The Mining Magazine

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EDITORIAL

THE telephone number of this office, which is also that of the Technical Bookshop, has been changed to Metropolitan 8938.

THE Director of the Geological Survey of Uganda is now visiting Kenya for the purpose of making a preliminary survey in Southern Kavirondo and discussing with the Kenya Government the inauguration of a joint Geological Survey for Kenya, Uganda, and Tanganyika Territory.

THE British Industries Fair, which is referred to in some detail elsewhere in this issue, was held simultaneously in London and in Birmingham. This marks the eleventh year of this successful aid to British trade which, started in 1920, has steadily increased in size and importance with each succeeding year

RECENTLY the legal advisers of the Crown have been sharply criticized by Lord Dunedin, during the hearing, in the House of Lords, of an income-tax appeal concerning the Burma Corporation. Judgment was against the Crown, and Lord Dunedin made the observation that it was high time that those who advised the Crown should make up their minds that the Crown might be wrong. Such a warning should serve as a check to those responsible for the appeal, for their use of the power to protract litigation seems to be exercised all too freely.

THE award of the James Douglas Medal to Dr. J. V. N. Dorr by the American Institute of Mining and Metallurgical Engineers, for his achievements in the development of hydro-metallurgical plant and practice, was announced in the MAGAZINE for January last. In accepting the award, on February 19, from the hands of Mr. F. W. Bradley, the retiring President of the Institute, Dr. Dorr paid gracious tribute to those who had contributed to his success—his associates and those professional men whose cordial co-operation had been so readily forthcoming.

THE Gold Medal of the Institution of Mining and Metallurgy has been awarded to Sir Thomas H. Holland, K.C.S.I., K.C.I.E., Vice-Chancellor of the University of Edinburgh, "in recognition of his eminent services to geological science and to the mineral industries during his tenure of high public appointments—notably those of Director of the Geological Survey of India and of Rector of the Imperial College of Science and Technology—and of his researches and publications upon the mineral resources of the British Empire and their relationship to national and international problems." The medal will be presented at the Annual General Meeting on June 26.

THE Third Empire Mining and Metallurgical Congress is on the eve of its opening. Delegates from this country, reinforced by some from Canada and the United States, sailed from Southampton in the Kenilworth Castle on March 7. Included in the party were Dr. Charles Camsell, Deputy Minister of Mines for Canada, and Mr. T. W. Gibson, Deputy Minister of Mines for Ontario. Dr. William Cullen and Mr. Frank Merricks travelled as the official representatives of the Institution on the Empire Council, the main business of which will be the continuation of the discussion of Sir Thomas Holland's proposals for the co-ordination of mineral resources. It will be recalled that Mr. Charles McDermid, who is also travelling with the delegates, was recently in New York discussing this subject with the American Institute of Mining and Metallurgical Engineers.

Metallurgy and Chemical Engineering

An interesting discussion followed the reading of a paper by Dr. W. E. Gibbs, professor of chemical engineering in London University, entitled "The Role of Chemical Engineering in Mining and Metallurgy," at the February meeting of the Institution. Before considering the subject of the paper it is as well to remark at the outset, as Dr. Sydney Smith emphasized in his contribution to the discussion, that the title is misleading. An alternative suggested by Dr. Smith, "Common Factors in Chemical and Metallurgical Engineering," would have been more suitable, although even this would probably have led metallurgical engineers to expect more from the paper than it actually possesses. In his paper Professor Gibbs analyses the functions and scope of the profession which has come to be known as chemical engineering, a

development of chemistry *cum* engineering which has resulted from exploration in the borderland sciences of physical chemistry and chemical physics. This train of thought suggested to the author's mind analogies between this subject and that which has long been known as metallurgical engineering. Thus there are in modern chemical industry many processes, such as crushing, filtration, sedimentation, crystallization, evaporation, drying, and distillation—to mention a few at random—which are common to the two and he feels that in virtue of this kinship there should be a closer *liaison* between chemical engineers and metallurgists. This is the substance of the paper, which concludes with a specific plea for exchange of information between the technical societies concerned and for research co-operation between these societies and plant manufacturers. The remainder of the paper is taken up with extensive exemplification of the various points raised and for this reason it makes good reading for the student or anyone with no previous exact knowledge of the sciences involved.

Any proposal for the pooling of information presupposes that the benefits of such an interchange shall be mutual, but it is difficult to see what benefit there is for metallurgical engineers in any closer conference with their chemical industry cousins than is provided for at present. On the other hand, having regard to the pioneer position of metallurgy in this matter, there is, perhaps, some reason for supposing that chemists engaged in the working out of non-metallic industrial processes may find some guidance in the metallurgist's technique. As Professor Lawn pertinently reminded the author, however, another consideration arises. An essential difference between a metallurgical and a non-metallurgical process is to be found in the fact that in the former the commercial asset consists in the mineral deposit, while in the latter it resides in the process itself. There is thus every reason for metallurgists to be open as to the methods which they employ, as it is by such free exchange of experience that improvement is made and extraction efficiency increased. The chemical engineer, on the other hand, is dependent on the process itself for commercial success and cannot, therefore, afford to disclose any details of his operations. As Dr. Sydney Smith insisted, the chemist in industry owes a considerable debt to his brother technician the metallurgist and will continue to do so.

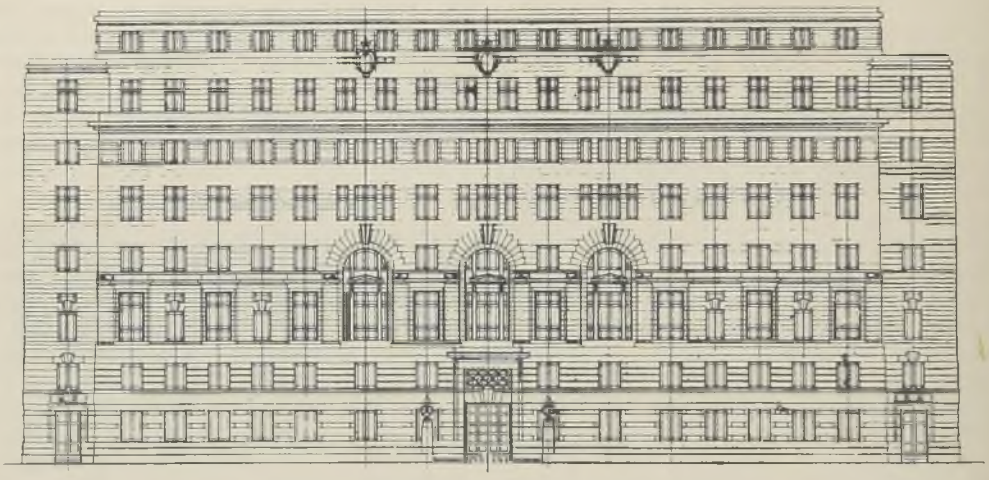
There is yet another aspect of this matter to which attention may with advantage be directed. In remarking in these columns on Dr. Cullen's recent paper on the future position of non-ferrous metallurgy in Great Britain, in February, 1929, consideration was invited of the desirability of dividing metallurgy into two parts conveniently called Metallurgy I and Metallurgy II, the first-named covering the extraction of metals from their ores, including all the prior processes of concentration, and the second the after-treatment of these metals, including alloying, heat treatment, and mechanical working. Admitting this sub-division, it is possible to agree with the author of the paper now under review, that there is some common ground between Metallurgy II and chemical engineering. In fact, both sciences are concerned with the industrial exploitation of raw materials.

Another Change

In May, 1921, when the Institution of Mining and Metallurgy decided to migrate from Finsbury Circus to Cleveland House, City Road, in referring to what were at the time considered to be the drawbacks of the change, the MAGAZINE said: "In any case, it is more than probable that the new home will prove to be only a temporary makeshift." That this view was warranted is evidenced by the proposal which, as the result of much negotiation, has now taken concrete form. The tendency for some time has been to bring about a larger amalgamation than that effected in 1921, when the Institution of Mining and Metallurgy and the Institution of Mining Engineers joined forces. It is doubtful, however, whether many of the individual members of the various societies concerned anticipated anything approaching the present ambitious scheme. This involves the linking up of no fewer than twelve institutions and societies, comprising the Institution of Mining and Metallurgy, the Institution of Mining Engineers, the Institution of Petroleum Technologists, the Iron and Steel Institute, the Institute of Metals, the Institute of Fuel, the Chemical Society, the Society of Chemical Industry, the Institution of Chemical Engineers, the Institution of the Rubber Industry, the Faraday Society, and the Physical Society. The building to house these is to be of a palatial character, as shown by the illustration we are able to give. The cost of this

edifice, for which a suitable site is stated to have been found at Tothill Street, Westminster, together with incidentals, is put at £350,000, for which an appeal is made to the various bodies concerned, and Sir Arnold T. Wilson, who is chairman of the representatives committee, has stated that £100,000 has been promised. The various bodies have, through their councils, agreed in principle to the scheme. The new structure is, however, not to be confined to the uses of technical and scientific institutions, but industrial bodies are to become tenants, and already two—the National Federation of Iron and Steel Manufacturers and the Mining Association of Great Britain—have expressed their desire in this direction. This, it is pointed out, will serve to bring the sales and manufacturing side of industry into touch with the scientific side, to their mutual advantage.

Turning from the general to the particular, the MAGAZINE, whilst fully sympathetic with the aims and objects of all the bodies included in the scheme, is mainly concerned with the Institution of Mining and Metallurgy. Starting in the City, this had three successive addresses, each almost within a stone's throw of the other, and it was surrounded by the offices of many of its members, naturally to their great convenience. In 1921, as already stated, the Institution was moved nearly a mile out of the City and, whilst this was regarded as a good financial deal and gave double the floor space of the Finsbury Circus building, what were facetiously called the amenities left much to be desired. The removal to City Road met with a certain amount of disapproval; we fear the proposed removal to Westminster will be even more unwelcome. The present tendency seems to be in the direction of combines on a gigantic scale; whether this is always to the advantage of the various bodies comprised therein may be open to doubt. At any rate, the end to be desired so far as the Institution of Mining and Metallurgy is concerned is—as also stated in the MAGAZINE of May, 1921—the strengthening of the status of the mining engineer.



SKETCH ELEVATION OF PROPOSED FRONTAGE.

The Indian Budget

There are two matters of interest for readers of the MAGAZINE arising out of the Indian Budget for the coming financial year. The proposal to increase the excise duty on kerosene and to reduce the import duty comes as a somewhat surprising sequel to the events which were discussed at some length in these columns in October, 1928. Thus the measure of protection which the indigenous oil industry was enjoying, and for an increase of which it was seeking, as recorded at that time, is now in fact reduced. The intention, as disclosed in the Budget presented to the Legislative Assembly last month, is to raise the excise duty on Indian refined kerosene from one anna to one anna six pies and to lower the duty on the imported product of whatever origin from two and a half to two and a quarter annas. As was demonstrated in these columns at the

time alluded to, the Government is, and has been for some time, evidently of opinion that the Indian Empire producers have been selling at exorbitant prices and now shows itself to be even less sympathetic to their interests than it was then. The consumer in India is thought, in fact, to have suffered long enough.

Other new taxation to be imposed includes the reintroduction of the silver duty of four annas per ounce, full rebate being allowed for the re-export of the metal. This is less surprising, considering the long continued fall in the price of the metal and having regard to the fact that there is an obvious advantage in improving the internal price of a commodity in which the savings of the great mass of the people are invested. It should be remembered that in India the average cultivator does not deposit his savings in a bank ; he either buries them secretly or, more generally, purchases jewellery for his womenfolk. Much of this jewellery is made of silver. Sir George Schuster, on the other hand, when explaining this tax, made it quite clear that the Government were willing, so far as the sale of surplus silver is concerned, to co-operate with other important interests in the world if these showed any desire to consider the possibility of joint action for the regulation of sales in accordance with world demand.

While the taxation changes here indicated will adversely affect the indigenous oil industry, they should prove beneficial to the mining industry. In the case of the Burma Corporation their contracts stipulate that in the event of the duty on imported silver being increased the amount of the increase is to be added to the price the corporation is paid for the metal.

