROGRESS IN ZINC AND LEAD METALLURGY

Zinc.—In the Mineral Industry during 1929 (Vol. 38) W. R. Ingalls reviews the progress in zinc metallurgy during that year. He says that although economically the zinc industry, the world over, was in a state of great depression during 1929, there never was a time when there was so much of metallurgical interest and so much looking forward technically. Perhaps there is a direct association of these conditions. Improvement generally is born in adversity.

Roasting.—The managements of Rose Lake and Langeloth plants are well satisfied with the big furnaces of the McDougall type that they installed. Other plants entered upon installations of the same type, although not so boldly except at Rosita where the Langeloth design was followed. The furnaces at Langeloth are unique in that they roast autogenously. Owing to certain constraints of the sulphuric acid system there, however, the roasters have not yet been pushed to their contemplated capacity.

In Europe also there was an increasing tendency toward the mechanization of blende roasting. The Vieille Montagne company continued to add to its equipment at Baelen which plant was expected to be 80% mechanized by the end of 1929. Its Borbeck plant in Germany has been similarly mechanized. At both of these plants Spirlet furnaces have been installed. The Soc. Metallurgique de Prayon erected 20 Spirlet furnaces at Prayon, substituting them for the Delplace.

Dust Collecting.—Furnaces of the McDougall type create a large percentage of dust, 8% or more, in roasting flotation slime. Rose Lake collects the dust and fume by Cottrell precipitation. Langeloth adventured with Sirocco collectors. The latter have not been entirely satisfactory in dealing with hot gas containing lead fume, and the draughting of the system by exhausters operating under severe conditions is not altogether agreeable. Either with Cottrell precipitation or other means the dust-laden gas is first conveyed through a settling flue, and it is really surprising how much of this excessively fine dust drops out if the velocity of the current be sufficiently reduced.

Sintering.—The practice in the United States is generally with the Bellefroid, or Baelen process, in which the pre-roasting is carried down pretty far and the sintering is done with the addition of 3 to 6% of carbon. Bartlesville has been the one plant following the Rigg process, in which the pre-roasting is carried down to only about 9% sulphur and no carbon is subsequently admixed. Recently Blackwell went over to the Rigg process. The pre-roasting is greatly expedited, but sintering appears to be slowed. In American practice, the Rigg process can be used only where the sintering gas can be dispersed without creating a sulphur nuisance. In some European practice the sinterers, both straight line and annular, are so sealed that their gas is sufficiently enriched to be useful for sulphuric acid manufacture. It may come to this in the United States, considering that more attention is being given to filtering the Dwight-Lloyd gas, wherefore it is desirable to reduce its volume. Further reference to this will be

found under the head of cadmium recovery. Reduction in the volume of this gas is desirable for other reasons.

The Overpelt process of super-roasting, so called, was described in a paper in the *Revue Universelle des Mines*. In this process the ore is pre-roasted down to 5 to 7% sulphur and is then moistened with water to which a small proportion of ferrous sulphate is added. The mixture is then kneaded and extruded as threads about 4 mm. in diameter and 20 mm. in length. After drying, these threads are delivered to the sintering machine, which is able to take a bed about 20 in. deep, which is more than is possible in the United States in dealing with fine ore. The purpose of the Overpelt process is obviously to increase the porosity of the bed. The Belgian report indicates good desulphurization and increase of density of the sintered product. The expense of making the ore-spaghetti, so to speak, must be considerable, however, if we may judge from similar trials in the United States.

Distilling.—The great event of 1929 was the commercialization of the method of continuous distillation that has been developed by the New Jersey Zinc Co. In the early part of the year a commercial unit was put in operation at Palmerton, distilling willemite ; and soon afterward a similar unit at Depue, distilling the ordinary run of western ore. The Palmerton unit possesses daily capacity for about 100 tons of ore and the Depue unit for about 50, these units having respectively 16 and 8 tubes. The ore charge is mixed with carbon and briquetted. The heating of the tubes is by external combustion of producer gas.

The St. Joseph Lead Co. did extensive and large scale experimentation with the Gaskill process, a continuous electrothermic process, which may be directed either toward the production of spelter or the zinc vapour may be burned for collection as zinc oxide. The Gaskill process differs from the Cornelius and other electrothermic methods in that it is a straight process of zinc reduction rather than a process of zinc-lead smelting. It is more in accordance with the ideas of Dr. C. H. Fulton, but it provides for continuous operation whereas his is intermittent.

The Roitzheim-Remy furnace installed at Avonmouth proved a failure. Nothing commendatory in respect to this furnace has been heard from anywhere in Europe, and it is doubtful if any of them be any longer in operation. As for conventional methods of distillation in the United States there are no longer opportunities for any great novelties. Under some conditions the silica-flour retorts have been definitely proved advantageous, but not universally so ; likewise as to carborundum retorts. In general, however, the regulation clay retorts are used. In the remodelling of Rose Lake plant Hughes gas producers were installed as a centralized battery, as at one of the plants at Stolberg. This has proved to be a good method. Rose Lake, using a good grade of coal, has the lowest consumption per ton of ore distilled of any plant known. However, the Rose Lake furnace practice is not of the order that would be characterized as hard driving.

Waelz Process.—The Waelz process has come into extensive application in Europe, especially as a means of burning the zinc out of low-grade ores that are not amenable to concentration by the flotation process, low-grade calamines coming generally under that head. The process is also useful for burning zinc out of residues from ordinary distillation. The addition of a Waelz furnace to a distillery enables a high final extraction of zinc to be made. Such an appendage has been provided at Donora, where it is giving highly satisfactory results. Similar provision has been made at Palmerton. The Waelz furnace for efficiency ought to be of 100 tons daily capacity at least. In order to get that quantity of retort residue there would have to be a smelting of about 250 tons daily of raw blende, which is in excess of the capacity of most plants. Deficiency may be made good, however, by drawing from old dumps. At a convention in Germany last October of concerns that are now using the Waelz process it was stated that such plants actually in operation were then treating 1,000,000 tons of raw material per annum, not taking into account plants in course of construction ; and that the actual zinc production of the Waelz plants amounted then to at least 5% of the world's total production.

Cadmium Recovery.—The good market for cadmium naturally attracted attention to its recovery, it being desirable anyhow to keep it out of the spelter. A considerable proportion of the cadmium in zinc ore is volatilized during roasting and is collected in the precipitated dust and fume. A further proportion is volatilized during sintering, and at least one American plant is filtering the sintering gas through a bag house. By the addition of a little salt to the ore the latter can be pretty completely deleaded and de-cadmiumized. From these several dusts cadmium and zinc may be dissolved with sulphuric acid and from the solution cadmium may be precipitated as a sludge by the addition of metallic zinc. With the purified zinc sulphate liquor several things may be done. The cadmium sludge may be subjected to electrolytic treatment or to fractional distillation.

The direct use of roasted zinc ore as a source of zinc for lithopone manufacture also results in cadmium as a purification by-product.

Electrolytic Process.—The Kellogg plant started regular operation during 1929, and later on so did the Monsanto plant. Both of these employ high current density, high acidity and the Tainton anodes. They make spelter assaying 99·99% Zn. With ordinary anodes spelter of the same grade is now being made, this being accomplished by better solution purification, which is only a matter of cost. The die-casters appear to have definitely made up their minds that they want super-zinc and are willing to pay a super-premium for it. About the only important change in Anaconda methods was a speedier separation of solution from residue in order to minimize resolution of impurities once precipitated.

The Consolidated Mining and Smelting Co. introduced the practice of dezinking its slags from residue smelting, substantially after the fashion of the Anaconda company at East Helena. One of the most radical changes in the electrolytic process at Trail was the installation of a mercury vapour arc rectifier to convert alternating current into direct current. The rectifier cylinders, which are water cooled, contain a pool of mercury forming the cathode, while projecting through the top are iron rods, forming the anode. A starting device produces an arc, which vaporizes mercury and thereafter the current passes continuously in one

direction from anode to cathode. The chief advantages as compared with rotary transformers are lower cost of maintenance, absence from disturbance by surges in the transmission line, silence and economy of space. With increased current obtained by this installation, electrolytic deposition capacity was increased by adding to the number of cathodes per vat.

The new electrolytic plant at Eitrheim, Norway, of the Norske Zink Kompani was put in operation during 1929. This plant treats ore from the Reocin mines in Spain. The plant follows the Anaconda design. The Reocin ore contains considerable soluble magnesia and consequently a portion of the electrolyte has to be diverted, stripped of zinc and discarded, in order to prevent unwieldy accumulation of magnesia in solution.

Lithopone.—The manufacture of lithopone is to be viewed more and more as a hydrometallurgical process for the beneficiation of zinc ore, which is becoming an increasing source of supply of the zinc for that material. The zinc may be burned out of the ore by the Waelz process and the collected fume may be digested with sulphuric acid; or the ore, if of sufficiently high grade and of good solubility after roasting may be digested directly. Joplin ore affords solubility as high as 98%, and incidentally yields its cadmium content. In 1929 a greatly increased quantity of Joplin ore was consigned to lithophone manufacture. In this instance there is a higher percentage of zinc recovery than from any other method for the treatment of zinc ore.

LEAD.—Developments in lead metallurgy are discussed by D. F. Walsh in the Mineral Industry for 1929 (Vol. 38), where he says that as regards the metallurgical extraction of metals from ores, in the case of no other metal have these changes been less marked recently than in that of lead. The lead blast-furnace is still holding its own in practice with no changes in design or operation over the past year.

Improved Ignition Muffle for the Dwight-Lloyd Roaster.—The Bunker Hill smelter reports the development of an improved ignition muffle for the Dwight-Lloyd sintering machine, which is said to be of especial worth in roasting ores high in lead and relatively low in sulphur. With this device the ore is ignited with the least amount of heat and suction, gradually increasing both until the pallet reaches the wind-box, where the greatest amount of suction occurs and the arch (of the igniter) is at its lowest point, thus giving the most intense heat. Ignition is advanced both in length and breadth of the ore-bed, and also in depth, so that ignition in this device amounts to a well-advanced combustion before the ore reaches or is subject to the full action of the wind-box. This prevents the fusing of the top of the ore charge, which so often forms a seal preventing the free passage of air and good roasting, a condition which occurs frequently when the charge is ignited initially over the wind-box, with a maximum amount of suction and intense heat over a narrow width.

Complex Ore Investigations.—Microscopic studies of complex ores conducted at the Intermountain Station of the U.S. Bureau of Mines show that the microscope has an almost unlimited field of application to the various phases of ore-dressing problems. Since the amenability of these ores to flotation or other treatment depends primarily upon a knowledge on the part of the operator of their physical structure, the data supplied are invaluable.

Blast-furnace Investigations.—A series of investigations on "Smelting in the Lead Blast Furnace" were undertaken during the past year by G. L. Oldright and Virgil Miller of the U.S. Bureau of Mines. Five different phases of the subject were covered: a method for approximating the form of the lead in slag and other products of the lead blast-furnace; gases from the top of the blast furnace; rate of descent of stock column and formation of accretions; composition and temperature of the gases at the tuyère zone; and the effect of conditions at various tuyères on the form of lead and composition of the slag. The investigators say: "In closing this first series of five papers on smelting in the lead blast furnace, the reader's attention is again directed to the fact that data have been collected from only one furnace that was thought typical of a large district. It is planned to continue and extend the examination of the lead blast furnace after the plan indicated, in order to learn the conditions obtaining elsewhere." In the paper dealing with stock descent and the formation of accretions, data show that the rates of smelting in various parts of the furnace cannot be calculated directly by measuring the rates of subsidence of various areas at the surface of the charge, due to lateral movement of the charge in the furnace, and to other irregularities in the descent of the stock column caused by accretions in the shaft. In general, the rate of subsidence is fastest over the slag-tap end. When more data are accumulated, some general fundamental conclusions may be drawn which no doubt will be of great aid in furthering the efficiency of blast-furnace operations.

Desilverization.—The double-crust system of desilverization is still in use at the Bunker Hill smelter; the past year has seen an improvement in gold-silver recovery together with a decrease in operating time required. After the usual drossing and softening of the bullion it contains 1·2 oz. gold and 100 oz. silver per ton; it then goes to the desilverizing kettles, where first a gold crust, containing practically all the gold and one-eighth of the silver, is obtained, and then a silver crust, which contains the rest of the silver and a trace of gold. The gold crust is retorted, cupelled, and parted with sulphuric acid in the ordinary way. The silver crust is liquated to remove the lead (48% of the total weight) and then retorted to a bullion, containing 12,800 oz. of silver. This is then cupelled (Rhodes type cupel) to a fineness of 997·4 Ag (0·015 Au) and melted in a Monarch furnace, where it is brought to a fineness of 999 + .