A Question of Ethics

There has been a good deal of perturbation in some quarters with regard to the assistance the Russian Government is receiving from mining engineers to enable them to resume operations on at least one of the confiscated properties in that country. No group has suffered more than the Russo-Asiatic Corporation in this direction, so the protest of Mr. Leslie Urquhart could hardly have occasioned surprise. The particular property to the working of which American and Continental engineers are now directing their energies is the Ridder. Without this assistance it is doubtful whether this or any of the other mines of the country could be successfully re-started. So far as the Russo-Asiatic properties are concerned, there have been negotiations for their return, but the agreements reached have not been kept. Perhaps it is as well for the corporation that this has been the case, in view of the experience of the Lena Goldfields.

At the present time the number of American mining engineers engaged in Russia could probably be counted on the fingers of one hand, but that there should be any is to be regretted—and this regret is felt by leading mining men in the United States as well as here. The property on which they are engaged belonged to an English company, formed in accordance with the laws then in existence, and a large amount of money was expended on its equipment and development. There is only one word which covers the forcible acquisition of such a property without compensation. Although to assist in the re-opening of a mine under such circumstances is not in the same category as receiving stolen property, it is surely abetting. That other countries have failed to fulfil their obligations —a view put forward in mitigation of the action of the present régime—is no justification, and in this connexion thoughtful people must often have felt surprised that a wealthy country should be willing to see certain of its States periodically scheduled as defaulters by the Council of Foreign Bondholders.

Whatever the outcome of the present controversy may be, it is to be hoped that those in control in Russia may yet realize that countries, like individuals, cannot expect to benefit by confiscation and repudiation. Until this stage is reached encouragement should not be given to the exploitation of expropriated properties, nor should the products therefrom be marketable. For some time past oil from properties confiscated by the Russian Government has been available at a price which would not have been possible had capital expenditure incurred in bringing them to the producing stage had to be considered, and the same applies to other commodities. In purchasing these products we have really provided the finance which has enabled those in control to carry on their operations. How much longer is this state of affairs to continue ?

REVIEW OF MINING

Introduction.—Business in this country remains dull and the immediate outlook does not appear to be too cheerful, although the last few days have witnessed a somewhat better tone for some of the metals. With the announcement of the Government's Budget proposals a revival may be witnessed; meanwhile the lowering of the Bank rate to 4% offers improved trading conditions.

Transvaal.—The output of gold on the Rand during February was 783,086 oz. and in outside districts 35,102 oz., making a total of 818,188 oz., as compared with 882,801 oz. in January. At the end of February the number of natives working at the gold mines was 196,752, as compared with 190,663 at the end of January.

In the January issue of the MAGAZINE it was recorded that Mr. John Martin, president of the Transvaal Chamber of Mines, had expressed the view that, although the native labour supply was then abnormally low, he took a hopeful view of the future. The embargo recently placed by the Northern Rhodesian Government on recruiting in that colony and the subsequent negotiations for increased recruiting facilities in Portuguese territory must have forced Mr. Martin to change his opinion, for he now states that he fears the gold-mining industry will have to face the permanent problem of a shortage of native labour.

The amalgamation of the Village Deep and Robinson Deep has now been approved and it is stated that, provided the companies carry out the undertakings given in regard to employment and the compensation of employees, the Minister of Mines will have no objection to the merger.

The Union Government is inviting tenders for leasing 1,500 claims in the Vogelstruisfontein area, adjoining the Consolidated Main Reef property on the east and the New Steyn Estate on the west. The area in question was formerly worked by the Bantjes New Reef Company. It is also stated that the Crown Reef and Consolidated Main Reef companies are acquiring 900 claims on the farm Diepkloof, which lies on the dip of their existing workings.

The report of the Tweefontein United Collieries for the year ended September 30 last shows that coal sales totalled 828,720 tons, an increase of 15,244 tons on the previous year. The whole of this tonnage was produced from the Tweefontein Colliery. The equipment of the New Waterpan Shaft is almost completed and the shaft is expected to be in use at an early date.

Cape Colony.—The Cape Asbestos Company proposes to increase the capital of the company from £200,000 to £300,000 by the creation of 50,000 cumulative 5% Participating Preference shares of £1 and 50,000 Ordinary shares of the same value, thus raising the number of each class to 150,000 shares. It is intended to issue 25,000 of both Preference and Ordinary shares, in order to provide funds to meet the expansion of business and to reimburse the company for subscribing capital required by Egnep for its amosite asbestos mines. The shares have been offered to shareholders in the proportion of one new share for every four held, at 12s. 6d. and 7s. 6d. premium for the Preference and Ordinary shares respectively.

In a circular to shareholders the Griqualand Exploration and Finance Company states that the new machinery is expected to be shipped from England in March and that development of the asbestos deposits is proceeding favourably.

Diamonds.—The output of diamonds from the Union of South Africa last year was 3,661,212 carats, valued at £10,590,000, a decrease from the previous year of 711,644 carats, or rather more than £6,000,000. Sales of mined stones increased by 20s. 6d. per carat and the decrease is entirely in alluvial stones, the value of which dropped 34s. per carat. Mined stones were valued at £5,750,000, an increase of £150,000 on the previous year.

The Diamond Corporation, a company with a capital of £2,500,000, has been registered in Pretoria, with the head office in Kimberley. Among those connected with the registration are Sir Ernest Oppenheimer and Mr. S. B. Joel, and it is expected that the new company will play an important part in the future of the diamond industry.

Southern Rhodesia.—The output of gold during January was 46,121 oz., as compared with 46,829 oz. in December and 46,231 oz. in January of 1929. Other outputs in January were: Silver, 6,112 oz.; copper, 100 tons; coal, 111,978 tons; chrome ore, 30,493 tons; asbestos, 4,775 tons; mica, 21 tons.

In his report to the British South Africa Company Mr. E. H. Clifford comments on the continued decline of the gold industry in Southern Rhodesia and its effect on the future revenue of the company. It is felt that although two new producers—the Wanderer and the Mayfair—came into operation during the year they will not be able to arrest the continuous decline.

Work at the Shamva mine is to cease not later than March 31. Owing to bad weather and other conditions, certain sections of the mine have become dangerous, and the expense of keeping them open is not warranted by the ore-reserves available.

The directors of Rezende mines propose to repay 2s. 6d. per £1 share, which will reduce the issued capital to £131,250 in shares of 17s. 6d. each.

Northern Rhodesia.—Some useful statistics for the copper mining industry in Northern Rhodesia are contained in Mr. Clifford's report to the Chartered Company. He states that proved ore amounts to 230,000,000 tons, containing an average of 3·9% copper. Included in this total are the 60,000,000 tons of oxidized ore which have been proved in the neighbourhood of the N'Changa mine and for which a suitable treatment process has yet to be found. The remaining ore, however, Mr. Clifford states, is a straightforward sulphide ore, averaging 4% copper, about which there is no uncertainty, either in respect of quantity, value, or treatment. Furthermore, the indications leave no doubt as to the existence of a further 100,000,000 tons which will shortly be proved by drilling. It is further pointed out by Mr. Clifford that no difficulties are anticipated as to an adequate supply of white labour, but he admits that the problem of native labour may present some trouble.

Shareholders of the Rhodesian Congo Border Concession have now been informed of the complete results from bore-hole N.E. 8, situated on the western extension of the N'Changa property. The interpretation of this hole shows that from 1,270 ft. to 1,369 ft. it was in ore averaging 9·72% copper, of which 94·3% is present in the form of sulphide.

Gold Coast.—It is proposed to reduce the capital of Taquah and Abosso Mines from £250,000 to £200,000 by reducing the 5s. shares to 4s. When the reduction has been approved it is proposed to create 250,000 new shares of 4s. each, which will restore the capital to £250,000. The reduction, it is hoped, will enable the company to reach the dividend-paying stage again.

Australia. — An asbestos property, situated three miles south of the Soanesville Asbestos mine, Pilbarra district, Western Australia, and known as the "South Soanesville," is to be acquired by Nigel (Transvaal) Goldfields, Ltd. The area is about 540 acres in extent, and the mineral is a chrysotile asbestos of good quality fibre. Mr. H. R. Sleeman has reported on the property and some promising development work has been done. It is proposed to increase the capital of the company to £125,000.

The Electrolytic Zinc Company of Australasia stopped forwarding ore to Zeehan at the end of January on account of the removal of plant to works at Rosebery. The mill at Rosebery is expected to start work in June.

The serious damage done by the floods in April last on the Briseis mine amounted to over £62,000 and the cost of re-opening and re-equipping the workings is estimated at £65,000. The Tasmanian Government has agreed to a loan not exceeding £25,000, and it is now proposed to reconstruct the company, with the same capital as at present, the new shares carrying a liability of 3s. a share.

Malaya.—During the year ended October 31 last, Petaling Tin, Ltd., treated 6,183,682 cu. yd. of ground and recovered 2,469 tons of tin concentrates. The total profit from mining operations was £202,610, an increase of £98,013 over that of the previous year, and £130,200 was distributed as dividends, equal to 60%. The area worked out in the period under review was approximately 77 acres. At the general meeting last month it was announced that instructions had been given to close down No. 1 dredge and to turn No. 2 dredge into ground of a lower grade. The former is to be replaced by a 15 cu. ft. dredge capable of treating 220,000 cu. yd. per month, estimated to cost £100,000.

It will be recalled that the directors of the Kay Yew (Kinta Valley) Tin Mines not being satisfied with Mr. Attenborough's report on their property appointed Mr. Frederick Wickett as manager and elected Mr. Nance Williams to the board. Mr. Williams is at present in Malaya and it is stated that, whilst the method he has adopted to open up the property will have

the effect of temporarily reducing the output, production by the end of April will have increased to 500 piculs per month, putting the mine on a profit earning basis.

The Penawat (Malaya) Tin Dredging Company announces that negotiations have been completed for the purchase of 833 acres of tin-bearing land situated at Malim Nawar Mukim, in the Kampar District of Kinta Perak, together with one bucket dredge. Of the newly-acquired area 327 acres, estimated to contain 23,879,853 cu. yd. of an average value of 0·47 katty, have been proved. The purchase consideration is 500,000 fully paid shares. Mr. E. P. Hargreaves has reported on the property, which has been check-bored by the company, and a favourable report of the dredge was given by Mr. C. H. Sharp, of the Malaya Consolidated Tin Dredging Company. It is estimated that the dredge will commence digging about November next.

India.—It is now nearly a year since there was trouble from rock-bursts in the Indian mines. Towards the end of February, however, rock-bursts were reported from the Ooregum and Champion Reef. At the Ooregum a heavy burst occurred in Bullen's section, which resulted in injuries to 13 workmen, whilst the Champion Reef announces that two rock-bursts occurred in Garland's secondary shaft from the 39th to 55th levels. It is not expected that output will be seriously affected in either case.

United States.—The estimated total value of mineral products in the United States in 1929 was approximately $5,900,000,000. This is an increase of nearly 10% over the value for 1928 and is due chiefly to the increase in quantity of copper and iron produced. Lead, zinc, and mineral fuels increased, but gold and silver decreased.

Mexico.—During the last quarter of 1929 the Fresnillo mill crushed and treated 216,329 short tons of oxide ore and 62,458 short tons of sulphide ore, a total of 278,787 tons, and the value of bullion and concentrates produced was $1,255,713. At the Teziutlan the mill crushed and treated 15,392 short tons of sulphide ore, producing concentrates worth $191,649.

The report of the Santa Gertrudis Company for the quarter ended December 31 last states that on the Dos Carlos Group 10,826 ft. of development work was done, of which 5,792 ft. was in ore. In accordance with the arrangement with the Real del Monte, driving was continued along the north boundary of the Ohio claim for a distance of 524 ft., all in country rock. Drilling in progress along the boundary between the Rialito and Ohio claims has cut 28 ft. of high-grade ore. This is thought to be a north-south vein and assays of the 6 ft. of core recovered went 60 oz. silver to the ton.

Venezuela.—Promising development of the property acquired from the North Venezuelan Petroleum Company is announced by Tocuyo Oilfields of Venezuela, Ltd. In addition to the three producing wells drilled by the former company, eleven further wells have been brought in and four wells are in course of drilling. A pipeline 33 kilometres in length, connecting the fields with the sea, is expected to be completed in the near future, and meanwhile production is being restricted.

Russia.—During the past month there has been a plethora of reports of a conflicting character concerning the Lena Goldfields and the Soviet Government, the latest being to the effect that the various matters in dispute are to be submitted to arbitration.

Asbestos.—Turner and Newall, Ltd., has acquired the whole of the share capital of the Quasi-Arc Company and its own capital is, in consequence, to be increased to £7,250,000 by the creation of 400,000 £1 shares.