Secondary Lead.—The recovery of lead from waste material is a branch of the lead industry not to be overlooked. In 1929 about 35% of the United States lead production came by way of reclamation of secondary lead, the sources being old pipe, battery plates, cable sheathing, lead linings, and junked bearing metal, solder, and type metal. The most important of these is old battery plates. The metallurgy involved in reclaiming this secondary lead is of a simple nature; no great improvements have been developed recently. More attention was given to careful sorting of scrap, minimizing health hazards, and to a study of metal losses in handling battery plates. This

branch industry is of considerable magnitude and is expected to grow.

New Uses for Lead.—In addition to Amaloy, which is being used for soldering work in the automotive and electrical industries, a few other new uses for lead have come into prominence lately. In building construction, interest is evoked by the use of lead mattresses to act as shock absorbers between the foundations and the steel framework of sky-scrapers. In one building in New York about 55 tons of lead appear to have been used for this purpose. A lead-calcium alloy which is finding wide application as cable sheathing has recently been developed. A small percentage of calcium added to lead increases fatigue strength and in consequence is of great value in standing up under reversals of stress so often encountered in cables due to expansion and contraction. The chromium-plating industry is taking considerable lead sheet for lining and anodes. More and more lead is used in the making of ethyl gasoline, not in terms of grams per gallon, but in terms of tons per annual gallon production, the amount of lead consumed increasing as the demand for the special gasoline increases. Through the work of the Bureau of Standards much valuable information is being obtained regarding lead-base bearing metals. A new bearing metal, 25% lead and 75% copper, is meeting with favourable comment in certain automobile plants. The new lead-alloy anodes for the electrolytic zinc industry are considered a development of technical importance. In the pigment field, " Subox " has been developed. It is a very finely divided lead suboxide suspended in linseed oil to be used for spraying. After being applied, it undergoes a slow transformation, resulting in a film of metallic lead held firmly as a protective coat by the oxidized oil.

THE READ-ROSEBERY GROUP OF MINES, TASMANIA

The *Chemical Engineering and Mining Review* of Melbourne for August contains some notes on the zinc-lead mines of the Read-Rosebery group. It is pointed out that the mines which will supply the Electrolytic Zinc Co.'s mill at Rosebery, consist of two groups of properties which were developed somewhat extensively many years ago. The primary zinc-lead ores, however, proved to be too complex for profitable treatment by the metallurgy of the time, and it is only the most recent developments in preferential flotation and fine grinding that have rendered the reopening of the mines economically possible. The first group, now known as the Rosebery mine, consists of the Primrose, Tasmanian Copper, and North Tasmanian copper mines, and is situated about the town of Rosebery. The second group, now called the Hercules mine, consists of the Hercules, South Hercules, and Mt. Read mines, and is situated at Williamsford, 4½ miles from Rosebery. The mill has been designed to treat 3,000 tons of ore per week of which the Rosebery and Hercules mines will supply 1,800 and 1,200 tons respectively. The company's present operations consist in preparing the developed portions of the mines for ore extraction on a more systematic plan than was possible with the original lay-out, and also in linking up the workings of the scattered units, and extending development of the known ore-bodies. Furthermore, a systematic diamond drilling campaign was undertaken to prove the extension of these ore bodies in length and depth. In the Hercules mine drilling and cross-cutting have successfully located two new lenses.

Geology.—The zinc-lead-iron sulphide ore bodies of Rosebery are metasomatic replacements of metamorphosed sediments known as the Read-Rosebery series. This series, which is continuous from Mount Read to Mount Black, three miles north-east of Rosebery, overlies the Dundas slates and breccias and is itself overlaid by a series of acid-intermediate igneous rocks which have been classed as porphyries, or, more correctly, keratophyres. Ward, whose work on these rocks appears to be the most authoritative yet published, classes them as an effusive differentiate of a series of plutonic syenites and intrusive porphyries of pre-Silurian age. Subsequent to the deposition of the porphyries, a succession of lateral thrusts contorted and sheared the whole mass and gave rise to the planes of schistosity which have a strike of approximately N. 20° W. in the two groups. These movements probably produced the fracturing parallel to the schistosity, which later served as circulation channels for the metalliferous solutions. A second plutonic intrusion of granite (Devonian) and concomitant metamorphism produced a further system of fissuring, and the formation of the ore bodies was due to the extrusion of the metalliferous solutions under high temperature and pressure during the last stages of the consolidation of this magma.

The lode-bearing rocks consist of the eastern portion of the Read-Rosebery series which has a northerly strike, and the sequence from the east is as follows :—(1) The porphyries, (2) a broad belt of schistose rock which is accepted as being sheared porphyry, (3) the so-called argillaceous schist, (4) quartz schist. With two exceptions the zinc-lead ore-bodies occur in the argillaceous schists. Of these exceptions the first, in quartz schist, has apparently no significance and the second is described below.

The ore-bodies vary from a series of lenses in the Hercules mine to a more or less continuous lode in the Rosebery. They consist of massive zinc-lead ore (sp. gr. 4) with the walls generally well defined. The metalliferous solutions, however, have penetrated far beyond the walls, forming siliceous ore-bodies too low in grade for economic treatment. The bedding planes of the original sediments are not parallel to the axial plane of the ore-bodies, but have been proved to dip at about 45° to the east, while the dip of the ore bodies varies between 40° and 70° to the east in conformity with the schistosity. Throughout the field the average ore consists of a fine-grained, almost microcrystalline intergrowth of massive sulphides containing 10–15% gangue. The distribution of the minerals is very variable, but the following may be accepted as approximately the average composition :—Sphalerite, 36% ; pyrite, 31% ; galena, 8% ; chalcopyrite, 1·5% ; tetrahedrite, 0·1%. The gangue consists of quartz and schistose material with smaller percentages of calcite, barytes, rhodocrosite, and siderite, and the ore contains about 7 oz. of silver and 2 dwt. of gold per ton.

In places the typical zinc-lead ore changes gradually to large masses of hard homogeneous pyritic ore containing only a small percentage of zinc.

Structurally the ore is characterized by persistent banding parallel to the schistosity and this banding, which is due to zones of variable composition, varies in thickness from 0·1 in. or less up to several feet. There is practically no coarse-grained ore and the bands are an intimate intergrowth of sphalerite with either galena or pyrite. The order of deposition given in various reports is pyrite, blende, galena and quartz, rhodocrosite, siderite. This is in accordance with Schuerman's and Weigel's laws.

Hercules Mine.—The ore-bodies in the Hercules mine as disclosed to date consist of 11 erratically distributed lenses of variable size and shape. The lenses have a strike approximately N. 20° W. and a dip of 70° to the east. They show definite foot- and hanging-walls, but the mineralization extends outside the walls in all directions. To the south they fade out into areas of low-grade siliceous and pyritic replacement while to the north they generally pinch or split into comparatively narrow veins. If the precipitation of the lode minerals has been due to some factor peculiar to the argillaceous schist, then it is probable that the steep dip of the lenses will cause them to die out as they approach the flat dipping quartz schists in depth and this has actually been the case up to the present. An occurrence, however, which must cause some diffidence in giving an unconditional acceptance to the present interpretation of the geological data is the recent discovery of the new G lode some hundreds of feet within the zone of so-called sheared porphyry. This ore body was originally located by a diamond drill bore at the No. 4 level. The bore showed a narrow width of medium grade ore in a mineralized formation; subsequent development work disclosed a lode of importance, which has now been opened up from the 3A to No. 5 level. Another distinct ore body has been developed in the old South Hercules mine. This lense is 80 ft. long of average ore, but has been developed on No. 4 level only.

The mine was opened up in the past by many adits, but the levels which will be used as working levels together with the altitude of their portals are as follows :—Level 3A, R.L. 2,855; level 3, R.L. 2,804; level 4, R.L. 2,751; level 5, R.L. 2,613. Level 6 at R.L. 2,402 has been driven but no development work has been done. The main adit level of the Mount Read section was driven at R.L. 2,845, but little work was done at this mine apart from open cutting. A second tunnel has been driven but no development carried out from it, and the present company has opened out the ore-body from an adit at No. 4 level. This lens has an approximate length of 170 ft.

The main haulage level of the mine will be No. 5 adit level which is being extended 1,500 ft. south to connect with the Mount Read section, giving 240 ft. of possible backs to the 2,845 ft. levels. All ore at present blocked out will be run in chutes to this level and future development in depth will be by shaft sunk from the level. The trucking lines will be 2 ft. in gauge, set on a grade of 1 in 150 and the trucks will be one-ton side tippers, horse drawn, in rakes of 10.

The brace of the main level is 1,600 ft. above the Williamsford aerial ropeway bins. Ore is at present conveyed from the mine to this bin by a gravity tram line consisting of a 1¼ in. endless ropeway controlled by a brake drum at the level of No. 4 adit. The mine trucks are attached to the ropeway with a long lead of chain which is necessary owing to sharp changes in slope of the incline. This system will be superseded by one in which the mine trucks will be discharged at the brace into a 200-ton storage bin erected astride the incline. The gravity system will consist of two 8-ton skips while for raising men and stores to the mine an electric hoist will be clutch-coupled to the drums. Owing to the rigorous winter climate a capacious snow-shed has been erected over the brace.

The cost of stope filling for this mine will be somewhat high as the country rock which will be quarried for that purpose by a glory-hole method is hard and difficult to mine. The compressor plant consists of a motor-driven high-speed Belliss and Morcom compressor delivering 1,200 cu. ft. of free air per min. at 90 lb. gauge pressure. The compressor is fitted with an air pressure governor which automatically unloads to the atmosphere as the working pressure is exceeded. Apart from periodical oiling no supervision is required.

From Williamsford the ore will be conveyed by aerial ropeway a distance of 4½ miles to the Rosebery bin. This ropeway, which has 7 cwt. skips, has been described by H. Hey in a recent paper. The layout of the mine and the stoping practice will be similar to that at the Rosebery mine described below.

Rosebery Mine.—In this mine the rock series is varied by an attenuated wedge of slate situated between the sheared porphyry and the argillaceous schist, which in this mine has decreased in width to about 160 ft. The lode is continuous but varies considerably in composition. There are large areas of siliceous and pyritic ore present which are too low in grade to be profitable. The strike of the lode is N. 20° W. and the dip averages 40° to the east and is parallel to both the schistosity and the bedding planes, which is a good augury for the extension of the ore body in depth. The width varies from 4 ft. to 60 ft. with an average of about 15 ft. and the variation in dip is also considerable, the lode being generally steeper in the north end of the present workings.

The ore-body has been opened up by various adits, but the working levels have been reduced somewhat in number. All these levels with the exception of No. 7 have access by means of adits, and have been laid out at the following vertical intervals :—No. 8 to No. 6, 120 ft.; No. 6 to No. 5, 85 ft.; No. 5 to No. 4, 85 ft.; No. 4 to No. 3, 96 ft.

The datum point for levels and sections is the intersection of the lowest adit, No. 8, with the ore-body. This point has a sea level elevation of approximately 549 ft. and all levels and distances given below have reference to it. The surface rises from south to north giving about 250 ft. of backs above the datum, and 1,000 ft. at the north end of the property. The extension of the main shoot is 200 ft. to the south and 3,300 ft. to the north where it has been located in a bore-hole to the north of the North Tasmanian mine workings. A systematic campaign of vertical bores has been carried out from surface to the east of the ore-body and the following are the depth results of a few of these bores :—

At section 2,400 north the lode was located at R.L. 619, at section 800 ft. north R.L. 507, at

section 500 ft. north R.L. 146; at section 200 ft. north R.L. 459, at section 200 ft. south R.L. 447; and at section 400 ft. south R.L. 511. The depths at which the bores cut the ore-body are of course dependent on their distance east of the main ore-body at No. 8 level.

From the datum the ore-body extends south 200 ft. with a width somewhat below the average. At this point it ends abruptly and its southern extension is a narrow vein 2 ft. 6 in. wide prolonging the hanging-wall. In this portion of the mine several small lenticular makes of ore have been located which may furnish isolated stopes. The walls of the lode are generally well marked and in stoping the ore should break easily and cleanly from the wall, but without any undue tendency towards caving.