Chemical and Metallurgical Corporation.—Following the dispute between the company and its general managers, there has been a good deal of restiveness among the shareholders, who have held a meeting and appointed a committee. The annual general meeting is to be held this month, when the position of the company is to be fully dealt with.

Tin.—The regulation of the production of tin concentrates is now assuming definite form. The producers of the Dutch East Indies will limit the output of Banka to 22,000 tons and that of Billiton to the average production of the past three years. Companies which are members of the Tin Producers' Association and which are actually curtailing output number 104, and their normal annual production is given as equivalent to over 47,000 tons of metallic tin. Other producers outside the association, with a normal annual output of over 68,000 tons metallic tin, have also undertaken to restrict production. The aggregate annual curtailment is now computed at over 24,000 tons.

MILLING PRACTICE AT FRESNILLO

By R. E. BYLER

The author, who is metallurgist to the Fresnillo Company, describes the practice on this silver-lead-zinc property, which is situated in the State of Zacatecas, Mexico.

The cyanidation of oxidized silver ore and the concentration of lead-silver-zinc sulphide ore by differential flotation comprise the metallurgical operations at Fresnillo. Beneficiation of the oxide ore, which is mined from a large surficial ore deposit, was begun on a 2,200 ton-per-day[1] basis in 1921 by the Mexican Corporation, S.A. This company developed the property and operated it under a lease-contract agreement with the owners, the former Fresnillo Company of New York, until May, 1929, when the interests of both companies in the property were merged to form the present Fresnillo Company. Mining and milling operations were confined to the oxidized silver ore until 1925, when exploitation of the sulphide ore-body underlying the surficial oxide ore was begun and a flotation plant was built to treat the complex sulphide ore.

Profitable treatment of the oxide ore predicates economy of practice and close attention to small economic gains or losses, as the ore is low grade and the silver is associated with manganese oxides in a form which reduces its amenability to cyanidation. The average ore milled during the six-year period 1921 to 1927 contained 5½ oz. of silver and 16 cents in gold per ton. The capacity of the mill was increased to 3,750 tons per day in 1924, and this tonnage was maintained until 1927. Since 1927 the grade of the ore has averaged 6½ oz. of silver at a milling rate of 2,500 tons per day. The ore from some sections of the mine is sufficiently refractory, in consequence of the manganese-silver association, to require a special preliminary treatment before an economic extraction of the silver can be obtained by cyanidation, and this treatment is given in a 400-ton plant by the McCluskey process, which was developed at Fresnillo. The current sulphide ore contains 9·5% lead, 10% zinc, 0·65% copper, and 11·5 oz. of silver per ton. The base metal content of the ore has approximately doubled since 1925. The tonnage of ore treated in the flotation plant has been increased from 165 to 690 tons per day, in co-ordination with the development of the sulphide ore-body. Operating costs have been reduced, and treatment of both the oxide and sulphide ores has been continuously improved under the vigorously progressive policy of the management. The present cost of the oxide ore treatment by cyaniding is $1·00 per ton, which is slightly lower than the cost obtaining at the former higher milling rate of 3,650 tons per day. The cost of concentrating the sulphide ore has been reduced from $2·55 to $1·36 per ton, and the flotation practice has been greatly simplified. The treatment of the oxide and sulphide ores is described in the following account of Fresnillo milling practice.

[1] Tonnage data refer to the short ton of 2,000 lb., and costs are expressed in United States currency.

Crushing Practice.—The crushing and grinding plants, originally designed for the oxide ore, are now used for both oxide and sulphide ores. The two classes of ore are crushed separately and delivered to separate compartments of an 8,800 ton crushed-ore storage bin at the head of the grinding plant. Ore is delivered to the crushing plant by electric haulage in trains of ten 12-ton cars each, and is dumped directly into the hopper of the primary breaker. Crushing is done in three stages; the primary breaker, a 30 in. McCully gyratory, reduces run-of-mine ore to 3½ in. or under, this product being reduced to 1½ in. by two 48 in. Symons horizontal disc crushers, and then to the final product containing 22% + ⅝ in. and 22% + ½ in., by two 48 in. Symons vertical disc crushers. A stationary grizzly removes the − 1½ in. material from the feed to the horizontal disc crushers, and Mitchell vibrating screens having ⅞ in. apertures remove the undersize from the feed to the vertical disc crushers. When operating on oxide ore alone the crusher plant delivered a ⅝ in. product, but owing to the tendency of the moist sulphide ore fines to pack, it has been necessary to increase the opening of the disc crushers and deliver a coarser product to the grinding plant. The average coarse crushing cost, including conveying, is 5½ cents per ton of ore, and the power consumption 0·88 kw.-hr. per ton.

Oxide Ore Treatment.—The grinding plant is divided into four independent units, one of which is now used for the sulphide

ore and three for the oxide. When refractory manganese-silver ore is being run, half of one oxide ore grinding unit is diverted to this ore. Primary grinding is done in the oxide ore units by 6 by 12 ft. Marcy rod-mills operating in open circuit, and secondary grinding by 6 by 14 ft. Traylor ball-mills in closed circuit with 12 ft. Dorr bowl classifiers as shown in the oxide ore flow-sheet (Fig. 1). The power consumption, including classifying, is 12·7 kw.-hr. per ton of ore, and the cost of grinding is 30 cents per ton. The consumption of liners and grinding media is given in Table I. A reduction in the consumption of mill liners has been effected by the use of manganese steel instead of white-iron liners, the reduction amounting to 50% for Marcy rod-mill liners.

TABLE I.

LINER, ROD, AND BALL CONSUMPTION OXIDE AND SULPHIDE ORE MILLING UNITS.

	Lb. per short ton.	
	Oxide Ore.	*Sulphide Ore.*
Mn steel liners—Primary rod-mills	0·206	—
Primary ball-mills	—	0·352
Secondary ball-mills	0·204	0·124
3 in. high-carbon steel rods	1·416	—
3 in. forged steel balls (secondary mills)	0·948	1·020
4 and 5 in. forged steel balls (primary mills)	—	3·188

Extraction of the silver from the oxide ore is improved in proportion to the degree of comminution, but the extent to which fine grinding can be economically carried is limited by the low grade of the ore. In order to obtain the highest economic outcome from the treatment, therefore, the ore was formerly segregated according to grade and differential grinding practised, one mill unit being used for each grade of ore. After grinding, the pulp from all units was combined for cyanidation. A summary of data representing this practice and showing the relation between extraction and degree of comminution of the segregated grades of ore, follows :—

Class.	*Short tons per day.*	*Assay oz. Ag.*	*Ground % − 200 mesh.*	*Extraction. %*
No. 1	865	6·5	67	75
,, 2	885	5·5	54	72
,, 3	950	5·0	53	71
,, 4	1050	4·5	51	68

The lower grade ores came from the upper levels of the oxide ore-body and the higher grade, making up class No. 1, from the lower levels from which the major part of the current ore is being mined. When mining of the higher grade oxide ore was begun in 1927, the practice of segregating the ore for grinding was discontinued, and all oxide ore mill units now grind to the same degree of comminution, 5% + 65 mesh and 60% through 200 mesh.

The oxide ore is cyanided by sand leaching and slime agitation, 30% of the tonnage being treated in the leaching plant. The ore was formerly treated by agitation of the whole pulp, but this practice was changed to sand-slime treatment in 1924, to lower the cost of cyaniding and to obtain a higher recovery of silver from the coarser components of the pulp. While sand leaching entails an expenditure of 2 cents per ton of ore, the cost of agitation was reduced by 7 cents per ton by the reduction in tonnage of pulp agitated, so that a net saving of 5 cents per ton was made in the cost of treatment. The total recovery of silver is increased by an average of 0·15 oz. (5 gm.) per ton of ore by the separate treatment of the sand and slime. The factors contributing to the increase in extraction are : The use of stronger solutions and a long contact period in the treatment of the coarse sizes of the pulp by leaching, and the longer slime agitation and filter-cake washing periods which result from the reduction in tonnage of pulp treated in the agitators. An extraction of 45% of the silver is obtained from the sand product and 55% from the slime. The more amenable silver is dissolved while the ore is being ground, and an extraction of 44% is made in the mills, the total combined extraction being 75%. The ore contains 0·3 to 0·4% manganese, which adversely affects its amenability, so that the recovery obtained represents practically complete extraction of the soluble silver, the total extraction of gold being 75%.

The sand-slime separation is made by two 15 ft. Dorr bowl-classifiers operation in parallel. Characteristic screen analyses of the two products under current grinding practice are as follows :—

TYLER STANDARD SCALE.

Product.	% + 48 *mesh.*	% + 65 *mesh.*	% + 100 *mesh.*	% + 200 *mesh.*	% − 200 *mesh.*
Sand	2	36	30	28	4
Slime	–	0·5	–	24·5	75

The sand is leached in five steel tanks 60 ft. in diameter by 16 ft. deep, each having a capacity of 1,815 dry tons. Although the sand charges are unusually deep, a leaching

rate of 5 to 6 in. per hour is obtained. A typical leaching cycle follows :—

	Hours.	*Tons solution per ton sand.*
Charging	65	–
Strong solution (3 lb. NaCN per ton)	60	0·65
Draining	8	–
Barren solution (1½ lb. NaCN per ton)	125	3·45
Water wash	12	0·20
Draining	13	–
Discharging	12	–
Total	295	4·30

The slime treatment conforms to general agitation practice. The overflow from the sand-slime classifiers is thickened to 38% solids and agitated for 60 hours with cyanide solution averaging 1½ lb. of sodium cyanide equivalent per ton and 0·06% lime as protective alkalinity. The agitator residue is filtered and washed in Butters type filters, the washed cake being discharged to thickeners for partial recovery of the filter washing-solution and water before pumping to the tailing dam. " Aero " Brand (calcium) cyanide is used, the total consumption per ton of ore being 2 lb. (equivalent to 0·98 lb. NaCN). The lime consumption is 19·3 lb. of 75% lime per ton of ore. The cost of the slime treatment is 12½ cents per ton of ore, and cost of chemicals 25 cents per ton.

Cyanide Recovery Plant.—The mechanical loss of cyanide incurred in filtering the slime residue was materially reduced, in 1925, by installing a Mills-Crowe cyanide recovery plant to provide cyanide-barren washing solution for the filtering operation. The Mills-Crowe process, as applied at Fresnillo, removes the cyanide from silver-barren precipitation tail solution which is then used for washing the slime filter-cake. The de-cyanided solution is practically equivalent to water in cyanide-replacing efficiency when used as a filter-cake wash, and it gives a higher cyanide recovery from the slime residue than was obtained with the low-grade cyanide solutions used for washing before the recovery plant was installed. The higher washing efficiency reduced the mechanical loss of cyanide from 0·970 lb. to 0·086 lb. sodium cyanide equivalent per ton of ore. The following data compare average conditions just before the recovery plant was put into operation and some months later after the plant had been brought up to full operating efficiency. It will be noted that the mechanical loss of cyanide before the recovery plant was installed was nearly equal to the present total consumption (0·98 lb.) of cyanide :—

	Before Recovery Plant (1924).	*After Recovery Plant (1925).*
Cake-washing solution, lb. NaCN per ton	3·358	0·166
Solution discharged to tailing dam, lb. NaCN	0·813	0·075
Mechanical loss, lb. NaCN per ton of ore	0·970	0·086
Mechanical loss, per cent total consumption	61·7	10·7

A flow-sheet of the recovery plant and filter washing solution circuits is included in Fig. 1. Solution is de-cyanided in the recovery plant by acidulating with sulphur dioxide to convert the alkaline cyanides into hydrocyanic acid (HCN), and then removing the HCN, which is a gas at normal temperature and pressure, by scrubbing the solution with a stream of air. The dispersed cyanide is recovered in absorbing towers by washing the air stream with alkaline solution, which dissolves the HCN gas and fixes it in solution as an alkaline cyanide. Chemical and mechanical details of the process have been described by others.[1] The reaction that takes place in the acidification step is regenerative, part of the cyanide in solution as complex salts of the base metals being liberated and the base metals precipitated out of solution. This regenerative action of the process is of secondary importance at Fresnillo, on account of the small amount of base metal cyanides normally in solution, but it has served to keep the mill solutions at maximum efficiency. The circulating load of zinc in the mill solution decreased from 0·41 lb. to 0·17 lb. per ton after the recovery plant was put into operation.