At the present stage of development No. 4 level has been driven to section 1,700 ft. north and No. 8 to section 1,300 ft. north, the faces of the other levels being at sections intermediate to the above. No. 2 level, the portal of which is at section 1,500 north and R.L. 1,140 has been driven north a distance of 1,500 ft. No work has been done below this level in the north end of the mine apart from diamond drilling. The possibilities of the shoots discovered in this level was shown in the extension of Nos. 3 and 4 levels. In driving No. 3 level the lode channel showed a wide siliceous replacement on the footwall to section 1,500 ft. north, and the drive, on being turned to the east, discovered a high grade hanging wall bulge about 100 ft. long and 40 ft. wide. This had been previously opened up on No. 4 level, but the indications at No. 2 level consisted of an insignificant lens of low grade ore near the mouth of the adit. This shoot has been proved by diamond drill at R.L. 340, but its thickness has decreased considerably at this level. No. 8 adit has been laid out as the main level in mining the ore-body. The cross-cut is 10 ft. wide and 1,450 ft. long; the main drive consists of two square sets each 5 ft. 6 in. wide in the clear; and the level has been driven with a grade of 1 in 150 to the breaker bin. Two tram tracks have been provided of 2 ft. gauge and constructed with 22 lb. rails.

Owing to the fact that the ore will not gravitate freely on the flat underlay of the lode, a main ore pass has been sunk in the footwall on an underlay of 56° at section 650 north. This pass is close to the footwall at No. 4 level, and has been connected to Nos. 5 and 6 levels by cross-cuts decreasing in length. From No. 8 level a main trucking drive was started at the intersection of the cross-cut and the ore-body, and extends to the ore pass on a bearing about N. 30° W. At 400 ft. north a subsidiary pass has been sunk to serve Nos. 6 and 7 levels.

Rises have been put up through the ore-body at 75 ft. intervals and are continuous from level to level. The passes are placed at 20 ft. intervals to obviate the necessity for trucking in the stopes. The chute doors are of the sliding type similar to those in use at Broken Hill. To facilitate the supply of timber and stores to the workings the present method of carting to the adits is being superseded by the formation of a service pass from the main level to the No. 4 at section 1,200 ft. north. This pass will consist of a manway and haulageway which will be operated by an electrically-driven winch placed above No. 4 level.

The ore is generally soft and easily bored except where an undue percentage of pyrite is present. It will be handled on the main level by horse-drawn rakes of 10 two-ton Granby type trucks. For trucking on all other levels horse-drawn rakes of side-tipping trucks will be used.

For mullocking purposes the glacial drift which overlies the outcrop will be used. This drift consists of about 40 ft. in thickness of argillaceous material which makes an excellent filling material as it sets compactly when damp. It will be quarried by a kind of glory-hole system into the main passes, 12 of which have been constructed.

Up to the present time no exploration work has been done below the main adit except by diamond drill.

GENERAL.—The rock drills used are either jack-hammers or light hammer-actuated stopers with water feed connexions. The compressor plant consists of two Belliss and Morcom compressors similar to that installed at the Hercules mine, and capable of delivering 2,000 and 1,200 cu. ft. of free air per min. respectively.

SHORT NOTICES

Mining by Top-Slicing.—H. Willey describes the method of top slicing with filling of slices, as used at the Charcas unit of the Cia. Minera Asarco, S.A., in Technical Publication No. 364 of the American Institute of Mining and Metallurgical Engineers.

Shaft Concreting.—*Engineering and Mining World* for September contains an article by M. D. Banghart on shaft concreting at Zaruma, Ecuador.

Shaker-Chute Mining for Coal.—Technical Publication No. 359 of the American Institute of Mining and Metallurgical Engineers contains a description of shaker-chute mining for anthracite by K. A. Lambert.

Fracture of Haulage Ropes.—H. Herbst discusses noteworthy fractures of haulage ropes in *Glückauf* for August 16.

Cadmium Plating.—Dr. W. S. Patterson contributed a paper on cadmium *versus* zinc plating as rust preventive, to a recent meeting of the Electroplaters' and Depositors' Technical Society.

Tube-Mill Research.—Dr. H. A. White describes experiments on cascading *versus* cataracting in tube-mills in the *Journal* of the Chemical, Metallurgical and Mining Society of South Africa for July.

Ore-Dressing.—Progress in ore-dressing during 1929 is discussed by Professor H. Madel in *Metall und Erz*, 1, Septemberheft.

Copper Leaching.—Technical Publication No. 350 of the American Institute of Mining and Metallurgical Engineers contains a description of the leaching process at Chuquicamata, Chile, by C. W. Eichrodt.

Copper Smelting.—Reactions between iron sulphide, sulphur dioxide, and iron oxides in the metallurgy of copper, form the subject of a paper by A. C. Halferdahl in *Industrial and Engineering Chemistry* for September.

Nickel Refinery.—*Engineering* for September 19 contains the first instalment of a description of the refinery of the Mond Nickel Company, Ltd., at Clydach, South Wales.

Chloride Roasting.—F. R. Hiemann discusses the chemistry of the chloride roasting of copper and silver ores in *Metall und Erz*, 2, Septemberheft.

Treatment of Low-Grade Ores.—*Zeitschrift V.D.* 1 for July 26 contains an article by Professor R. Hoffmann on the treatment of low-grade ores of lead, zinc and tin, particularly by the "Wälzverfahren" processes.

Blast Furnace Practice.—Technical Paper 476 of the United States Bureau of Mines, by C. C. Furnas and T. L. Joseph, discusses stock distribution and gas-solid contact in the blast furnace.

Flotation of Anthracite.—Control of Chance cone operation is described by J. F. McLaughlin in Technical Publication No. 361 of the American Institute of Mining and Metallurgical Engineers.

Calumet Island, Quebec.—Occurrences of nickel-cobalt minerals on Calumet Island, Quebec, are described by H. V. Ellsworth in the *Canadian Mining Journal* for September 12.

Coal and Salt in South Africa.—Professor P. Kukuk describes the coal and salt occurrences of South Africa in *Glückauf* for September 20.

Morocco.—Some notes on the mineral industry of Morocco, by M. Despujols, appear in *Revue de l'Industrie Minérale* for August 15.

Patiño Mines.—R. R. Beard describes the property and operation of the Patiño Mines and Enterprises at Llallagua, Bolivia, in *Engineering and Mining World* for September.

Underground Water in South Australia.—Bulletin No. 14 of the Geological Survey of South Australia, by R. L. Jack, considers geological structure and other factors in relation to underground water supply in portions of that province.

Gold Occurrences at Saint-Yrieix (Haute-Vienne).—L. Duparc and C. Wakker describe the gold deposits of the neighbourhood of Saint-Yrieix in the *Archives des Sciences Physiques et Naturelles* for January-February.

Molybdenite in Morocco.—A molybdenite occurrence at Azegour in Morocco is described in a brochure, by Professor L. Duparc, which has been issued by the Société le Molybdène of Paris.

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 patents.*

2,594 of 1929 (305,026). W. J. Huff, L. Logan, and O. W. Lusby, Baltimore. Gases containing hydrogen sulphide and organic sulphur compounds as impurities are brought in contact with a purifying material consisting of certain metals which are adapted for the fixation of the sulphur compounds and for subsequent revivification.

6,421 of 1929 (317,035). Siemens and Halske A.-G., Berlin. Rhenium is prepared from natural molybdenum minerals, the molybdenum being dissolved in nitric acid and precipitated by phosphoric acid, leaving the rhenium in solution.

6,435 of 1929 (332,627). Siemens and Halske A.-G., Berlin. Process for the extraction of rhenium concentrations.

12,889 of 1929 (310,425). I. G. Farbenindustrie A.-G., Frankfort-on-Main, Germany. Spent copper lyes, such as those obtained during the manufacture of artificial silk, may be freed from copper by heating them with an adsorbent material such as silicic acid or fuller's earth, from which the adsorbed copper can be dissolved by a weak acid.

13,751 of 1929 (333,246). W. F. Grupe, Lynd-hurst, New Jersey. Process for the electrolytic deposition of gold on a non-metallic material such as paper.

14,178 of 1929 (311,239). J. E. Barnitzke, Clausthal/Harz, Germany. Oxidized ores, particularly cassiterite, may be concentrated by a froth flotation process after the ore has been subjected, in fluid suspension, to a surface reducing treatment by means of, say, hydrogen.

15,548 of 1929 (313,597). Trent Process Corporation, New York. Metallic iron, in the form of sponge or finely divided particles, is recovered from iron ore by a process which involves reduction with hydrocarbons and subsequent immersion of the freshly reduced material in liquid hydrocarbons, which prevents re-oxidation.

15,638 of 1929 (313,045). I. G. Farbenindustrie A.-G., Frankfort-on-Main, Germany. Process for recovering copper, in the form of hydroxide, from dilute ammoniacal solutions by treating the solution with acid added in the quantity necessary to neutralize the complex combined ammonia and then decanting or filtering.

16,324 of 1929 (332,682). J. Brass, Barnsley. Apparatus for washing, separating or concentrating minerals in which the material is fed with water into an inclined shell fitted with a helical projecting ledge which slopes with the shell, whereby lighter particles are carried away with the water and the concentrate travels along the screw path.

25,395 of 1929 (317,734). F. Hensler, Hessen-Nassau, Germany. For the preparation of cast-iron or steel containing copper, an alloy of copper with silicon or manganese, preferably manganese, is added to the molten metal.

32,987 of 1929 (333,462). A. Mozer, Berlin-Friedenau. Electrolytic deposition of gold and silver from solutions containing the iodides of those metals.

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.

A Practical Treatise on Single and Multi-Stage Centrifugal Pumps. By R. Defeld. Translated by C. W. Olliver. Cloth, octavo, 221 pages, illustrated. Price 21s. London: Chapman and Hall.

Milling Methods, 1930. Transactions of the American Institute of Mining and Metallurgical Engineers. Cloth, octavo, 554 pages, illustrated. Price $5. New York: The American Institute of Mining and Metallurgical Engineers.

The Metallurgy of Bronze. By H. C. Dews. Cloth, octavo, 147 pages, illustrated. Price 12s. 6d. London: Sir Isaac Pitman and Sons.

Coke for Blast Furnaces. First Report of the Midland Coke Research Committee. By R. A. Mott and R. V. Wheeler. Cloth, octavo, 260 pages, illustrated. Price 25s. London: The Colliery Guardian Co.

Limestones. Their origins, distribution and uses. By Dr. F. J. North. Cloth, octavo, 467 pages, ilustrated. Price 16s. London: Thomas Murby and Co.

The Study of Crystals. A general introduction. By T. V. Barker. Cloth, octavo, 137 pages, illustrated. Price 8s. 6d. London: Thomas Murby and Co.

The Mineral Industry during 1929. Vol. XXXVIII. Edited by G. A. Roush. Cloth, octavo, 845 pages. Price $12. New York: McGraw-Hill.

The Significance of Spores in the Correlation of Coal Seams. Part I.—The Parkgate Seam—South Yorkshire Area. Physical and Chemical Survey of the National Coal Resources No. 17. Paper backs, pp. vi + 28, illustrated. Price 1s. 3d. London: H.M. Stationery Office.

The Support of Underground Workings in the Coalfields of the North of England. Safety in Mines Research Board. Paper No. 61. Paper backs, 140 pages, illustrated. Price 2d. London: H.M. Stationery Office.

Catalogue of Plans of Abandoned Mines. Vol. IV. Paper backs. Price 15s. London: H.M. Stationery Office.

The Country around Huddersfield and Halifax. Explanation of One-Inch Sheet 77. By D. A. Wray, J. V. Stephens, W. N. Edwards, and C. E. N. Bromehead. Paper boards, 221 pages, illustrated. Price 4s. 6d. London: H.M. Stationery Office.

Quebec: Annual Report of the Quebec Bureau of Mines, 1929. Part A. Mining Operations and Statistics. Part B. Report on the Oil and Gas Resources of the Province, by W. A. Parks. Each part in paper backs and illustrated. Quebec: Bureau of Mines.

Alberta: Tenth Annual Report of the Scientific and Industrial Research Council of Alberta, 1929. Paper backs, 65 pages, illustrated. Edmonton: University of Alberta.

Tanganyika Territory. Short Paper No. 5 of the Geological Survey Department. Water Supplies for Cattle along the Kondoa Irangi—Handeni Stock Route. By F. B. Wade. Paper backs, 24 pages, illustrated. Dodoma: Geological Survey Department.

New South Wales. Annual Report of the Department of Mines, 1929. Paper backs, 126 pages, illustrated. Sydney: Department of Mines.

Geology and Ore Deposits of the Wood River Region, Idaho. U.S. Geological Survey Bulletin 814. Paper backs, 250 pages, illustrated. Price 90 cents. Washington: Superintendent of Documents.

Alaska. Mineral Industry in 1928 and Administrative Report. By P. S. Smith. Paper backs, pp. xiii + 96. Price 15 cents. Washington: Superintendent of Documents.

Mineral Resources of the United States, 1928. Part I, pp. 423–427, Bauxite and Aluminium; pp. 607–643, Lead, by E. W. Pehrson. Part II, pp. 1–21, Fluorspar and Cryolite, by H. W. Davis; pp. 23–33, Fuel Briquets, by O. E. Kiessling and J. M. Corse; pp. 337–372, Cement, by B. W. Bagley; pp. 391–422, Asphalt and Related Bitumens, by A. H. Redfield; pp. 423–606, Coal, by F. G. Tryon, O. E. Kiessling, and L. Mann; pp. 607–614, Mica, by B. H. Stoddard; pp. 615–703, Petroleum, by G. R. Hopkins and A. B. Coons; pp. 705–801, Coke and By-Products, by F. G. Tryon and H. L. Bennit.

COMPANY REPORTS

Consolidated Main Reef Mines and Estate.—This company was formed in 1896 and works gold-mining properties on the middle West Rand. The report for the year ended June 30 last shows that 710,000 tons of ore was milled, as compared with 710,800 tons in the previous year. The gold recovered totalled 258,208 oz., worth £1,093,669, and silver and osmiridium recovered increased the total revenue to £1,096,176, or 30s. 10d. per ton milled, as compared with 32s. 3d. per ton in the year before. The working profit was consequently lower at £166,196, from which £106,079 was distributed as dividends, equal to 8¾%. The ore reserves at June 30 last were estimated to be 2,132,300 tons averaging 7·2 dwt., as compared with 1,985,700 tons, averaging 7·5 dwt., at the end of the previous year. During the year "shrinkage" or "reef-pack" stoping was adopted, with encouraging results.

Onverwacht Platinum.—This company was formed in 1926 to work platinum property in the Transvaal. The report for the year ended June 30 last shows that 31,100 tons of ore was milled during the year, of which 15,352 tons was from the mine, 9,560 tons from the eluvial deposit, and 6,188 tons was of accumulated sands sent for retreatment. The platinum metals recovered amounted to 4,672 fine oz., as compared with 5,655 fine oz. in the previous year. The working profit for the year was £10,192 and £11,250 was distributed as dividends, equal to 2½%. The mill was closed down on June 12, 1930 and the final clean-up was completed on July 12.

Rooiberg Minerals Development.—This company, formed in 1908, works tin-mining properties in the Waterberg district of the Transvaal. The report for the year ended June 30 last shows that 22,219 tons of ore was mined, of which 10,841 tons was from the Rooiberg and 11,378 tons from the Nieuwpoort properties. The ore milled amounted to 21,432 tons and 425 tons of tin concentrates were recovered, as compared with 444 tons in the previous year. The profit for the year was £1,167 which, together with £17,482 brought forward, made an available total of £18,619. From this sum various appropriations were made and the balance of £14,532 was carried forward.

Sherwood Starr.—This company was formed in 1923 to work gold deposits 8 miles north of the Globe and Phoenix mine in Southern Rhodesia. Milling of oxidized ore started in 1924 and a complex sulphide plant was started in 1926. The report for the year ended June 30 last shows that 57,800 tons of ore was sent to the mill where 31,325 oz. of gold was recovered, worth £132,966. The working profit was £67,072, as compared with £33,221 in the previous year. After payment of £6,649 as royalty to the B.S.A. company, the net working profit was £60,423, and of this amount £25,000 was distributed as dividends, equal to 25%. At the end of the period under review the ore reserves were estimated to be 110,000 tons, averaging 66·7s. per ton, as compared with 113,000 tons, averaging 58·1s. per ton at the end of the previous year.

Tin Fields of Nigeria.—This company was formed in 1928 to operate alluvial tin property in Northern Nigeria. The report for the year ended March 31 last shows that 59½ tons of tin concentrates was recovered during the period under review, as compared with 81¾ tons during the previous year, the price realized per ton also being lower at £113 17s. 5d. The working profit was £298, which was carried forward. In May last arrangements were made whereby the company undertook to work on tribute the areas held by Rukuba Tin Mines, Ltd.

Kinta Kellas Tin Dredging.—This company, formed in 1926, works alluvial tin ground on the Kinta Kellas Rubber Estate on a royalty basis. The report for the year ended March 31 last shows that during the period under review 1,469,000 cu. yd. of ground was treated and 485 tons of tin concentrates recovered, which realized £117 11s. 6d. per ton. The profit for the year was £24,028 and £10,250 was distributed as dividends, equal to 10%.

Renong Tin Dredging.—This company, formed in 1913 to take over the Renong Dredging Company, has issued its report for the year ended June 30 last. During the year 2,186,517 cu. yd. of ground was treated by the two dredges on the Rasa property recovering 912 tons of tin concentrates, as compared with 654 tons in the previous year, although work was restricted during the last 5 months of the period under review. The trading profit for the year was £51,204 and £23,990 was distributed as dividends.

Temoh Tin Dredging.—Formed in 1927, this company works alluvial tin-bearing property in the F.M.S. The report for the year ended June 30 last shows that the dredge treated 1,043,850 cu. yd. of ground and recovered 474 tons of tin ore, as compared with the 163 tons recovered the year before, although restriction of output was applied during the period January–June last. The area worked out during the year amounted to 18 acres. The profit for the year was £21,528 and £14,000 was distributed as dividends, equal to 2s. per share.

El Oro Mining and Railway.—This company, formed in 1899, is now mainly interested in the railway and the La Noria silver mine. During the year ended June 30 last the railway made a profit of £18,895 and the mine a loss of £2,538, other items bringing the net profit up to £45,399, to which must be added £13,899 brought forward, making an available total of £59,298. At the silver mine 168,000 metric tons of ore, averaging 19·19 oz. silver and 10·03 grains gold per ton, was treated and the yield was 4,337 tons of concentrates, averaging 18,807 grammes silver and 13·97 grammes gold per ton, in addition to which 119 tons of ore was shipped direct to the smelter. The ore reserves at June 30 last were estimated to be 205,150 tons averaging 19¾ oz. silver per ton—a decrease of 95,349 tons when compared with the previous year. The decrease is mainly due to the fact that much ore previously classed in the reserves is no longer payable with silver at the present price. Developments during the last three months appear to have located the downward continuation of the San Pedro ore-body. The discovery of secondary values at depth encourages the belief that similar zones of enrichment may underlie some of the other larger masses of leached siliceous vein-matter which occur in the mine.

New Goldfields of Venezuela.—This company was formed in 1926 to acquire gold-mining concessions in the Roscio district, State of Bolivar, Venezuela. The report for the year ended January 31 last shows that 18,942 tons of ore, averaging 14·38 dwt., was crushed in the pilot mill and 13,284 oz. gold recovered, worth £47,170. Erection of the power plant and the new mill proceeded in spite of losses of machinery in transit, but the delay involved materially retarded development work. During the current year the company has been amalgamated with Bolivar Venezuela Gold Mines, Ltd., details of the merger appearing in the MAGAZINE for April last.

DIVIDENDS DECLARED

Broken Hill South.—6d., less tax, payable November 21.

Chicago-Gaika Development.—3d., less tax, payable October 1.

El Oro Mining and Railway.—10d., less tax, payable October 27.

Globe and Phoenix Gold.—1s., free of tax, payable October 16.

Gopeng Consolidated.—6d., less tax, payable September 30.

International Nickel of Canada.—Pref. 7%, payable November 1.

Kinta Kellas.—2¼d., less tax, payable October 21.

Mount Morgan Gold.—10½d., less exchange, payable December 15 (final liquidation).

Mysore Gold.—6d., less tax, payable October 18.

Premier Gold.—6 cents, payable October 4.

Rio Tinto.—Pref., 2s. 6d., Ord., 10s., less tax, payable November 1.

St. John del Rey.—Pref. 1s., tax free, Ord. 9d., less tax, payable November 21.

Temoh Tin Dredging.—1s., less tax, payable October 10.

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

West African Diamond.—3d., less tax, payable October 1.

NEW COMPANIES REGISTERED

Birim (West Africa).—Registered as a private company. Capital: £20,000 in £1 shares. Objects: To adopt an agreement with Alice M. Shepstone (executrix of the late Max Shepstone) for the acquisition of four concessions in the Birim district of Gold Coast Colony, held under four leases with respect of mining rights, and to carry on the business of a mining, smelting and refining company, etc. Director: Hon. Nana Sir Ofori Atta.

Pattani Tin.—Registered September 22. Nominal Capital: £170,000 in 5s. shares. Objects: To acquire Pattani Consolidated Alluvial Tin, and to prospect for, work and develop tin, lead, wolfram, silver, gold, copper, coal, iron and other mines, minerals and other rights, etc. Office: 411–419, Salisbury House, London Wall, E.C. 2.

Sierra Leone Development Company.—Registered as a private company. Capital: £600,000 in £1 shares (500,000 Ordinary and 100,000 Deferred). Objects: To acquire from the African and Eastern Trade Corporation, United Africa Company and the Northern Mercantile and Investment Corporation certain concessions in the Sierra Leone Protectorate; to acquire from any sovereign, State or authorities in Africa or elsewhere any concessions, etc., to carry on the business of miners, iron and steel manufacturers, shipowners, etc. Office: 24, Old Broad Street, E.C.

Sierra Morena Mining Corporation.—Registered as a private company. Capital: £1,000 in £1 shares. Objects: To acquire from G. Wilckens the mines of Maria, Teresa and Otilia, situated near Fuenteovejuna, Province of Cordoba, Spain. Directors: E. De Arraga Vidal and G. Wilckens. Office: 69, Fleet Street, E.C.

Vulcan Copper Mines.—Additional particulars were filed on September 26. Capital: £200,000 in 10s. shares. Company has power to increase capital to £300,000. Incorporated in Southern Rhodesia in 1930 to acquire mining rights in South Africa or elsewhere. Directors: A. Fraser, S. A. Redrup, A. P. Sprange, and A. H. Bonnard.

COMPANY MEETINGS AND REPORTS SECTION

RHODESIAN SELECTION TRUST, LTD.

Directors : A. Chester Beatty (*Chairman*), A. D. Storke, C. W. Boise, J. A. Dunn, T. F. Field, E. E. Marshall, G. R. Nicolaus, D. Richardson, W. Selkirk. *Manager in Northern Rhodesia :* R. J. Parker. *Secretary :* D. C. D'Eath. *Office :* Selection Trust Building, Mason's Avenue, Coleman Street, London, E.C. 2. *Formed* 1928. *Capital issued :* £881,081 5s. in 5s. shares.

Business : Prospection and development of mining properties in Northern Rhodesia.

The second ordinary general meeting of the Rhodesian Selection Trust, Ltd., was held on October 2 at River Plate House, Finsbury Circus, E.C. 2, Mr. A. Chester Beatty (Chairman of the company) presiding.

The Chairman, in moving the adoption of the report and accounts for the year ended June 30 last, said: Gentlemen,—With your permission we will take the directors' report and balance-sheet as read. In order to comply with the Companies Act, 1929, an income and expenditure account for the year ended June 30 last has been prepared. In accordance with the agreement with the American Metal Company and others which shareholders approved at the last annual meeting, advances have been made to the company to date amounting to approximately £500,000, and there remains about £1,000,000 further advance to be received.

The sum of £319,960 has been expended to date on prospecting and development work on the 21 special grants in the N'Kana concession other than Mufulira, and of this sum the Bwana Company provided £106,389. For the time being our resources are being conserved and general development work somewhat restricted, so that we can provide our share of the expenditure on plant, construction and mine development now being incurred by the Mufulira Copper Mines, Ltd., and also for the carrying on of more extensive prospecting of the Chambishi deposit. To enable us to concentrate our efforts and resources at these two points which are the ones in the most advanced state of development, we have given the Bwana Company notice to terminate at the end of this month the agreement with them for further prospecting the remaining area of the N'Kana concession outside the 21 special grants now registered in the name of our company.

Last year I informed you that our company had taken up 149,686 acres under its agreement with the British South Africa Company. During the present financial year the Mufulira Copper Mines, Ltd., has been formed and 9,344 acres of the above area have been taken over by that company, leaving 140,342 acres, made up of 21 special grants, still held in the name of our company and in which the Bwana Company holds one-third interest.