From 91 to 92% of the cyanide is removed from the solution treated, leaving 0·13 to 0·16 lb. NaCN equivalent per ton in the filter wash. The slight acidity (0·03%) of the de-cyanided solution wash is neutralized by the latent alkalinity in the slime filter-cake. Low-grade effluent solutions from the filter and sand plants are used for absorbing solution in the recovery plant and, after being enriched in cyanide in the absorbent towers, are returned to the mill solution circuit. The tonnage of solution treated per day is varied to meet the requirements of the filters, maximum and minimum tonnages

[1] C. W. Lawr, " Cyanide Regeneration or Recovery as Practised by the Compania Beneficiadora de Pachuca, Mexico," Tech. Pub. No. 208, American Institute Mining and Metallurgical Engineers (1929), Bibliography, p. 35.

for the past year (1929) being 1,900 and 1,200 tons per day, respectively. The cost of operation of the recovery plant is 3½ cents per ton of solution treated. This includes no charge for sulphur, the sulphur dioxide gas being supplied by roasting pyrite concentrate made in the flotation plant. Before roaster gas was available, crude sulphur was used for making sulphur dioxide, the average consumption being 1·7 lb. at an added cost of 4 cents per ton of solution treated. The consumption of power in the recovery plant is 0·82 kw.-hr. per ton solution.

A small amount of the roaster gas is used for making sulphurous acid, which has been substituted for commercial hydrochloric acid in the treatment or cleaning of the Butters filter leaves. A saving of approximately 33% of the cost of leaf washing was made by utilizing excess roaster gas for this purpose. The acid is made in a small absorption tower and is maintained at a strength of 2 to 4 lb. per ton, by returning the spent wash to the absorption tower in a closed circuit. Saturation of the circulating acid with calcium sulphite is prevented by continuously bleeding off a portion of the return wash and replacing it with an equal volume of water.

Precipitation.—Enriched solutions from the leaching plant and the slime thickeners and filters are clarified and then precipitated with zinc dust, using the Crowe vacuum process and Merrill presses. Under the present milling schedule of 2,500 tons of oxide ore per day, an average of 7,790 tons of solution containing 1·3 oz. of silver per ton are precipitated daily. This grade of solution is precipitated to a trace (0·003 oz.) of silver. The consumption of zinc dust is 0·047 lb. per ton of solution precipitated. The precipitate, which averages 85% silver and 0·1% gold, is dried on steam plates and shipped to a local refinery. The cost of precipitation is 4½ cents per ton of ore. The total cost of cyaniding the oxide ore is distributed as follows :—

	Per Ton Ore.
	$
Labour	0·21
Supplies	0·47
Power	0·27
Water	0·05
Total	$1·00

Mine water is used, and the mill is charged a proportionate part of the cost of pumping.

Treatment of the Refractory Ore.—Differentiation between oxide ore which is amenable to the above cyanide treatment and the refractory ore which requires a preliminary treatment before it can be economically cyanided is made by metallurgical testing, as the amenability of the silver does not vary directly with the manganese assays. Manganese is disseminated through the entire surficial orebody in varying amounts up to 3% and its deleterious effect on the amenability of the silver to cyanide may cause a variation of as much as 50% in the silver extraction, between ore with low and high manganese content. Generally, if the manganese is present in excess of 0·5% the extraction from the average grade ore becomes too low for economic treatment by ordinary cyanidation, and the ore is classified as refractory.

The grade of available ore added an economic pre-requisite of low plant installation and operating costs to the metallurgical problem involved in developing a treatment for the ore, and precluded roasting or expensive hydrometallurgical operations from consideration. An efficacious treatment for manganese-silver ores in which the oxides of manganese are dissolved out by sulphurous acid and the silver left in a form amenable to cyanide, has been recorded by a number of investigators, but the process was never commercially applied because of the difficulties encountered in filtering and washing the acid-treated pulp before cyaniding. The treatment offered promise for the Fresnillo refractory ore, however, owing to the relatively low manganese content, and to an assured supply of cheap sulphur from the pyrite in the sulphide ore. Experiments made by Mr. S. B. McCluskey to develop the treatment were successfully concluded, and a process[1] devised in which filtering and washing of the acid-treated pulp, before cyanidation, was obviated by conditioning the pulp so as to destroy the cyanicidal character of the salts formed in the acid treatment. After conditioning, the pulp is neutralized and cyanided. The experimental work was confirmed by thoroughly testing in a pilot plant, and a full size unit having a capacity of 400 tons per day was built. The McCluskey process increases the extraction of silver 20% over that obtained by straight cyanidation of refractory ore of the average grade (6½ oz. Ag, 0·75% Mn). Data showing the extractions made from various other grades of the refractory ore are given in Table II.

[1] Patented : Brit. Pat. No. 278,742 ; Canad. Pat. No. 283,696 ; U.S. Pat. No. 1,658,249.

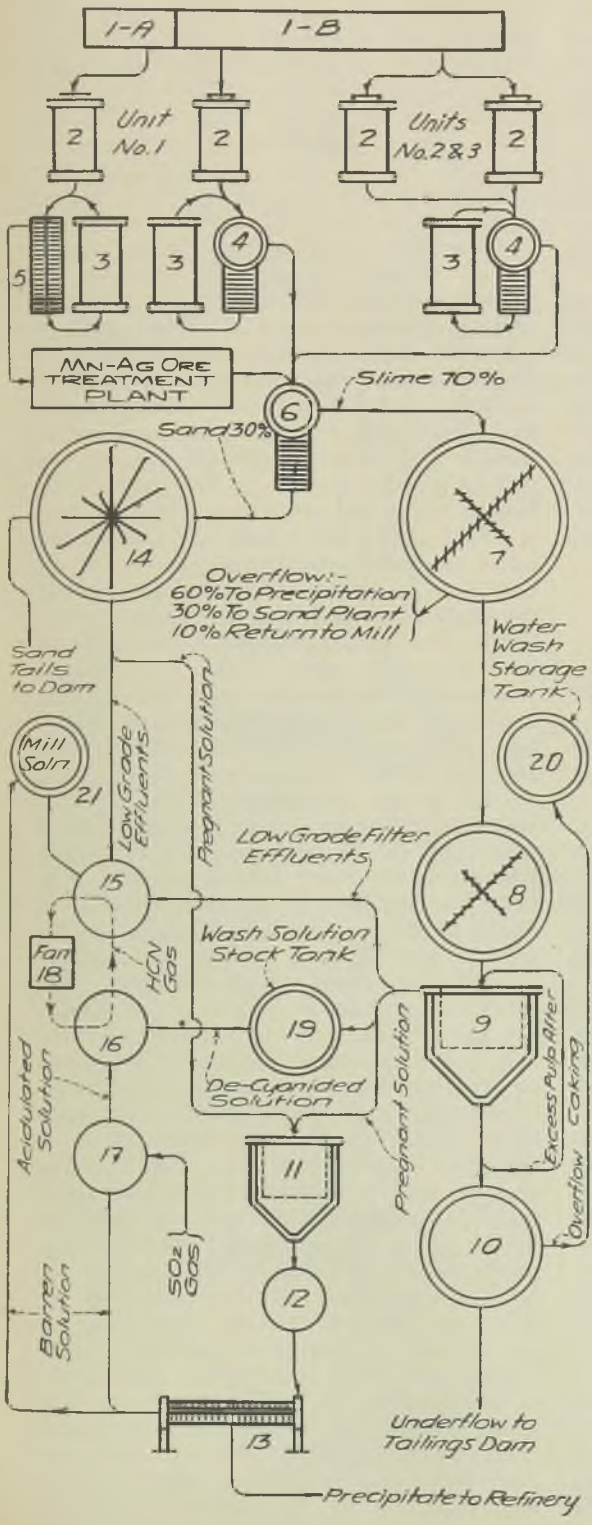


Fig. No. 1.
Flow-sheet of Cyanide Mill.
Fresnillo Company.

LEGEND.

1-A.—Crushed Ore Bin, Manganese-Silver Ore Section.
1-B.—Crushed Ore Bin, Oxide Ore Section.
2.—6 × 12 ft. Marcy Rod-Mills.
3.—6 × 14 ft. Traylor Ball-Mills.
4.—12 ft. Dorr Duplex Bowl Classifier.
5.—8 ft. Dorr Duplex Rake Classifier.
6.—Two 15 ft. Dorr Bowl Sand Slime Classifiers.
7.—Six 60 × 10 ft. Dorr Thickeners.
8.—Thirteen 40 × 25 ft. Modified Dorr Agitator Tanks.
9.—Four Butters Slime Filters, 156 Leaves Each.
10.—Four 35 × 12 ft. Dewatering Thickeners.
11.—One Butters Clarifying Filter, 156 Leaves.
12.—Two Crowe Vacuum Tanks.
13.—Six 52 × 52 in. Merrill Presses, 43 Leaves Each.
14.—Five 60 × 16 ft. Sand Leaching Tanks.
15.—Cyanide Recovery Plant—Two HCN Absorption Towers.
16.—Cyanide Recovery Plant—Two HCN Dispersing Towers.
17.—Cyanide Recovery Plant — Two Solution Acidifying Towers.
18.—Cyanide Recovery Plant—No. 10 Sturtevant Fan.
19.—Filter Wash-Solution Storage Tank.
20.—Filter Wash-Water Storage Tank.
21.—Mill Solution Storage Tank.

A flow-sheet of the pretreatment plant is shown in Fig. 2. The ore is ground and thickened in cyanide solution as in the ordinary treatment, except that only sufficient lime is added to protect the cyanide and facilitate settling in the thickeners. The pulp is thickened to 38% solids before the acid treatment, so that no further thickening is required before cyanidation. The thickened pulp then flows through a roller-sprayer chamber (A, see flow-sheet) and is acidulated with sulphur dioxide gas, which is drawn through the chamber counter-currently to the pulp flow. Sulphur dioxide in the gas from the pyrite roasting plant is utilized for the acidification of the pulp. The sprayer chamber is a wooden box 85 ft. long and 24 sq. ft. in cross-sectional area, equipped with 13 transverse rollers spaced equidistantly along the length. The rollers, which operate at 900 r.p.m., are light-weight,

Table II.

Extraction from Manganese-Silver Ore Samples—Laboratory Tests.

	Assay of Sample		*Per Cent Extraction.*	
Sample No.	*Ag. oz.*	*Mn. %*	*By Cyanidation only.*	*Pretreatment by McCluskey process followed by cyanidation.*
1	6·0	0·61	58%	78%
2	6·2	0·82	45	76
3	5·1	1·07	30	70
4	7·2	1·25	21	74

hollow, sheet iron cylinders, 12 in. in diameter by 4 ft. long, protected against corrosion by a cover of soft vulcanized rubber. The pulp flows in a shallow stream along the slightly sloping bottom of the chamber and is picked up by the rollers and thrown as a dense, finely divided spray into the stream of gas, this operation being repeated by each roller as the pulp passes through the chamber. As the pulp becomes acid, the cyanide in solution is converted into hydrocyanic acid which is dispersed from the pulp by the stream of gas passing through the chamber, and is recovered in absorbing towers (T-T) as in the Mills-Crowe cyanide recovery plant. In order to provide a sufficient volume of gas to disperse the cyanide, the sulphur dioxide gas from the roasting plant is diluted with a larger volume of air, which is circulated through the sprayer chamber and absorption towers by a separate fan (F). The alkaline pulp spray at the head of the chamber scrubs the residual sulphur dioxide out of the gas stream before it enters the absorbing towers, and prevents destruction of the alkali in the absorbing solutions. Acidification of the pulp is controlled by adjustment of the roaster gas flow and the cyanide dispersion by regulation of the volume of diluting air.

The acidulated pulp, which contains 0·7 to 0·8% of free acidity when it leaves the roller sprayer, is digested in a paddle-wheel agitator to continue solution of the manganese. An average of 60% of the manganese is dissolved in the treatment, the remainder being manganese carbonates and/or silicates which are insoluble in sulphurous acid. The pulp flows from the digester through a series of similar agitators where calcium carbonate slurry is added to neutralize any remaining free acidity, and the pulp is aerated to oxidize the ferrous and manganese salts formed in the acid treatment. The iron precipitates out of the neutral solution as a basic ferric salt which has no cyanicidal properties. Milk of lime is added at the last conditioner tank in the series to precipitate the manganese in an inert form (as regards cyanide) and to provide the alkalinity required for the cyanide treatment. The conditioned pulp is then pumped to the cyanide plant where it is treated jointly with the amenable oxide ore. Cyanide is added to the conditioned pulp at the pump box. The consumption of calcium carbonate and lime in the conditioners is 42 lb. each, per ton of ore. The adjustments and titrations required to control the process are easily made and the plant is operated by native attendants with very uniform results. The plant has not been in operation a sufficient length of time to establish cost data, but the present cost (after 5 months operation) is 45 cents per ton for the pretreatment. The total consumption of power is 8·8 kw.-hr. per ton. Gravity flow is used through the entire acid-treatment section of the plant to avoid the expense of pumping acid pulp.

Sulphide Ore Treatment.—The treatment of the lead-silver-zinc sulphide ore is indicated by the flow-sheet, Fig. 3. The present simple differential flotation treatment was adopted in 1927, following an initial period of operation characterized by numerous modifications of practice and by an increasing grade and amenability of the ore. The principal metallic minerals in the ore are galena, argentite, marmatite (ferriferous sphalerite), chalcopyrite, and pyrite. A small amount of gold (58 cents per ton) is associated with the minerals, principally the galena and pyrite. The lead, zinc, and iron minerals are coarsely crystalline and are separated at approximately 65-mesh grinding, but the argentite and part of the

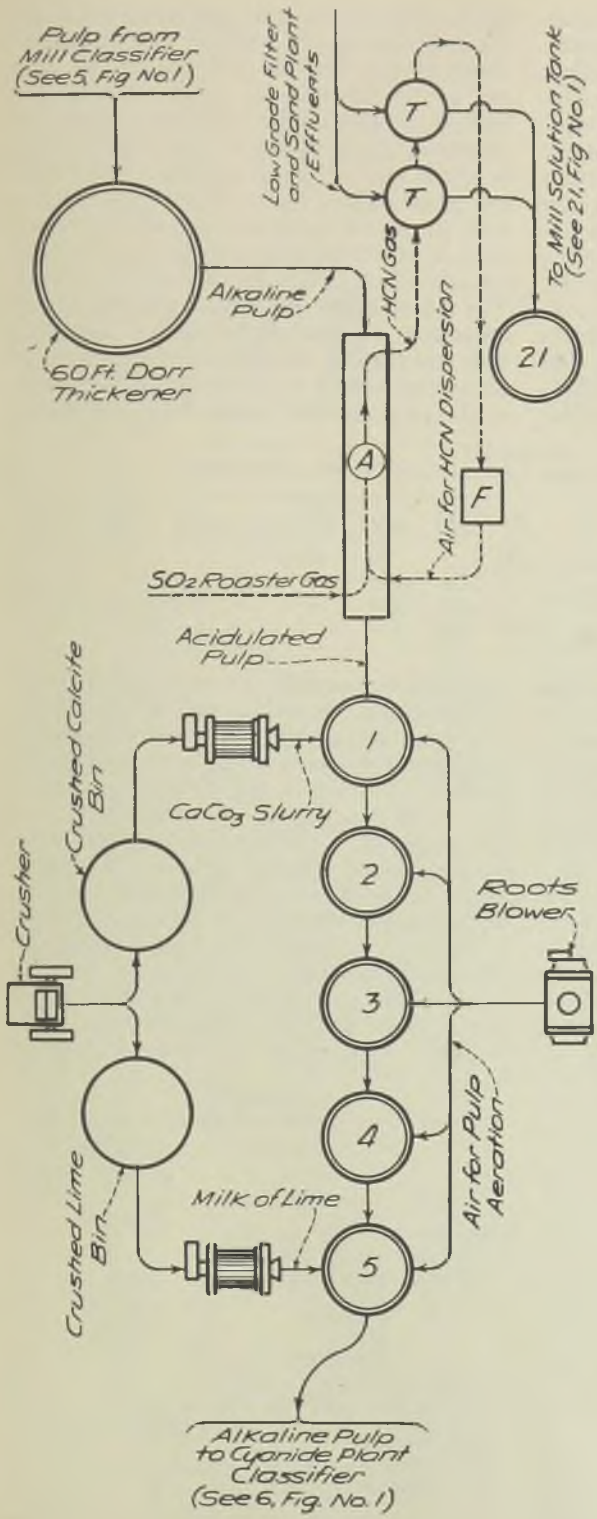


Fig. No. 2.
Flow-sheet of Manganese-Silver Ore. Treatment Plant.
Fresnillo Company.

LEGEND.

A.—85 ft. Roller Sprayer Acidifier.
T.—HCN Absorption Towers.
F.—No. 7½ Buffalo Fan.
1 to 5.—18 × 12 ft. Devereux Agitators.
21.—Mill Solution Storage Tank.

chalcopyrite are intimately locked up in the other minerals and cannot be entirely liberated by 200-mesh grinding. The gangue is composed of quartz and shale. The minerals are separated into lead-silver, zinc, and iron-silver concentrates, the treatment being adjusted so as to obtain the maximum recovery of lead, silver, and copper in the first product and maximum grade for the zinc and iron-silver products, these being the requisites for highest economic return per ton of ore under the present smelter contracts. The average grade of the products and the metal recoveries made from the current ore (9·5% Pb, 10% Zn, 0·65% Cu, and 11·5 oz. Ag) are given in Table III.

Table III.
Typical Metallurgical Summary—Treatment of Sulphide Ore.

Ore Product.	*Assays.*						*Recoveries.*						*Ratio of Concentration.*
	Au dwt.	*Ag* oz.	*Cu* %	*Pb* %	*Zn* %	*Fe* %	*Au* %	*Ag* %	*Cu* %	*Pb* %	*Zn* %	*Fe* %	
Mill Head	0·57	11·5	0·65	9·5	10·0	8·75	—	—	—	—	—	—	—
Lead Conct.	2·10	54·8	2·9	57·1	8·2	5·7	58·9	75·4	71·9	93·9	—	—	6·318
Zinc. Conct.	0·47	9·2	—	—	50·6	—	12·6	12·8	—	—	78·5	—	6·279
Iron Conct.	1·40	13·6	0·55	1·22	—	40·2	9·6	4·6	—	—	—	18·0	25·45
Mill Tail	0·17	1·3	0·10	0·68	1·04	6·8	—	—	—	—	—	—	—

Crushing of the sulphide ore has been described. In the main sulphide ore grinding unit, two 8 ft. by 48 in. Hardinge ball-mills are used for primary grinding and one 6 ft. by 14 ft. Traylor ball-mill for secondary grinding, each mill in this unit operating in closed circuit with a classifier as shown in the flowsheet (Fig. 3). The final product averages 1% + 65 and 74% − 200 mesh, and represents the economic limit in the grinding. The total cost of grinding is 43 cents and the power consumption 17·4 kw.-hr. per ton of ore. The distributed costs for the entire sulphide ore treatment are given in Table IV. The consumption of manganese steel liners and forged steel balls in the sulphide ore mills is given in Table I. A small grinding unit formerly used in metallurgical test work was recommissioned recently as an auxiliary sulphide-ore unit, to take care of increased tonnage. This unit consists of two 4 ft. by 12 ft. Krupp ball-mills, one being used for primary grinding in open circuit and the other for secondary grinding in closed circuit with a classifier. The auxiliary unit has a capacity of 100 tons and the main unit 650 tons of ore per day. Under the present milling schedule the two units are grinding a total of 690 tons of ore per day.

The pulp overflows from the secondary classifiers at a dilution of 20 to 24% solids, and is thickened in two 60 ft. Dorr thickeners to from 40 to 42% solids before entering the flotation section. In addition to the classifier overflow the thickeners de-water 100 tons per day of cleaner tail returned from the lead flotation section. The thickening area provided, 7½ sq. ft. per ton of solids per day, is ample except for occasional periods when the requirements may become as high as 9 sq. ft. per ton owing to more than the usual amount of colloidal slime in the ore, in which case two 25 ft. auxiliary thickeners are used. The use of thickeners following the grinding operation eliminates surges in the pulp flow and permits adjustment of the grinding-classifying circuit to be made independently of the pulp dilution required for best results in the flotation cells, so that both grinding and flotation operations can be done under the most favourable conditions. Maximum capacity consistent with best metallugical work is obtained in the flotation section at 40 to 42% solids in the feed. At lower dilutions, 46 to 48% solids, the separation of gangue and mineral particles is interfered with by mechanical entrainment and the metallurgical efficiency of the cells decreases.

Flotation Procedure.—Standard 18 in. Minerals Separation sub-aeration cells are used in the lead section to make a rougher concentrate and a middling product. The rougher concentrate is cleaned once in

Table IV.
Sulphide Ore Concentration Distributed Costs.

	U.S. Curr'cy. per short ton.
Crushing	$0·05
Conveying	·02
Grinding	·43
Classifying	·01
Flotation—Oils, Reagents	·27
Labour	·07
Supplies	·04
Power	·12
Royalty	·04
Water Supply	·06
Filtering and handling concts.	·08
Assaying	·04
Surface expense	·04
Supervision	·07
Miscellaneous	·02
Total	$1·36

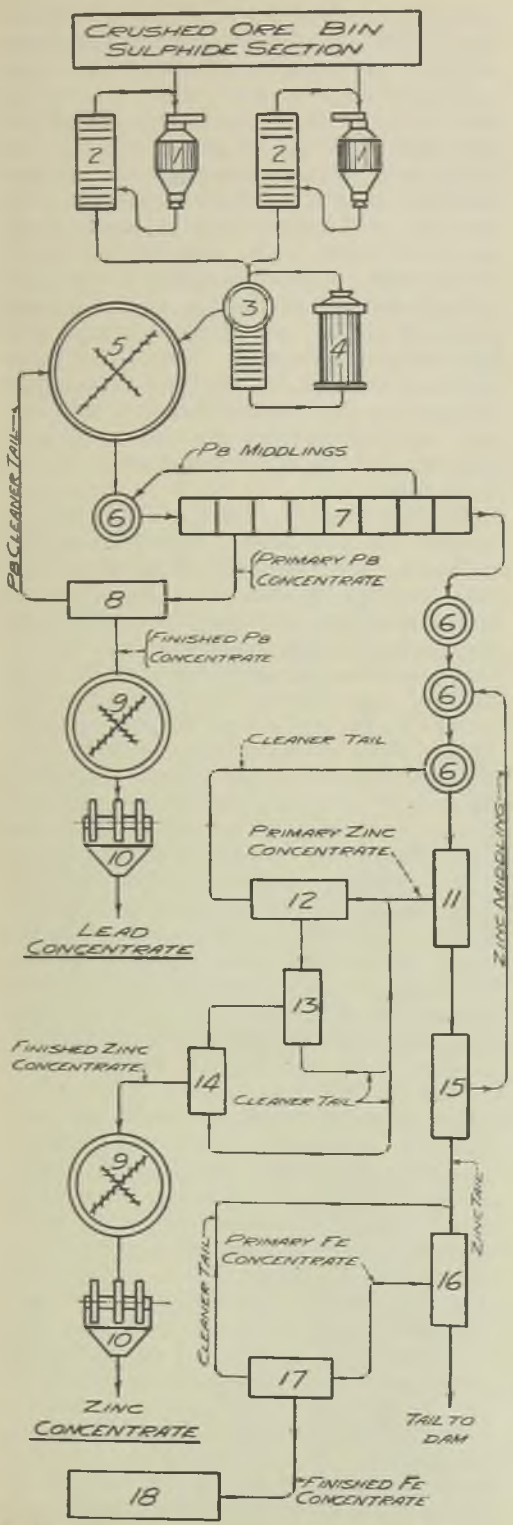


Fig. No. 3.
Flotation Plant Flow-sheet.
Fresnillo Company.

LEGEND.

1.—8 ft. × 48″ Hardinge Ball-Mill.
2.—Dorr Simplex Rake Classifier.
3.—12 ft. Dorr Duplex Bowl Classifier.
4.—6 ft. × 14 ft. Traylor Ball-Mill.
5.—Two 60 ft. Thickeners.
6.—8 × 6 ft. Devereux Agitator.
7.—Two Parallel Banks, Twenty-four 18″ M.S. Flotation Cells each.
8.—Two 10 ft. McIntosh Cells, in parallel.
9.—40 ft. Thickener.
10.—American Disc Filter—Three 6 ft. Discs.
11.—Six 3 ft. × 15 ft. Std. Callow Flotation Cells, in parallel.
12.—Two 3 ft. × 15 ft. Std. Callow Flotation Cells, in parallel.
13.—Two 12 ft. McIntosh Flotation Cells, in parallel.
14.—Two 10 ft. McIntosh Flotation Cells, in parallel.
15.—28 ft. Forrester Cell.
16.—Two 12 ft. Forrester Cells, in parallel.
17.—12 ft. McIntosh Flotation Cell.
18.—Settling Vats for Iron Concentrate.