During the past year, prospecting, geological work and drilling was carried out at Mufulira prior to its being formed into a company and in the areas still held by our company. Drilling was chiefly concentrated on Mufulira, Chambishi, Baluba and Luansobe, but a certain amount of prospect drilling was also carried out at Kalulushi, Mokambo North and South, Luansobe extension and Mutundu South. The drilling carried out during the year was extremely satisfactory and while in certain of the special grants our work has not yet reached the stage where we can decide as to the value of the ground we have definitely blocked out three large ore-bodies—namely, Mufulira, Chambishi and Baluba.

In these three properties we have already proved the following quantities of sulphide ore :—

	Tons.	Average % of copper.
Mufulira . . .	45,000,000	4·68
Chambishi . .	24,000,000	3·68
Baluba . . .	21,000,000	3·47
Total . .	90,000,000	4·13

I am confident that this figure does not represent more than a small portion of the ore that will be eventually found in the special grants which have been taken up by Rhodesian Selection Trust, but for the present it is deemed advisable to curtail our drilling programme with the exception of completing borehole 29 at Mufulira and a small amount of work at Chambishi to prove additional reserves of high-grade ore.

On February 3, 1930, the Mufulira special grant was handed over to Mufulira Copper Mines, Ltd., the Rhodesian Selection Trust retaining approximately a two-thirds interest in the new company. At our last general meeting I informed you that the 12 bore-holes then completed indicated the presence of 45,000,000 tons of sulphide ore averaging 4·68% copper, and this estimate was based on the results of bore-holes, the deepest of which cut the ore beds at 1,030 ft. Since then drilling has proved the continuity of the ore-bodies at greater depth. Bore-hole 20 cut 86 ft. true width of ore carrying 4·82% copper, beginning at a depth of 1,526 ft., and bore-hole 21a cut 100 ft. true width of ore averaging 3·71% cu. beginning at a depth of 2,000 ft. It is evident therefore that there is a very much larger tonnage at this mine than was estimated last year, and on the completion of bore-hole 29, which is a deep hole laid out to cut the beds at an estimated depth of approximately 3,000 ft. the ore reserves will be recalculated. The depth of drill-hole No. 29 is now 2,429 ft.

Developments at Chambishi during the past year have been extremely encouraging, and eight further bore-holes have cut satisfactory thicknesses of sulphide copper ore. There is indicated at this mine 24,000,000 tons of sulphide ore, averaging 3·68% copper. The outstanding development

at Chambishi during the past year has been the discovery of a continuous body of high-grade sulphide ore following the foot-wall of the ore deposit. This averages approximately 8·6 ft. true width, and assays the very high average of 10·45% copper. Bore-holes Nos. 20, 23, 31, 32, 33 and 35 all cut this high-grade band, and they indicate the existence of 2,000,000 tons of sulphide ore, averaging 10·45% copper. Further drilling is being carried on to prove additional reserves of this high-grade ore.

I consider the discovery of this high-grade ore-body of great importance, because it will be possible to work this high-grade ore separately and make low-cost copper even when mining a relatively small tonnage, and since this small tonnage of high-grade ore can be shipped to one of the plants now under construction in the district the capital cost of producing copper will also be low.

In order to secure representative bulk samples of the high-grade ore in particular for milling tests, two vertical shafts are being put down. The results of such tests, together with the knowledge gained of underground conditions, will enable decisions to be made as to the future programme of operations on this property.

So far as rail connexion is concerned, Chambishi is in a very favourable position, because the line which is now under construction from N'Kana to N'Changa passes across the property, and it will require only a short spur to connect up with the Rhodesian Railway system. We are advised that this line will be completed some time early in 1931.

In the Baluba area 10 diamond drill-holes were put down during the year, seven of which cut payable ore. Drilling in this area has already indicated 21,000,000 tons of sulphide ore, averaging 3·47% copper. For the present no further development work is being carried on.

Full details concerning our drilling and development in the various properties, and the progress of the construction work on the Mufulira plant, have been set out in the quarterly and annual reports.

During the past year general conditions in Rhodesia have shown a very rapid improvement by the application of scientific methods to the problem of the elimination of the malarial mosquito and by the introduction of modern sanitary methods. Living conditions have been improved to a point where they compare favourably with Europe. By training, and particularly by the use of mechanical equipment underground, the efficiency of the native labour in the mines has made great progress. During the year a central recruiting bureau was formed, with the result that a decided improvement in both the numbers and quality of natives available was evident within a very short time. I have no hesitation in stating that the supply of both white and native labour is entirely satisfactory and their health conditions good.

In a time like this, when there is a general world-wide depression, and when the price of commodities is considerably below the actual cost of production, it is necessary to take a long view and not be confused by existing prices. Copper at the present price of about £47 per ton is selling below the production cost of more than half the world's mines. There are several reasons why such a condition may continue much longer than is at first apparent. In the first place, such a drop in price as we have just had must be the result of both over-production and over-buying. The manufacturer buys too far ahead, and, because of this, the price rises, and in turn the producer strains every effort to equal consumption and to derive the benefits of a high price. Eventually there must be a day of reckoning, which, when it arrives, finds all consumers overstocked with the supply of metal. This can mean only one thing—a rapid drop in price and a loss of confidence on the part of both the producer and the consumer. When such a condition exists, the manufacturer must, of course, use up his stocks, which in turn must be sold to the ultimate consumer at a time when new work is being curtailed. On the other hand, the producers of copper attempt to keep their heads above water, and in doing so large numbers of small mines, whose production cost is high, will stop all development work, and for a time may actually operate at a cost which shows them a slight profit. The aggregate tonnage that comes from mines of this type is fairly large, and will not show a material reduction until a low price is continued for some little time.

It is certain that over a period of years we may look forward with the greatest confidence to the normal increase in copper consumption. Over 60% of the world's copper is used in the electrical industry, and the whole world to-day is increasing its consumption of electrical energy very rapidly. In the United States, where there has been a huge expansion in the quantity of electricity consumed during the last 20 years, we find that the copper consumed per capita is increased as follows:—

In 1912, with a population of 95,000,000, there was a consumption of 8·66 lb. per person, while in 1928, with a population of 119,000,000, the consumption per person was 16·49 lb.

In Great Britain in 1912, with a population of 45,000,000, the consumption was 6·98 lb. per person, and in 1928, with a population of 46,000,000, it was 7·89 lb. per person.

This condition holds similarly for France and Germany, where there has been a slight increase in this particular period. However, the electrical industry is expanding in these countries to-day rapidly, and with this expansion must come an increase in the consumption of copper.

For the past 50 years there has been an increase of 6% per annum in the world's copper consumption. If we use this figure, we find that by 1940 the world should be consuming 3,000,000 tons of copper per annum, which would mean that there is only enough copper ore proved in the world to-day to take care of the world's requirements for about 20 years. There may be times in the next ten years when too much copper will be produced, but the average consumption during that period should be sufficient to give a fair average price, and I am sure that we can look forward with great confidence to the future of Northern Rhodesia, and that there is no cause for alarm because of the present low prices.

The resolution for the adoption of the report and accounts was unanimously carried.

JOHANNESBURG CONSOLIDATED INVESTMENT CO., LTD.

(Incorporated in the Union of South Africa.)

REPORT OF DIRECTORS TO BE SUBMITTED TO THE SHAREHOLDERS AT A MEETING TO BE HELD IN JOHANNESBURG ON NOVEMBER 25, 1930.

The directors have pleasure in submitting the company's balance-sheet and profit and loss accounts for the financial year ended June 30, 1930. After providing for depreciation and all other charges the profits for the year amount to £565,192 11s. 7d. This sum, together with £181,497 5s. 7d. brought forward from the previous year, brings the total available profit to £746,689 17s. 2d. The directors, in December last, declared an interim dividend of 7½%, and a further 7½% was declared last June. These payments absorb £592,500, and the balance carried forward to next account is £154,189 17s. 2d. In this connexion the directors have pleasure in stating that the gross profits of the company have been well maintained, but having regard to the long period of general depression, which has adversely affected all markets, the company has had to make provision for abnormal depreciation in the value of certain of its shareholdings. The company's reserve fund remains at £1,000,000. The value of the company's shareholdings stand in the books at current market prices as at June 30 last, or below those figures. The financial position of the company continues to be strong and satisfactory.

The results of the operations of the various gold mining companies controlled by the company have been periodically published, as usual, and have all been of a gratifying nature. During the twelve months ended June 30 last, the value of gold produced by the mines of the group was, approximately, £12,235,000. The relations between the white employees and the company's group of mines have, generally speaking, been satisfactory. For the first half of the present year the supply of native labour to the mines of the group has been sufficient for requirements, but the limitations imposed by the Mozambique Convention on recruiting in Portuguese East Africa are adversely affecting the supply of labour from that source. Strong representations are being made to induce the Union Government to permit recruiting in areas not at present available.

Government Gold Mining Areas.—For the year ended December 31 last, 2,416,000 tons of ore were crushed, resulting in a working profit of £2,667,812, of which the Union Government received £1,448,863 as its share of the profit. The total sum paid to the Union Government now amounts to £12,982,803. Dividends totalling 90% have been paid for the twelve months ended June 30 last. Sandfilling on an extensive scale has been introduced on the mine, and this will enable all the ore left in the pillars and supports (amounting to over one and three-quarter million tons) to be extracted. The ore reserves at the end of the year were estimated to amount to 10,876,000 tons, with an average value of 8·9 dwt. over a stoping width of 63 in.

Langlaagte Estate.—The ore treated during 1929 amounted to 968,500 tons, and resulted in a working profit of £311,832, showing an increase of £29,181 over the same period in 1928. Dividends totalling 17½% were paid for the period ended June 30 last. The ore reserves at the end of the year were estimated to contain 1,596,000 tons, with a value of 7·4 dwt. over a stoping width of 42 in. The increase in the monthly profits enabled the company to raise its last half-yearly dividend from 7½% to 10%. Capital expenditure during 1929 was practically met by the sale of property and township stands. The percentage of payability of the ore sampled shows considerable improvement.

New State Areas.—For the twelve months ended December 31 last, 918,000 tons of ore were crushed, resulting in a working profit of £710,274, an increase of £41,373 as compared with the previous year. The Union Government's share of profit absorbed £384,974, and dividends totalling 12½% were paid to the shareholders for the period ended June 30 last. Operations during 1929 were in every way satisfactory, and excellent progress has been made in the major development programme of the mine. The ore reserves at the end of December last stood at 2,696,000 tons of an average value of 8·9 dwt. over a stoping width of 50 in.

Randfontein Estates.—The ore treated during 1929 amounted to 2,528,000 tons, and resulted in a working profit of £246,705. The ore reserves at the end of December, 1929, stood at 4,505,000 tons of an average value of 5·8 dwt. over a stoping width of 41 in. The monthly profits for the first half of the present year show considerable improvement, and the outlook is very encouraging. With a view to ensuring the future exploitation of the northern portion of the Main Reef section of the property, it has been decided to sink the North Shaft of the old Randfontein Deep property to a depth of 4,600 ft. This work is being carried out, and it is anticipated that this shaft will be in commission by the end of next year.

Van Ryn Deep.—The tonnage milled for the twelve months to December 31 amounted to 748,000 tons, which resulted in a working profit of £502,217. Dividends totalling 32½% were declared for the year ended June 30, 1930. The ore reserves at the end of December last were estimated at 3,022,000 tons of an average value of 7·3 dwt. over a stoping width of 50 in.

Witwatersrand Gold.—In 1929 the tonnage milled amounted to 641,000 tons, and showed a working profit of £15,347. The increase shown in the monthly profits for the first half of the present year enabled the company to declare a dividend of 5% for the six months to June 30 last, which with the dividend of 2½% declared in December, 1929, makes a total of 7½% for the year. The ore reserves at December 31, 1929, were estimated to amount to 372,000 tons, with an average value of 5·4 dwt. over a stoping width of 53 in.

The general depression has affected the diamond trade very severely, and has led to greatly reduced sales. As the United States is the Industry's principal customer, it was hoped that the settlement of the tariff question in that country would result in increased business, but its effect was overshadowed by the after results of the financial crisis. The position has been aggravated by the methods adopted by the Union Government in the

disposal to South African cutters of part of the Government diamonds found in Namaqualand. However, periods of depression have been experienced previously, but in course of time have passed away, and the vitality of the trade gives every assurance that history will repeat itself.

The company has increased its interest in the Northern Rhodesian copper fields. Mr. Lawn, one of the company's directors, and Mr. Beatty, the company's consulting engineer in South Africa, paid a visit to these fields last December and found that the progress made had been excellent. Further exploration has enhanced their value and importance. Development and equipment are being proceeded with energetically. There has been a considerable fall in the price of copper during recent months, but the grade and conditions appertaining to these mines are such as to enable them favourably to compete with other copper producing districts of the world. Although these fields remain under British control, American interests are largely represented, and it is the desire of all parties to work harmoniously together. Approximately the latter part of 1931 should see the commencement of what will undoubtedly prove a large and increasing copper production from the Northern Rhodesian fields.