MacIntosh cells to drop out zinc and insoluble, the single cleaning increasing the grade of the lead product from 32% to 57% lead. Further cleaning of the concentrate results in a loss of some silver and copper and would therefore be opposed to the economic requirement of maximum recovery of these metals in the lead concentrate. The cleaner tail is returned to the primary thickeners, and the lead middling product is returned to the head of the lead section where it is mixed with fresh pulp in a Devereux agitator. Mixing of these intermediate products with fresh pulp assists in making a final separation of the minerals as it de-oils and washes the sulphide surfaces and leaves them clean for reconditioning by the flotation reagents. An 8 ft. Wilfley pilot table treating tailing from the lead section gives a continuous visual check on the operation of the lead flotation cells.

In the zinc section, a rougher concentrate containing 43% zinc is made with Callow cells and is cleaned three times to meet the economic requirement of maximum grade for this product. Triple cleaning of the zinc is necessary because of the similarity in flotability of high-iron marmatite and pyrite, which makes it difficult to drop out the latter mineral. Callow cells are used for the first cleaning and MacIntosh cells for the second and third. The final concentrate assays 50·6% zinc, and represents a high grade product since the zinc mineral, marmatite, contains well over 10% iron in chemical combination. Zinc escaping the rougher cells is recovered by a 28 ft. Forrester scavenger cell which makes an iron-zinc middling that is returned to the first zinc conditioner.

The iron concentrate is made with Forrester cells and cleaned once in a MacIntosh cell to drop out "insoluble," giving a final product assaying 1·4 dwt. of gold, 13·5 oz. of silver, and 40% iron. The product depends for its commercial value on the gold and silver content, hence a high grade concentrate rather than a high recovery of iron is made. About 18 tons of the iron concentrate are roasted daily, and the remainder is sold to the smelter at a small profit. The grade of the concentrate is raised 25% by roasting and the resulting increase in revenue from sale of the roasted product pays for the cost of roasting, which is 57 cents per ton of concentrates, so that sulphur dioxide gas is supplied at no charge to the cyanide recovery and manganese-silver ore treatment plants. The iron concentrate is roasted in two 8 ft., four roasting-hearth, MacDougall type furnaces, which were designed and built by the company.

The lead and zinc concentrates are de-watered in 40 ft. thickeners and filtered with American disc filters, three 6 ft. discs being used for each product. The average moisture content of the zinc cake is 10% and of the lead, which is finely comminuted, 12%. The iron concentrate is settled and drained in pilas (open vats) and shipped without filtering, to obtain cheap handling. The concentrate averages 11% moisture when shipped. The coarser pyrite which settles out at the head of the pilas is taken for the roasting furnaces. The lead and iron concentrates are sold to Mexican smelters and the zinc concentrate is shipped to Europe.

Reagents.—The flotation reagents in present use are those which have been retained after trial and elimination of a large number by both plant and laboratory tests. Simplification of practice and improved technique in operation have reduced the consumption of reagents from 8·75 lb. in 1927 to the present (1929) consumption of 3·95 lb. per ton of ore. Sodium carbonate in the form of tequesquite (a local crude natural salt from saline deposits, averaging 35 to 40% soda) is added at the thickeners to precipitate metallic salts in the mine water and provide an alkaline flotation circuit. The alkalinity carried is low, the pH value being 7·7 to 7·8, or just over the neutral point. Xanthate is used as the collecting agent in the lead, zinc, and iron sections. The zinc and iron minerals are depressed during the lead float, by sodium cyanide and zinc sulphate which are used in the proportion of one part of sodium cyanide to four parts of zinc sulphate. The cyanide and zinc sulphate together with an "oil" mixture containing five parts coal-tar creosote, three parts cresylic acid, and one part of pine oil, are added to the intake of the pump which delivers the pulp to the first lead rougher cell. This gives a very short contact period; but it suffices owing to the positive emulsification of pulp obtained in the Minerals Separation type of cell and, by avoiding a long conditioning period, the effect of the depressing reagents on the marmatite and pyrite is made to carry through the entire lead section, thereby minimizing the consumption of these reagents. Copper sulphate is used to condition the zinc mineral for flotation. The contact period and emulsification of pulp

required for the zinc conditioning are provided by a series of three 8 ft. Devereux agitators. Cyanide is added to the first agitator, to re-inhibit the pyrite ; the copper sulphate is added to the second, and coal tar and pine oil to the third. Xanthate, coal tar, and pine oil are added as required in both the lead and zinc flotation sections. A small amount of cyanide and zinc sulphate are used to depress marmatite in the lead-cleaning circuit, and small additions of cyanide to depress pyrite in the zinc cleaners. The pyrite eliminated in the zinc cleaning operation caused considerable mechanical trouble by packing around the rotor in the bottom of the MacIntosh cells, until the amount of this mineral entering the zinc rougher concentrate was reduced by inhibiting it with cyanide in the first Devereux agitator. Xanthate is the only reagent used in making the iron concentrate. All dry reagents are made up and added as solutions for convenience in distribution and greater accuracy in regulation of the amount used. The average consumption of the various reagents per ton of ore follows :

Reagent.	*lb. per short ton.*
Tequesquite (Na_2CO_3)	1·462
Xanthate	0·468
Copper Sulphate	0·770
Zinc Sulphate	0·492
Sodium Cyanide	0·136
Coal-tar creosote	0·194
Coal tar	0·226
Pine oil	0·080
Cresylic acid	0·120
Total	3·948

The total consumption of air by the flotation cells is 6,000 cu. ft. per min. The air is supplied by Roots blowers at a pressure of 1½ lb. for the Forrester, MacIntosh, and Minerals Separation cells and 3½ lb. for the Callows. The unit consumption of air by the different types of pneumatic cells used is as follows :—

Forrester cell	44 cu. ft. per min. per lineal foot of cell.
MacIntosh cell	9 cu. ft. per min. per lineal foot of rotor.
Callow cell	6·5 cu. ft. per min. per sq. ft. of mat area.

The MacIntosh cells were formerly equipped with canvas covered rotors and required 3½ lb. air pressure ; but by substituting perforated rubber covers for canvas, the pressure required to operate the cells was reduced to 1½ lb., and the power consumption reduced proportionately. The use of rubber covered rotors has also improved the mechanical operation of the cell, as perforated rubber does not "blind" so easily as the canvas and consequently has a longer life. The first test rubber cover is still in use after six months' service. A comparative test between perforated rubber and canvas-covered pans in the Callow cells is being made with the object of placing the entire plant on low pressure air should the rubber mat prove as satisfactory in the Callow as in the MacIntosh cell.

Power for the operations at Fresnillo is generated by a 6,000 kw. turbo-alternator unit at a cost of 1·23 cents per kw-hr. net delivery. The total consumption of power by the mill is 22 kw-hr. per ton of oxide ore treated and 32 kw-hr. per ton of sulphide ore.

NEW SEISMOGRAPH FOR GEOPHYSICAL SURVEY

By A. O. RANKINE, D.Sc.

Professor of Physics in the Imperial College of Science and Technology.

In view of the growing interest in this country in geophysical methods of prospecting,[1] the production commercially by the Cambridge Instrument Company of the portable seismograph and accessories described below is a notable event. The instrument is the first of its kind manufactured and offered for sale by a British firm. Hitherto practically all seismographic field work on problems of underground structure in relation to mineral (principally oil) deposits has been carried out with seismographs of foreign (mainly German) construction, even in fields under British control. There now becomes available this new instrument which is in several important respects an improvement on its predecessors. The principal of these improvements is the ingenious linking device for obtaining the greater part of the magnification required of the small earth movements. In previous instruments the corresponding link has usually been of a frictional character, giving rise to possible slipping which renders uncertain the degree of magnification, besides making adjustment rather difficult. In the Cambridge instru-

[1] Reference may be made, for example, to the Symposium on this subject on March 21 and April 18, 1929, at the Institution of Mining and Metallurgy. A description of the underlying principles of the seismographic method by the present writer will be found in the Bulletin of the Institution for April, 1929.

ment the magnifying mechanism is positive in action throughout, and the movements of the recording spot of light correspond closely to the movements of the earth. The seismograph measures and records in relation to time the vertical component of the motion of the earth where it is erected, giving a magnification which can be arranged during construction to suit special conditions, and may be as high as 50,000 or even 100,000. The photographic recorder is of elegant and efficient construction and easy to manipulate.

During April, 1929, the first experimental model was tested in the field near Cambridge, the writer being present. Good results were obtained, and it was apparent that the sensitivity of the instrument was considerably superior to that of other mechanical seismographs then on the market. Since then modifications have been made, mainly for the purpose of fulfilling the requirements of field conditions, and further tests carried out during the summer of 1929 on Chobham Ridges proved that the seismograph could be used satisfactorily in determining the depth of the chalk in this neighbourhood. It is worth noting, as showing its ease of manipulation, that one of the independent operators in these observations has intimated that the seismograph and recorder could be erected on a new station, and adjusted in readiness for recording, in fifteen minutes.

There follows a brief description, illustrated by photographs, supplied for the purposes of this article by the makers. In it the principal features are suitably indicated. A more complete description of the working parts of the instrument may be found in the British Patent Specification No. 17402/29.

The seismograph is of a mechanical form and is particularly adapted for detecting salt domes and other hard structures, and for locating faults etc. It comprises a highly sensitive instrument for measuring vertical vibrations (the vibrometer) and a camera whereby such vibrations

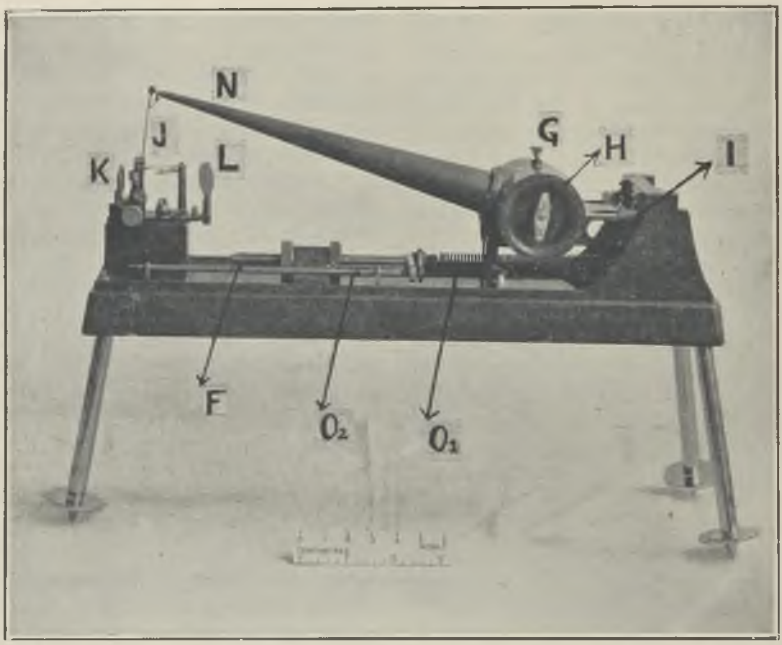


FIG. 1.

are recorded. The vibrometer, which is shown in Fig. 1 with the outer cover removed, consists of a heavy mass H fixed on a short lever which is carried on flexible metal hinges at I. This weight is balanced by springs O_1 and O_2. O_1 is the main spring and O_2 is a fine adjustment spring controlled by the screw F. The lever carrying the mass H is extended by the light cone N. For transit the clamping screw G is released and the weight H is withdrawn from the tubular fitting into which it is normally fitted. The system is then automatically clamped owing to the load on the spring O_1. At the end of the cone N is a fine rod J the other end of which bears lightly on a horizontal disc in such a way that any small movement of the mass H relative to the base of the instrument causes a rotation of the disc. A mirror is so

mounted that this rotation causes a corresponding movement of the mirror which is recorded photographically by a compact form of paper camera. The moving mirror system, which is the only delicate part of the apparatus, forms a complete unit which can be easily removed, and replaced, and which is disconnected from the rod J by a simple automatic device. Light from a lamp mounted in the camera passes through a convex lens K and is reflected from the mirror so that an image of a slit in front of the lamp is focussed down to a bright spot of light on the photographic paper. A white screen L facilitates correct adjustment of the optical system. The moving parts of the vibrometer are light and have little inertia, so that friction effects are reduced to a minimum.

The camera is shown in Fig. 2. X is the lamp. Z is a light-tight container which will hold 24 metres of unused photographic paper (60 millimetres wide) and which is loaded in a dark room, but may be inserted in, or removed from the camera in daylight. It is fitted with a red glass window, so that the quantity of paper remaining in the box at any time can be observed. The paper is driven past the camera aperture by means of a clock (wound by the handle S) and is automatically fed round a drum W. When a length of paper up to 4 metres in length has been exposed, it is severed from the main length by means of a knife operated by the handle Q. The drum W consists of two parts R and P, as shown in the lower part of Fig. 2. R is the main drum on which the exposed paper is wound, and which by its

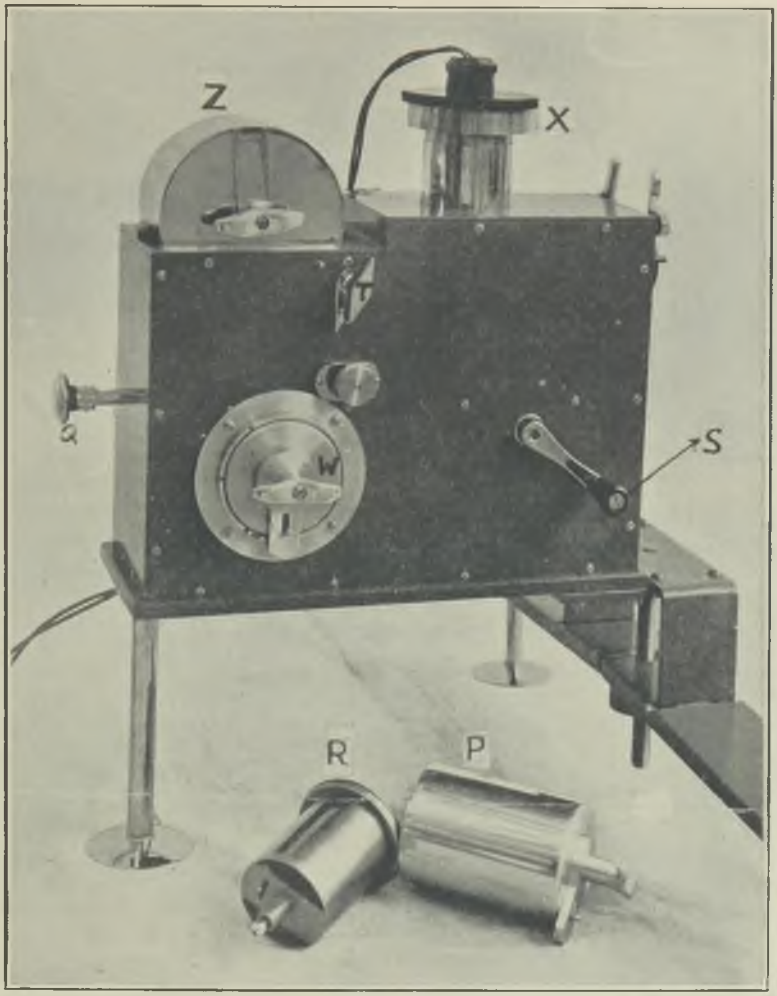


FIG. 2.

rotation, draws the paper through the camera. P is the cover which is partially withdrawn when taking a photograph and which is pushed completely over the drum R when loading and unloading from the camera, and in fact until the exposed paper is ready to be removed for development in the dark room. Four of the drums W are supplied with each outfit, and they can be removed from, or inserted in the camera in broad daylight. T is the handle for starting and stopping the camera.

Fig. 3 shows the complete assembled instrument, A being the vibrometer and B the camera. These two parts are set up opposite one another, and the separate telescopic tube C is fixed to the front of the camera and then extended until it nearly makes contact with the window of the vibrometer. By looking down the tube D, the observer can see the spot of light from the vibrometer mirror just before it enters the camera, and by means of the screw E, he can adjust the position of the spot.

Fig. 4 is a reproduction reduced to nearly half actual size from two records, taken with this instrument, of small explosions of gelignite buried a short depth in chalk and exploded at a distance of nearly three-quarters of a mile from the seismograph. The time marking consists of a broken black line, each black dash and each space covering a tenth of a second, so that there are five black dashes per second. The time marker is automatically started when the handle T, which starts and stops the camera mechanism, is operated. The extraordinary resemblance of the two records, even to many of the smaller details, shows that all the smaller waves recorded are true phenomena due to the nature of the ground between the explosion and the instrument.

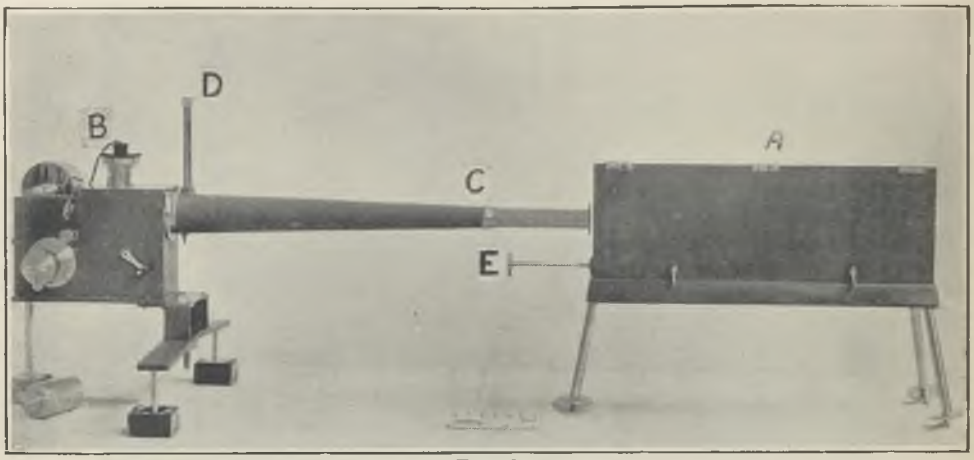


FIG. 3.

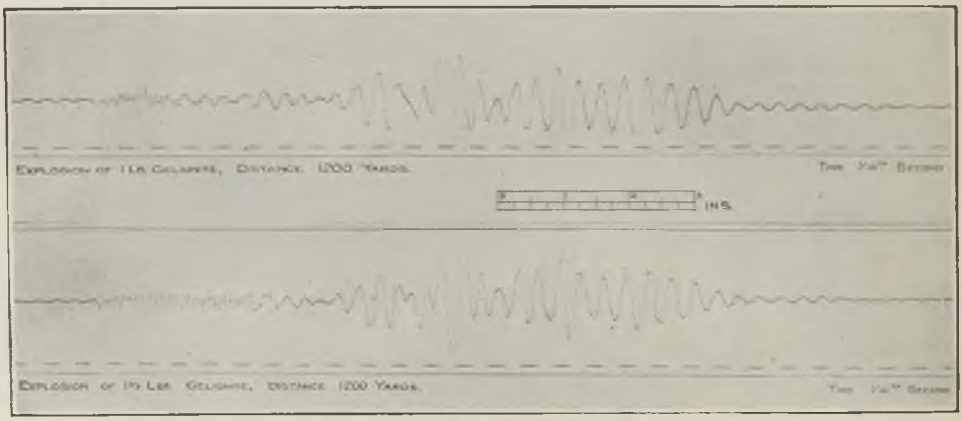


FIG. 4.

THE TIN DEPOSITS OF GUNONG BAKAU

By F. T. INGHAM, Ph.D., D.I.C., F.G.S., A.I.M.M.

The author gives an account of the lode-tin deposits on Gunong Bakau, at the inter-state boundary between Selangor and Pahang, based on recent observations.

INTRODUCTION.—The tin deposits of Gunong Bakau are of a particularly interesting geological character. They have previously been studied and described by

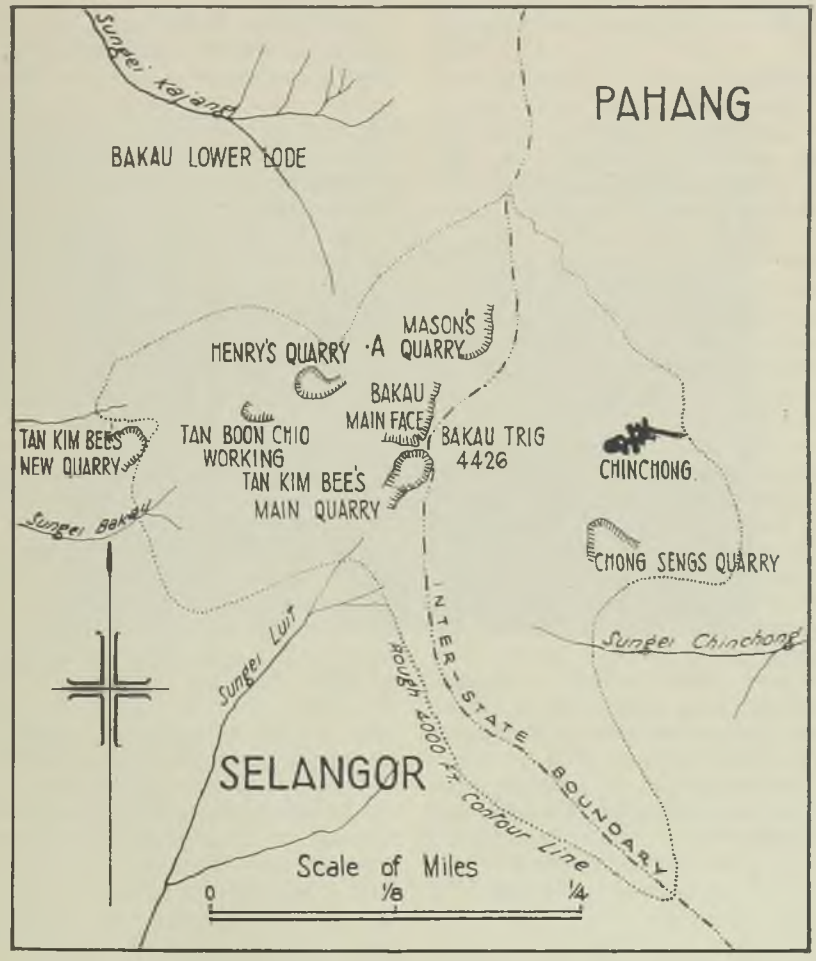


FIG. 1.—SKETCH-MAP OF GUNONG BAKAU AND NEIGHBOURHOOD. Based on plan by J. B. Scrivenor.

Mr. J. B. Scrivenor, the Director of the Geological Survey, Federated Malay States, and by Dr. W. R. Jones, formerly an officer of the same geological staff. The conclusions arrived at by Mr. Scrivenor have been published under the title "Topaz-bearing Rocks of Gunong Bakau" in the *Quarterly Journal of the Geological Society*, vol. lxx, p. 363, 1914; Dr. Jones's views are expressed in "The Origin of Topaz and Cassiterite at Gunong Bakau, Malaya" in the *Geological Magazine*, 1916, p. 255, and also in "A Preliminary Report on Tin Mining on the Main Range at Ulu Bakau and Neighbourhood" in the same magazine, p. 453. Further reference by Dr. Jones is also made in THE MINING MAGAZINE, October, 1915, under the title "Mineralization in Malaya."

As the opinions expressed by these authors, more especially concerning the origin of the topaz and cassiterite present, were of rather

diverse nature, the writer was requested to examine and report on the deposits, which were visited during April, 1928, and again in January, 1929.

Gunong Bakau is a mountain 4,426 ft. high, situated on the watershed of the Main Range on the Selangor–Pahang boundary to the north of Gunong Raja. It is approached by the jungle path which leads from Peretak, near Kuala Kubu, to Bentong in Pahang. The strenuous walk and climb are more than compensated for by the grandeur of the jungle traversed.

Present Workings.—At the present time there are three main areas where mining operations are taking place. These for convenience are here defined as the Chinchong, Bakau, and Tan Kim Bee's workings and the position of these is shown on Fig. 1.

It is here desirable to state that the predominant types of rock found in this neighbourhood may be suitably classified as granite, quartz-topaz rock, and topaz-aplite. Notes concerning these will be found in a later paragraph.

(*a*) *Chinchong.*—These workings are situated to the east of Gunong Bakau Trigonometrical Station at a height just over 4,000 ft. At the present time the ore is being reached by an adit which has been driven into the hill a distance of about 300 ft. in a general westerly direction. A new adit is also now being constructed from Chong Seng's quarry.