The portion of the plant at the Rustenburg property of Potgietersrust Platinums, Ltd., for the gravitational concentration of the ore, commenced work in January last, but it was not until June that the flotation section of the plant was completed. The plant is now working steadily, and improved results are being obtained. The grade of ore is well up to expectations, and the development of the mine continues satisfactory. The fall, however, in the price of platinum, which is now lower than it has ruled for fifteen years, renders the position somewhat difficult. The directors are of opinion, notwithstanding this fact, that it will be possible to work the mines profitably.

The company continues to receive a steady revenue from its coal interests. The sinking of the new shaft on the New Springs Colliery has now been completed.

There has been a steady sale of building sites on the Lower Houghton Estate during the period under review.

CONSOLIDATED MAIN REEF MINES AND ESTATE, LIMITED.

(*Incorporated in the Union of South Africa.*)

Extracted from the Annual Report for the year ended June 30, 1930.

Capital £1,247,602 in 1,247,602 shares of £1 each (all issued).

NOTE.—Of the above Issued Capital 35,267 ex-Enemy Shares are held by the Company.

Directorate: F. Raleigh (*Chairman*), Major C. S. Goldman, J. L. Jourdan, W. H. A. Lawrence, A. A. Auret, D. Christopherson, J. Martin, Sir Abe Bailey, Bart., K.C.M.G., C.B.E., J. H. L. Manisty.

Tonnage milled, 710,000.	£	s.	d.	Per ton milled. £	s.	d.
Total Working Revenue	1,096,176	8	6	1	10	10
Total Working Costs .	929,980	11	11	1	6	2
Working Profit .	£166,195	16	7	£0	4	8

	£	s.	d.
Total Profit for the year . .	178,303	9	10
Balance unappropriated at June 30 1929	183,609	14	0
Forfeited Dividends Account .	223	17	7
	£362,137	1	5

The available Ore Reserve as re-estimated at June 30, 1930, is as follows:—

	Tons.	Value Per ton.	Stoping width. Dwt.	Inches.
Main Reef Leader . .	1,548,830	7·9		40·0
South Reef . . .	88,100	6·0		39·3
Bird Reef	495,370	5·1		59·2
Total . . .	2,132,300	7·2		43·3

This amount has been dealt with as follows:—

	£	s.	d.	£	s.	d.
Net Expenditure on Capital Account for the Year—Equipment, £55,008 6s. 4d.; Property, £34,094 4s. 4d.	89,102	10	8			
Miners' Phthisis—Provision on account of Outstanding Liability as at July 31, 1929	10,201	0	0			
Government and Provincial Taxes .	16,763	16	10			
				116,067	7	6
				£246,069	13	11

Dividends declared during the year:—

No. 40 of 5% and No. 41 of 3¾%	106,079	6	3
Leaving a balance unappropriated of	£139,990	7	8

The Full Report and Accounts (with Plans of Workings) may be obtained from the London Secretaries, A. Moir & Co., No. 1, London Wall Buildings, London, E.C. 2.

TEMOH TIN DREDGING, LTD.

Directors : R. Sancroft Baker (*Chairman*), R. Pawle, E. T. McCarthy, L. G. Attenborough. *Agents in the F.M.S. :* The Borneo Company, Ltd. *Secretary :* J. Barnes. *Office :* 4, London Wall Buildings, London, E.C. 2. *Formed* 1927. *Capital issued :* £140,000.

Business : Operates alluvial tin property in the State of Perak, F.M.S.

The fourth ordinary general meeting of the shareholders of Temoh Tin Dredging, Ltd., was held on October 7, 1930, at Winchester House, Old Broad Street, E.C., Mr. R. Sancroft Baker (Chairman of the company) presiding.

The Chairman, in moving the adoption of the report and accounts for the year ended June 30 last, said : We have made a net profit of £24,672 3s. 11d. After depreciating the dredge and all fixed assets, and adding the amount of £2,215 16s. 11d. brought forward from last year, gives us a balance of £26,888 0s. 10d. to be dealt with. We propose writing off £3,144 11s. 11d. from our miscellaneous expenditure account, which now has no value, leaving a balance of £3,000 to be dealt with next year. We are placing £5,000 to income-tax reserve ; the reason for this is that the method of computing the income-tax assessment is at present in dispute between your company and the authorities, and the matter will in due course come before the Commissioners. Your Board has, therefore, deemed it advisable to reserve this sum, but, should it ultimately be found that the whole of this amount is not required, an adjustment will be made in next year's accounts. We have already paid you an interim dividend of 1s. per share, less tax, and now propose, if these accounts are passed, paying a final dividend of 1s. per share, less tax, amounting in all to £11,025, and leaving £7,718 8s. 11d. to be carried forward. During the year we have had to spend a considerable sum in improving our water supply to the dredge paddock, but all difficulties have been overcome, and now the supply is ample. The dredge has worked smoothly all the year and is in every way efficient.

After allowing for numerous stoppages under the restriction scheme, the dredge has worked over 90% of the possible time, which is very gratifying. We have strictly adhered to the programme of restriction as suggested by the Tin Producers' Association, and in consequence our mine costs are higher than last year at 4·61d. per yard, against 3·6d., but from June, 1929, to January, 1930, when we were working full time, our expenses were only 4d. per yard. It will be interesting to you to know that, with tin at to-day's price and assuming an output of 40 tons per month, which was the average for the year under review, and that with over 20% stoppage through restriction over, say, half a year, we should still make a profit. We feel, however, it is unwise to waste our good ground while tin is at such a low price, and we therefore do not propose starting up the dredge just yet—a policy which we hope the shareholders will approve, as we shall be repaid when market conditions become more normal. All the managers in the East have agreed upon a common policy of paying the coolies, and by this means we hope to avoid any trouble and also to keep our crews together for the time when we decide to start dredging again. The cost to the company during the period the dredge is shut down will amount to about £500 per month, and we have ample funds to meet what we might term this temporary dead expenditure.

You will remember we estimated in our statement of particulars when this company was formed an output of 30 tons of tin concentrates per month, but owing to the very satisfactory fact that the recovery has averaged 1·01 lb. per cubic yard, against the average bore-hole value of 0·70 lb. on the area dredged during the year in spite of restriction since January, we have actually recovered an average of 39½ tons of concentrates per month throughout the year. With this experience we have good reason to think that the bore-holes over the whole of our dredging area have been valued on the low side and that the ultimate yield of concentrates over the whole of the property will be increased in similar ratio.

In regard to our dredging area, I would like to mention that, as I told you last year, we were able to come to a very satisfactory arrangement with the French mining company, the Société des Etains de Kinta, whereby we were able to take over and work on tribute some ten acres of land adjoining our property. The previous year we worked out some three acres of this area, and the balance of seven acres has been worked out during the year under review, with very profitable results. In February of this year we were able to secure a free option until the end of June over some fifteen acres of adjoining land to the east of our property, which we bored and found to contain good values. At the date of expiration of the option, owing to the fall in price of tin, we decided not to purchase, but we were, however, successful in obtaining an extension for a further year on payment of about £100, which will merge into purchase price should we decide to take up the land.

In conclusion, I would like to ask the shareholders to propose a vote of thanks to the staff in the East for their loyal and efficient services. The restriction scheme has naturally caused a good deal of dislocation in the work, and they have handled a difficult situation with tact and fairness to our Asiatic employees. We have had our manager, Mr. John Templeton, at home this summer, and so have had the opportunity of discussing many points with him.

Mr. R. Pawle seconded the resolution, which was carried unanimously.

RENONG TIN DREDGING CO., LTD.

Directors : A. E. Percy (*Chairman*), J. B. David, E. T. McCarthy, C. K. Morrison. *Secretaries and Agents :* Guthrie and Co., Ltd. *Office :* 5, Whittington Avenue, London, E.C. 3. *Formed* 1913. *Capital issued :* £159,267.

Business : Operates alluvial tin property in the State of Selangor, F.M.S.

The seventeenth annual general meeting of the Renong Tin Dredging Co., Ltd., was held on October 9, 1930, at Winchester House, Old Broad Street, E.C. Mr. A. E. Percy (Chairman of the company) presiding.

The Chairman, in moving the adoption of the report and accounts for the year ended June 30 last, said that shareholders would be satisfied with the results disclosed by the accounts in face of the depression which had been hanging like a pall over the industries of the whole world for nearly twelve months, with up to the present little sign of lifting. The profit was £51,204, an increase of £11,045—notwithstanding that the average price of metallic tin during the year had dropped from £216 to £178 per ton.

Dealing with the attitude of the board towards restriction, the Chairman said that, although the company's output of 911 tons was in excess of last year, yet the company produced nearly 1,000 tons in the year 1917, and again in 1922, and the output in several other years had exceeded 800 tons, so that it could not be said that they had contributed to the great increase in production which had taken place in recent years. They had joined in the first scheme for voluntarily restricting output established by the Tin Producers' Association by closing the plant for a certain number of hours every week, and under the later scheme they had undertaken to close for a period of two months.

At the same time, the effect of the Restriction Scheme upon their own company must be their first consideration. If they had a large unworked area and a life of 12 or 15 years, the cost of the restriction would be spread over that period, but in their own and some other companies where the life was much shorter, it was obvious that the effect of restriction was more serious. For their company they considered the best method of contributing to the restriction was to suspend totally operations from time to time, reducing expenses to the lowest possible level and leaving the tin in the ground to be recovered at a later period. During the current period they would work to the utmost capacity, turning over as much yardage as possible and, by reducing cost per yard, endeavour to increase profit on the tonnage obtained. That policy might be altered as conditions changed in the industry.

During the past year they had spent a considerable sum on the re-boring of the property, and many acres had been proved to be practically virgin ground and very rich in tin.

The report and accounts were adopted.

TIGON MINING AND FINANCE CORPORATION, LTD.

Directors : R. E. Palmer (*Chairman*), Col. A. Weston Jarvis, Marquis del Moral, W. M. Treglown, H. Vandervell. *Secretary :* S. Staveley Briggs. *Office :* 688–692, Salisbury House, London, E.C. 2. *Formed* 1913. *Capital issued :* £162,470 in 5s. shares.

Business : Is developing sulphur properties in Spain and other interests in Spain and South America.

The ordinary general meeting of Tigon Mining and Finance Corporation, Ltd., was held on October 7, 1930, at Winchester House, London, E.C., Mr. R. E. Palmer (Chairman of the company) presiding.

The Chairman, in moving the adoption of the report and accounts for the year ended March 31 last, said that the activities of the board during the past year had been confined especially to the production of sulphur as brimstone, and of gold. The board having decided that if ever the opportunity offered of extending the company's interests in the sulphur producing business they should avail themselves of it. Such an opportunity had presented itself, and they had been able to secure what they considered to be the most important available sulphur supply in a portion of the globe other than Spain, i.e. in Chile. The company now controlled, therefore, important sources of supply in two of the five producing countries of the world.

With regard to their mines in Spain, it had been found that the conclusions arrived at from the results of the drill-holes were well borne out by the opening up of the areas drilled. It was confidently expected that, upon the completion of alterations to the treatment plant, production of brimstone could be commenced at the rate of 5,000 to 6,000 tons per annum.

In their report the directors had referred to the acquisition of three groups of mines in the Tacora district, adjacent to the Arica-La Paz Railway, in the extreme northern part of Chile. These properties had been examined and valued by three of the company's engineers acting independently, and their agreed estimate was that they contained some 11,000,000 tons of sulphur ore proven of a grade ranging from 60% to 85% sulphur and averaging about 76%, besides some 7,500,000 tons of probable ore of approximately the same tenor.

In order to operate them and define the various interests a company had been formed in Chile with a capital of £225,000 in £1 shares, and the Tigon Co. would participate to the extent of 160,000 shares. All three groups of properties were now actually producing. The production from the first two taken over within the last few days by the new company was at a rate which the engineers estimated would yield a net initial profit of £2,300 per month. Possession of the third would naturally increase this figure. A feature of the enterprise was that the consolidation of the three groups had undoubtedly given them the control of this industry in Chile. The investment which they had made included the subscription for the whole of the working capital.

The report and accounts were unanimously adopted.

MUREX, LTD.

Directors : G. P. Joseph (*Chairman*), Edmund Spyer, David Anderson, H. T. Box, E. D. Metcalfe. *General Manager :* H. A. Green. *Secretary :* W. Weir. *Office :* 1, London Wall Buildings, London Wall, E.C. 2. *Formed* 1918. *Capital issued :* £134,422 10s. in 10s. shares.

Business : Owns an ore treatment process, is interested in tungsten, and controls various welding processes.

The eleventh ordinary general meeting of Murex, Ltd., was held on October 9, 1930, at Winchester House, Old Broad Street, E.C. Mr. George P. Joseph (Chairman of the company) presiding.

The Chairman, in moving the adoption of the report and accounts for the year ended June 30 last, said that since the last meeting the authorized capital had been increased to £200,000. During the year a further 64,249 shares had been issued, of which 25,000 were offered pro rata to the shareholders at £2 a share, the issue being oversubscribed, and the balance of 39,249 issued as consideration for the purchase of shareholdings of subsidiary companies. Since the date of the balance-sheet a further 104,125 shares had been issued in connexion with another purchase, so that the issued capital to-day was 373,034 shares of 10s. each, representing a nominal capital of £186,517. The premiums received on these issues amounted to £84,648. In addition there was the previous reserve account of £23,153, making a total reserve of £107,781, from which £2,000 had been written off investments as a precautionary measure, and £37,500 transferred to a general reserve, leaving the premium reserve at £68,281. The increases in sundry creditors, buildings and plant, machinery, etc., were due to the company's larger business, as was also the increased amount for stock of ore, work in hand and stores.

Shares in and amounts owing by subsidiary companies stood at £66,286 and comprised their interests in the Pure Metal Manufacturing Company and the Premier Electric Welding Company. In the case of the Pure Metal Manufacturing Company they had had a full year's trading, and the results were quite satisfactory inasmuch as the sales showed a considerable expansion since the business was acquired. As the trading year of the Premier Electric Welding Company did not close until December 31 none of their profits had been brought into the accounts under review, but in this case also the turnover showed a very satisfactory increase, and the directors were satisfied that the acquisition of this concern would be of considerable benefit to the company in the future. Up to date the profits were well up to expectations.

With regard to their latest acquisition—namely, the entire purchase of the shareholding of Alloy Welding Processes, Ltd., known as the "A.W.P." company—this concern, as well as the premier company—of which they also held all the shares—was engaged in the manufacture of electrodes for arc welding, and were suppliers of the necessary welding plants. The directors were also very well satisfied with the progress of the "A.W.P." company to date. The "A.W.P." company had about 2½ acres of freehold land with well-equipped buildings at Walthamstow and ample space for further extensions. It had been decided to concentrate the manufacture of electrodes there. The two companies would, for the time being, continue to function as separate entities.

The use of electric welding was extending rapidly, and the directors believed there was a big field for development. In this connexion he would mention that Imperial Chemical Industries were affording them great assistance, and their company was working in close collaboration with that company over research work. The "A.W.P." company had certain subsidiaries abroad, which were doing well, and it was intended that these should be developed to the fullest possible extent.

In every case the purchase of subsidiary companies or of shares therein had been effected by the issue of fully-paid Murex shares.

The cash position was quite satisfactory, the amount standing to the company's credit being £47,686, and on all their liquid assets there was a surplus of £111,644, which on an issued capital of £134,422 was well over 80% compared with 60% in the previous balance-sheet. This was after spending £22,000 on fixed assets during the year. During the year a profit of £52,275, subject to income-tax and depreciation, was made. This compared with £20,981 for the previous year, an increase of £31,294.

With regard to their separation business, although during the year under review they had received a comparatively small amount of concentrates from the Mawchi Mines, he was glad to say that they had received increasing quantities of complex and other ores from various sources for treatment, and this branch of their trade had expanded satisfactorily. The Mawchi Mines were likely in the near future to be increasing their milling from 4,000 tons of ore per month to 6,000 tons.

During the year under review, Imperial Chemical Industries had again extended to them every facility in every possible direction, and he would again like to thank them for their assistance, which was extremely useful to them, and which they valued very much. He would also like again to refer to the untiring efforts of Mr. Green, their general manager, and to the whole of the staff who co-operated so loyally with him in furthering the interests of the company.

Whether the worst of the world depression in trade had been passed through remained to be seen. If not, of course, their current year's results might not be so satisfactory, but if, on the other hand, it had—and he sincerely hoped it had—then he did not see any reason for not repeating what he said last year—namely that unless anything unforeseen happened, the Board felt they could look forward with confidence to the results for the ensuing year.

The reports and accounts were unanimously adopted.

FRANCOIS CEMENTATION CO., LTD.

Directors : Harry Clayton (*Chairman*), A. R. Neelands (*Managing Director*), John A. Agnew, L. Chevrillon, G. Du Cros, J. P. Harman. *Secretaries :* Stocker and Mann. *Office :* Salisbury House, London, E.C. 2. *Formed* 1919. *Capital issued :* £310,000.

The tenth ordinary annual general meeting of the Francois Cementation Company, Ltd., was held on September 17 at River Plate House, Finsbury Circus, E.C., Mr. Harry Clayton (Chairman of the company) presiding.

The Chairman, in moving the adoption of the report and accounts for the year ended March 31 last, said : Turning to the assets side of the balance-sheet, in the first total the expenditure on experimental and development work has been increased by £13,000. This was in regard to the tunnelling machine, on which expenditure has now practically ceased. We are very pleased with the development of the tunnelling machine and its possibilities. We do not consider it advisable though, that our company should continue to spend money on further experiments, and advise the formation of a separate company so that our shareholders may choose for themselves.

I should point out that we have had the benefit of the new capital for only six months of our financial year, and that, owing to delays in delivery and erection of particular boring machinery, the company received no benefit from the expenditure during the year under review. Work in progress is higher than last year owing to the particular type of contracts in hand not allowing of the exact figure being charged out at the date of our balance-sheet, and, taking this figure with sundry debtors and unexpired expenditure, an increase of £20,000 is shown. Unexpired expenditure, representing payments made in advance, accounts for £3,625 of the £81,500, and the remainder is due from clients and is good.

In regard to subsidiary companies, these are four—namely, the South African, the French, the Italian, and, in this country, Sika-Francois, Ltd. The South African company, while relatively small, is excellently managed and shows each year a good return on the capital invested.

In France the French company did excellent work and made a net trading profit (after providing for French taxation) of over £40,000. At the date of our current balance-sheet, therefore, the position of this investment has entirely changed. Last year we considered it necessary to make an investment reserve of £15,000 against the book value of this investment to cover the accumulated loss and a decrease in the value of assets due to the depreciation in the franc since the time we made the investment. It was not possible to have these profits paid to us by way of a dividend, as the French company's available funds had already been applied to the repayment of advances which we have previously made to it. Our French directors have pointed out to us that we should take in some French partners. We agreed to this and they were able to introduce two very important groups—namely, the Credit Mobilier and the Union des Mines. These companies, directly and through their subsidiaries, have a large measure of control over mining and hydro-electric schemes, and should be of the very greatest assistance to the company in obtaining further work. Already, partly through their help, contracts have been received for two important cementation sinkings.

To allow of the subscription of shares in the French company by these groups, a reorganization of its capital was necessary. Since the date of our balance-sheet it has been increased from 2,000,000 francs to 10,000,000 francs, and, after allowing for the receipt of £16,000 for part of our holding sold to the French groups, we now own approximately 50% of that company. At the same time the whole of the advances which we had made have been repaid and to-day the position is that we own shares in the French company worth at least £40,000, which stand in our books at cost—namely, £9,000.

Turning to Italy, I have not such a pleasant story to tell, as the accounts show a loss, but with the experience of France before us we need not be surprised. This loss, as explained, is covered by the surplus on the French investment. While we cannot expect large results from the Italian company immediately, we are satisfied that it has already established a good name, which is evidenced by the increasing number of inquiries of importance which it receives.

The results of Sika-Francois, as stated in our report, have also been disappointing. Here, again, expert workmanship is of importance, and as this meant training men before serious contracts could be undertaken we quite anticipated a period of development. Unfortunately, during the latter part of 1929 we had serious difficulties, and it was only in December, after much difficulty, that these were finally settled. The Sika waterproofing is very successful and the process is a most desirable adjunct to waterproofing by cementation. At the time of our last balance-sheet, Sika-Francois had made a loss which was covered by the balance of the investment reserve, and now this, and the further loss made during the year, have been covered by the appreciation in the value of the French investment. Recent returns on the business show a definite improvement due to better workmanship and increasing popularity of the products. These four subsidiary companies now stand in our books at the cost figure—namely, £96,291—which amount is fully covered by actual assets in those companies.

Of the mining contracts in progress at the beginning of the year, the Kingshill and Overtown sinkings by cementation through water-bearing ground for the Coltness Iron Company have been satisfactorily completed, and we are now working at both these sites on further contracts for the excavation of the shaft bottom headings. At Beighton, for the Sheffield Coal Company, Ltd., sinking has proceeded satisfactorily since March, and is now practically completed. Eleven general mining contracts were secured. In Spain a contract was commenced for the cementation, sinking and lining of a shaft at Santander.

Work at Leighton reservoir for the Leeds Corporation was not resumed during the year, it having been stopped at the end of March, 1929, in order to

ascertain by the filling of the reservoir the results of the work. Work at Blaenavon reservoir consisted mainly of tests to determine the source of the small remaining leakage, which amounts to less than 5% of the original leakage. A new waterworks contract was that at the Ryburn reservoir for the Wakefield Corporation. This was the precementation of the strata underneath the dam and beyond the wing walls. An important contract still in progress is the cementation of the leakages at Broomhead reservoir for the Sheffield Corporation waterworks. A small contract was completed for the consolidation of the ground underlying part of a storage reservoir of the Swindon Corporation waterworks. A leakage of some 25,000 gallons a day was successfully cemented at the Denby Dale reservoir for the Denby Dale Urban District Council. In January a contract for the sealing of leakages at the Llangefni reservoir, Anglesey, was commenced, and since the end of the year has been successfully completed.

In Spain, work at Camarasa reservoir was continued without cessation, the treatment continuing along the normal lines developed in this particular case. At the end of the year the total leakage sealed off amounted to approximately 142,000,000 gallons per day. At La Toba, Cuenca, for the Electrica de Castilla, the cementation of fissured foundations prior to the construction of a reservoir dam proceeded satisfactorily till March 10, when work was completed.

As is known to you, our company were the contractors for and had the honour of carrying out the restoration work at St. Paul's Cathedral. The consolidation of the turbine engine foundations at the Rotherham Power Station was successfully completed, as was also the cementation of made-up ground to prevent subsidence under annealing furnaces at Sheffield for Messrs. Flathers and Sons, Ltd.

At the Gerrard Bridge Works, St. Helens, of Messrs. Pilkington Bros., Ltd., some made-up ground was treated by cementation as an experiment, and the results were quite successful.

At the Sandy Lane pumping station, work was carried out for the Doncaster Corporation on the cementation of the ground underlying three sewage tanks to prevent subsidence and leakage.

An important contract was carried out for H.M. Office of Works at Birmingham, where it was discovered that serious cavities existed behind the lining of the subway under the head post office and in the ground above the lift chambers. Proper filling of the cavities and the thorough consolidation of the ground around and above the subway and above the lift chambers was absolutely essential for the safety of the structures, and we were given the contract for this work, which was successfully completed.

Two foundation contracts of some interest, carried out by piling as opposed to cementation, might be mentioned. At Durham 200 piles were driven by the Express system to an approximate depth of 30 ft. in soft water-logged ground to form the foundations of a new garage. At Newcastle-on-Tyne 47 Express piles were driven in connexion with the foundations of the new police and fire station.

A very important contract secured and commenced during the year was the Severn Tunnel contract for the Great Western Railway. Towards the end of our year we commenced another contract for the Great Western Railway, consisting of the consolidation of the sea wall at Dawlish.

A number of minor bore-hole contracts were completed in England, and important ones were secured in Spain.

Betonac continues to grow in popularity as a paving material. Thirty contracts were carried out, taking some three hundred tons of hardening material and covering approximately 14,000 square yards. These contracts included floor surfacing in factories, warehouses, dairies, garages, power stations, etc.

Concerning the Bicknell tunnelling machine, tests with the experimental machine have proved that a successful mechanical method of abrading the hardest rock was assured.

In South Africa, the work carried out consisted of the sealing of fissures and feeders in shafts, drives, and workings for many important mines.

In France, work has been mainly confined to civil engineering, particularly the cementation of large dams, including in France the cementation of the foundations of the Champagney Reservoir, and, in Algeria, in the cementation of the foundations of the reservoirs of Oued Riou, Oued Fodda and Du Ghrib. Other civil engineering work is the consolidation of foundations for the Bridge de l'Arche, and the drilling of exploratory bore-holes for a proposed dam on the River Arve. Mining work consisted of the injection of shaft lining of two shafts at Cuvulette.

In Italy a gratifying measure of public and technical confidence has been secured, and the company is already recognized as the most competent in waterproofing works by specialized cementation methods. Among the contracts carried out during the past year were 14 boring contracts, including bore-holes both for water and the testing of strata ; while a number of cementation contracts were secured, including the sealing off of leakages from the Lago Della Bacca dam, the sealing off of leakages from a quarry at Travertino, the sealing off ground behind the walls of underground chambers used as explosive stores, the sealing of the lining of the tunnel at Domodossola for the Italian State Railways, and the consolidation of the foundations of a railway bridge at Torrente Resce for the Italian State Railways. In addition, a contract has been commenced for the placing of concrete piles for the foundations of a railway bridge at Cupra over the River Menocchia. Much of the work carried out has aroused considerable technical interest, and has been visited by Government and other engineers of high professional standing.

As to the present year, we have already tenders in for quite a number of contracts. One of these is for the most important undertaking for which we have yet tendered—namely, the Haweswater Conduit Contract " B." I am glad to say we have secured the contract for this. Also we have recently secured an important gravel cementation contract for the foundations of the turbines for Messrs. Ford's factory at Dagenham.

Mr. John A. Agnew seconded the resolution, which was carried unanimously.

IMPERIAL SMELTING CORPORATION, LTD.

Directors : Sir Robert Horne (*Chairman*), Earl of Inchcape, Sir Cecil L. Budd, Hon. W. L. Baillieu, Sir Lingard Goulding, J. R. Govett, R. S. Guinness, Capt. Oliver Lyttelton, P. E. Marmion, R. G. Perry, W. S. Robinson. *Secretary :* F. Morrell Gilder. *Office :* 95 Gresham Street, London, E.C. 2. *Formed* 1929.
Capital issued : £4,494,766.

Business : Owns smelters and sulphuric acid plant in this country and holds interests in companies operating in Australia and the East.

The first ordinary annual meeting of the Imperial Smelting Corporation, Ltd., was held on October 2 at Winchester House, Old Broad Street, E.C., Sir Robert Horne (Chairman of the company) presiding.

The Chairman, in moving the adoption of the report and accounts for the year ended June 30 last, said : Subject to the repayment on January 1 next of the relatively small balance of debenture stock, provision for which has already been made, the whole of the share and loan capital of the National Smelting Company, Ltd., belongs to the Imperial Smelting Corporation, Ltd. The National Smelting Company, Ltd., as you are aware, owns extensive roasting, acid and zinc-smelting works at Avonmouth and Swansea in this country, and has substantial investments in mining and other associated enterprises both here and overseas. The Imperial Smelting Corporation also owns, through its control of Non-Ferrous Metal Products, Ltd., all the share capital of Orr's Zinc White, Ltd., which possesses an important barytes mine and is the largest British producer of lithopone.

When I addressed the shareholders of the National Smelting Company at the annual meeting in July, 1929, I stated that " unless there be materially adverse movements in the non-ferrous metal markets," shareholders might reasonably expect their dividends to show no decline. Not long after that statement was made, a movement, quite unexpected in its suddenness and unsurpassed in its severity, developed in the non-ferrous metal markets, resulting in extraordinary declines. These steep declines in metal prices and their effect on our revenues supply the reason why the expectations which I myself cherished and may have raised in your minds in July, 1929, have not been fully realized. As the owners of the National Smelting Company, we are deeply concerned in spelter, while lead, copper and silver are among the chief interests of the external investments from which our income flows. You will readily understand, therefore, that our revenue is acutely affected by the drop in metal prices, and so long as abnormally low values prevail will continue to suffer.

I have to report to you that the plants employed in roasting ores, acid-making and zinc distillation which we control through the National Smelting Company have, during the last year, been extended and modernized at considerable capital cost. Their efficiencies continue to improve, and I do not think I exaggerate when I say that our metallurgical results are at least equal to the best recorded in any other part of the world where similar processes are applied.

With regard to our raw material supplies I am pleased to be able to say that we have recently made an arrangement which, subject to reasonable metal prices, will provide on fair terms for most of our estimated requirements for some years to come. Jointly with our friends the Electrolytic Zinc Company of Australasia, Ltd., we have entered into an agreement to purchase from the North Broken Hill, Ltd., Broken Hill South, Ltd., and Zinc Corporation, Ltd., their output of zinc concentrates over a period of years. In addition to the ordinary commercial terms, the contract covering this business provides for the close association of the various interests in developing the British zinc industry, carries privileges to the sellers in the event of improved processes and grants them an option to increase their investment in our capital in accordance with the tonnage of concentrates delivered to us. The contract is one of considerable magnitude and will, we believe, be of substantial help in maintaining and extending the zinc industry of the Empire.

While this contract helps us with a reasonable assurance of raw material, and while our works have been made as efficient as possible it would be folly to forget the handicaps to which an industry such as smelting in this country is subjected in competition with our rivals in other countries. There is no reason why all the zinc requirements of the United Kingdom, both for its home and export trades, should not be produced within the Empire, and provide a profitable use for our own resources and more stable employment for our people.

Our interests in the lithopone industry are in excellent hands, and we are well satisfied with the revenues that are being earned and the prospects which our business discloses.

Our investments in mining through our subsidiaries are entirely in companies the value and extent of whose ore reserves, the efficiency of whose management and the completeness of whose equipment give us every ground for confidence.

You will probably expect me to refer to the fall in metal prices and the outlook for the future. Declining prices have not been confined to the metal markets, but have been general among almost all staple commodities. Whether this adverse movement in commodity prices is nearing its end, or whether a recovery is now near at hand are questions which are being actively debated. The prospect of rapid recovery is, however, far from promising. No group of industries has felt the effects of the world-wide industrial malaise more severely than the base-metal industries, and it speaks well for the equipment and arrangement of your concerns that they have stood up so well against the violent and sudden market movements to which I have already referred. We have to accustom ourselves to a lower level of prices, but by effort and economy and sacrifice, fairly distributed among all concerned, we feel that we can face the future with calm—a calm which would grow into assurance if we could rely upon the Government to mitigate the unequal burdens which industry has to bear in this country and to make the conditions of competition between ourselves and our foreign rivals fair to the products of our own people.

Mr. William S. Robinson seconded the resolution and it was carried unanimously.

KINTA KELLAS TIN DREDGING CO., LTD.

Directors : P. J. Burgess (*Chairman*), A. T. Macer, F. G. Payne, W. Benning Galloway. *Consulting Engineers :* F. W. Payne and Son. *Secretaries :* Taylor, Noble and Co., Ltd. *Office :* 481–4, Salisbury House, London Wall, E.C. 2. *Formed* 1926. *Capital issued :* £105,000 in 5s. shares.

Business : Operates alluvial tin property in the State of Perak, F.M.S.

The third ordinary general meeting of the Kinta Kellas Tin Dredging Company, Ltd., was held on October 10, 1930, in the Council Room of the Rubber Growers' Association, 2–4, Idol Lane, E.C., Mr. P. J. Burgess (Chairman of the company) presiding.

The Chairman, in moving the adoption of the report and accounts for the year ended March 31 last, said that shareholders would notice that there was a considerable sum in the balance sheet under the heading of development account. That represented the second half of the payment for additional areas which had been bought and reported to the shareholders the previous year and which had brought the mining life of their property, with the present equipment of one dredge, to something over 20 years. The profit and loss account detailed fully the charges made against their mine revenue and allowance had been made for depreciation of plant, buildings, machinery and equipment. The net result of the year's working was that they had a profit of £16,877 carried to the balance sheet. The board were asking the shareholders to confirm one payment of the two interim dividends of 5% which had already been made. No final dividend was being paid for the year, but the board were proposing to pay an interim dividend on account of the current year. The investments were satisfactory and their financial position gave the directors no anxiety at the present time.

The year's work on the mine had been uneventful, and their thanks were due to their manager for his good work on the spot. They had agreed this year to reduce their output to 80% of what it was last year, and they had, in addition, completely ceased operations during August and September. At the present time they were faced with tin at £114 a ton, which corresponded to tin ore of 70% at £80 a ton. It would be seen from the report that their profits were made up on the sale of tin ore averaging £117 a ton, so that, if for the past year they had been compelled to sell their tin ore at the prices which they could get for it to-day, profit would have been nearly non-existent. The question therefore arose—and it was one to which the directors had given careful consideration—of whether it was worth while at the present continuing to work and use up their tin ore, if the final result was only a small profit. This consideration had been before not themselves only but in their own case they felt it was not justifiable to adopt that policy. Their reasons were firstly that they did not think that the present low price would remain for a prolonged period, and, secondly, they calculated that they would be making a bigger working loss if they were to stop operations altogether and carry the cost of putting the dredges to bed, so to speak, for a prolonged period.

Mr. F. G. Payne seconded the motion which was carried unanimously.

Professional Directory

ADDICKS, Lawrence,
Consulting Engineer,
Bel Air, Maryland, U.S.A.
Cables: Galis, New York.

AGNEW, John A., Tel.: Metropolitan 7751.
49, Moorgate London, E.C.2.
Cables: Lingulina, London.

ALDRIDGE, Walter H.,
Mining and Metallurgical Engineer,
75, East 45th Street, New York.

ALLAN, Clyde,
Mining Engineer,
P.O. Jos, Northern Nigeria.

ANDERSON, Robert J.,
Consultant on Aluminium Metallurgy,
16,200, Hilliard Road, Lakewood, Cleveland, Ohio, U.S.A.

ASHCROFT, Edgar A.,
Consulting Metallurgist,
New Methods in Metallurgy.
Waye House Laboratories, nr. Ashburton, S. Devon.
Cables: Nutalgy, Ashburton.

BANKS, Charles A.,
Mining Engineer,
Pacific Building, Hastings Street, W.,
Vancouver, B.C.
Cables: Bankca. Code: Bedford McNeill.

BARRY, John G.,
Consulting Mining Geologist and Engineer,
609, Mills Building, El Paso, Texas.
Cables: Bargo. Code: Bedford McNeill.

BARTON, Donald C.,
Consulting Geologist and Geophysicist
Specialist: Eötvös Torsion Balance.
Petroleum Building, Houston, Texas.

Phone: Metropolitan 8018
BATEMAN, H. Bertram,
Geophysical Prospecting,
Geophysical Company (Elbof), 668, Salisbury House,
Cables: Elbofcompy, London. London, E.C. 2.

BEATTY, A. Chester,
25, Broad Street, New York.
No professional work entertained.

BEST, James P.,
Mining & Mechanical Engineer
(Alluvials),
P.O. Gudi, Plateau Province, N. Nigeria.
Code: Broomhall.

Tel.: Metropolitan 2655.
BEWICK, MOREING & Co.,
62, London Wall, London, E.C. 2.
Cables: Bewick.

BLACKMAN, H.,
Mining and Structural Engineer,
Explorations, Examinations, and Development in Canada.
Room 523: 276, St. James Street, Montreal, Que., Canada.

BOISE, Charles W.,
Mining Engineer,
Foreign Exploration,
Room 1507—14 Wall Street, New York.
Cables: Mukeba.

BOTSFORD, R. S.,
Mining Engineer,
Fraser Brace, Ltd., Medellin, Colombia, S. Am.
265, Gresham House, London, E.C. 2.

BOYD, Julian,
Consulting Mining Engineer,
1014, Central Building, Los Angeles, California.
Cables: Boydite.

BOYDELL, H. C.,
Mining Geologist and Engineer,
310, McKinnon Building, Toronto, Canada.
Cables: Husky.

BOYES, H. H. W.,
Messrs. Foley, Boyes, Butler & Peek,
Consulting and Mining Engineers,
P.O. Jos, Northern Nigeria.
Cables: Foyes, Jos. Codes: Bentley, Broomhall.

Tel.: Metropolitan 6144.
BROADBRIDGE, Walter,
Consulting, Mining & Metallurgical Engineer,
Minerals Separation, Ltd., 62, London Wall, E.C. 2.
Cable: Rillstope, London.

BRODIE, Walter M.,
Mining Engineer and Metallurgist,
1807, Phelps Place, Washington, D.C., U.S.A.

BROOKS, Raymond,
Mining Engineer,
15, William Street, New York.
16, Colonial Mutual Bldgs., Johannesburg.
Cables: Brookray, New York and Johannesburg.