Quartz-topaz rock at this locality constitutes the ore. The ore-body is flat and tabular in shape, lying practically in a horizontal plane, with a thickness, varying but slightly, averaging 12 ft. Thus its form greatly resembles that of an igneous sill.

The country-rock is granite, of which rock both the hanging and foot walls of the deposit are composed. At one spot in the northern portion of the workings at a distance of roughly 150 ft. from the adit entrance the ore has been cut out by topaz-aplite.

In 1914 a vein of ore, which is stated by the Chinese miners to have been at a lower level, was worked in a south-westerly direction for over 300 ft. Since this vein had a similar composition and form it is practically certain that two distinct bands of quartz-topaz rock more or less parallel and of a horizontal nature occur in the immediate vicinity. Moreover, higher up the hill other outcrops of quartz-topaz rock have been observed and the evidence of there being at least four such sill-like deposits of quartz-topaz rock on the eastern slope of Gunong Bakau is very strong.

The ore from the Chinchong workings is transported in baskets by wire ropeway to the mill, where it is crushed in a five-head Thompson battery driven by a Pelton wheel.

(*b*) *Bakau.*—These workings may conveniently be divided into two sections, namely the Bakau Main Face and the Bakau Lower Lode.

The Bakau Main Face is situated just to the north of the trigonometrical beacon. Here a large open quarry has been made in the hill slope, the top of the working now reaching to the original site of the beacon. Much topaz-aplite is present and this carries a small percentage of cassiterite, and constitutes the major source of ore at this quarry. Fortunately the aplite is intensely weathered which allows for its easy removal. (Fig. 3.) By working in this opencast fashion not only is the tin recovered from the aplite but valuable prospecting is achieved since sill-like bodies of quartz-topaz rock in granite are exposed and brought to the foot of the quarry at a cost considerably less than by underground mining. The quartz-topaz rock in this quarry generally contains zinnwaldite and the cassiterite content is slightly less than at Chinchong.

The Bakau Lower Lode, which is also known as the East–West lode, is situated in the north-west portion of lot 272. The lode is a composite one consisting of several parallel veins, practically vertical and having a strike trending between 74°–254° and 78°–258°. On the surface the mineralized zone did not exceed 2 ft., but at a depth of 40 ft. this had increased to 4 ft. When last visited a depth of 54 ft. below the adit level (12 ft. below the surface of the hill) had been reached, and the workable portion was no less than 8 ft. wide over a distance of 150 ft. The veins, which consist chiefly of quartz associated with a greenish secondary mica, vary from minute veinlets to veins over 9 in. wide and in depth coalescence of veins has been observed.

The lode carries on an average from 1·6 to 1·7% SnO_2. Besides the quartz and mica previously mentioned a little tourmaline, pyrite, and in lesser amount chalcopyrite, are present. On the joint planes bright green flakes of torbernite (a hydrated phosphate of uranium and copper) occur. This mineral, which is at the present time being allowed to go to waste, has not previously been

discovered in Malaya. No uraninite, from which it has probably been derived, has yet been found in this locality. Since the lode cuts both the granite and the topaz-aplite it is obvious that it is later in age than both these rocks.

(*c*) *Tan Kim Bee's Workings.*—These are divided into the Main Working and the New Working.

The Main Working is situated to the south-west of the beacon and is quite close to Bakau Main Face. It consists of a large quarry greatly resembling that of the adjoining mine. Aplite is the predominant rock type,

Rock Types.—As previously stated the three main types of rocks in this area are (1) granite, (2) quartz-topaz rock, and (3) topaz-aplite. As these have been described in detail by Mr. Scrivenor, only the main characteristics are mentioned here.

(*a*) *Granite.*—Over a large portion of the area at the surface this rock is intensely weathered owing to kaolinization of the felspar present. Occasionally, however, large core boulders of hard granite can be observed. The granite is porphyritic in character, the phenocrysts being orthoclase. In the groundmass both orthoclase and plagioclase are

Fig. 2.—View along Chinchong Valley taken from adit. In the distance the smoke from the roaster can be seen.

but three flat tabular veins of quartz-topaz rock have been observed occurring in granite. The uppermost of these forms a capping to the mountain, and contains little or no cassiterite, but the middle vein, which is 12 ft. thick, constitutes ore suitable for crushing. The aplite is also stanniferous.

The country rock in the New Working, which is situated further to the west, is granite. In this there occurs a mineralized band consisting of mainly cassiterite, tourmaline, and felspar. Unfortunately the deposit was not well opened up at time of visit and the exact relationship was therefore obscure. Mr. Scrivenor, who has more recently examined the deposit, says that it is a vein of pegmatite 30 ft. broad, containing micaceous patches similar to the stone once worked in Hemy's quarry, towards which it trends.

present. Some biotite together with a little tourmaline also occur. Zircon and apatite are common accessory minerals. A trace of cassiterite has been identified in this rock.

(*b*) *Quartz-Topaz Rock.*—This is by far the least altered and the hardest rock of the series and it always occurs associated with the softer granite. As the name implies, the esential constituents are quartz and topaz. Of these the quartz predominates and the amount of topaz present is not constant. Although the quartz occurs as irregular grains, occasionally crystal boundaries are exhibited by the topaz. This latter mineral sometimes shows partial alteration to micaceous aggregates and this alteration in some cases has proceeded to such an extent that "islands" of topaz in optical continuity with one another have been left in a white micaceous matrix. Cassiterite and

also arsenopyrite are of fairly constant occurrence throughout the quartz-topaz rock, although the amount present shows considerable variation. In the case of the cassiterite, although very rich ore is occasionally met, an average of between 1% and 1·5% is probable. In a few places, for example, Main Face working, portions of the quartz-topaz rock rich in mica have been observed. This mica (zinnwaldite) is pale brown in colour and has small optic axial angle ; such rock is comparable with that described by Mr. Scrivenor from Mason's quarry. Small patches rich in tourmaline are of rare occurrence. It should, however, be stressed that in no specimen of quartz-topaz rock has felspar been identified.

(*c*) *Topaz-Aplite.*—Usually this is the most weathered rock present in the series and for some considerable distance from the surface it is sufficiently friable to be removed by a "changkol." Only in the underground workings at Chinchong and the Lower Lode were obtained specimens hard enough to permit of sections being made. The rock is composed of quartz, orthoclase partially kaolinized, acid andesine, topaz showing alteration to secondary mica, and a pale brown mica containing zircon inclusions exhibiting pronounced pleochroic haloes. Muscovite usually occurs also and a little tourmaline is accessory. Cassiterite is usually present and it would appear that in the Chinchong area from the yardage worked and the tin-ore recovered that this mineral is present to the extent of between 0·5 and 0·6 katties per cubic yard.

Besides these main types of rock there occur certain special modifications which deserve notice :—

Reaction Border.—This term was applied by Mr. Scrivenor to the dark border present between the veins of quartz-topaz rock and the granite. This border, which has an average thickness of between 2 and 4 in., is always apparent even with the thinnest veins. Its colour is due to the presence of brown tourmaline ; topaz in the sections examined was absent but quartz is abundant and a brownish mica also occurs. Since it has been proved that zircons, common in the normal granite but practically absent in the quartz-topaz rock, are also abundant in this rock it appears certain that the "reaction border" has been formed by the action of volatile emanations from the quartz-topaz rock on the surrounding granite.

Pegmatite.—Although no large veins or masses of this rock, with the exception of the newly discovered vein in Tan Kim Bee's new working, are known in this area, small outcrops about 1 ft. thick have been observed both in Tan Kim Bee's Main working and at a spot about 30 yards south of Bakau Lower lode. In both cases the pegmatite occurred between the topaz-aplite with which it is genetically related and the granite. Similar occurrences associated with the aplite have previously been noted by Mr. Scrivenor.

Mica Rock with Beryl.—This interesting modification of the aplite was observed in Hemy's quarry. This variety consists predominantly of a pseudo-uniaxial green mica

FIG. 3.—BAKAU MAIN FACE—BARRING DOWN WEATHERED TOPAZ-APLITE.

associated with numerous prismatic crystals of beryl over $\frac{1}{4}$ in. in length. An acid plagioclase is also present and usually a little quartz occurs.

Beryl, which has only once previously been recorded from Malaya, also was observed in crystals having a diameter occasionally of $\frac{1}{2}$ in. in a stanniferous vein in aplite in Tan Boon Chia's working. The cassiterite of a coarsely crystalline nature was associated with, in addition to the beryl, quartz, and in lesser amount with wolfram.

ORDER OF INTRUSION.—It is evident both from the underground workings and

exposures on the surface that of the three main rock types topaz-aplite is the youngest since this rock cuts out the quartz-topaz veins in granite. The relationship is well shown in a small pit situated at A on the plan (Fig. 1). Here the porphyritic granite is traversed by two more or less parallel veins of quartz-topaz rock. Moreover, these veins and the granite containing them are cut by an almost vertical vein of topaz-aplite (see Fig. 4).

Confirmatory evidence of a different nature was exhibited in Tan Kim Bee's quarry, where residual fragments of both granite and quartz-topaz rock were observed in a matrix of topaz-aplite (see Fig. 5). The exposure was in close proximity to a large quartz-topaz vein in granite.

The Lower Bakau Lode is certainly of a later period of intrusion than the topaz-aplite and there are, moreover, small veins rich in tourmaline which cut both the quartz-topaz rock and the topaz-aplite exposed in Bakau Main Face. Other later veins include the stanniferous quartz-vein carrying beryl exposed in Tan Boon Chia's working.

Origin of the Quartz-Topaz Rock.—Concerning this, two totally different views have been expressed in the papers referred to in the introduction. Mr. Scrivenor is of the opinion that this rock is an intrusion, while Dr. W. R. Jones considers that the quartz-topaz rock bears striking similarities in its mode of occurrence and mineral content to rocks found at Erzgebirge. As in the latter field the topaz and cassiterite are considered to be of secondary origin, Dr. Jones believes these minerals are also secondary at Gunong Bakau.

Mr. Scrivenor has given his views in detail, and his deduction that the quartz-topaz rock is of primary origin and has been intruded into the granite forming veins is based chiefly on the following premises :—

(1) The absence of alteration, other than the "reaction border," in the country rock.

(2) The pronounced differences in mineral composition of the quartz-topaz rock from the "reaction border" which is clearly an alteration product.

(3) The presence of a mica (zinnwaldite) different from the secondary mica in the granite.

(4) The marked difference between the quartz-topaz veins and ore-bodies previously worked known to be of secondary origin.

Dr. Jones compares these veins with a description of the Erzgebirge tin-deposits by J. T. Singewald, which was published in *Economic Geology*, vol. v, 1910. Thus Dr. Jones states in reference to the "reaction border" : "The alteration is certainly as extensive as is the case in places at Geyer and Ehrenfriedersdorf, for there the alteration of the country rock is for a distance of only 2 to 6 in., whereas in the Graupen area the country rock of the Luxer cassiterite-bearing vein has not been altered at all into

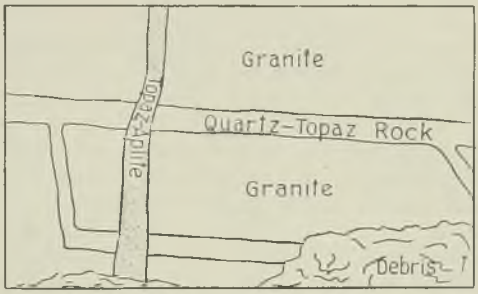


Fig. 4.—Veins of Quartz-Topaz rock in Granite cut by later Topaz-Aplite Vein.
Scale 2½ in. = 16 ft.

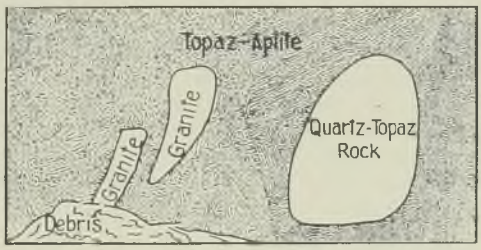


Fig. 5.—Topaz-Aplite containing residual blocks of Granite and Quartz-Topaz rock.
Scale 2½ in. = 6 feet.

greisen." No mention is, however, made of the fact that at Geyer the individual veins vary from only ¼ in. to 4 in. in width, which is incomparable with a thickness of 12 ft. at Chinchong. Moreover, the Luxer cassiterite-bearing vein is of a type which was considered by R. Beck to be related to tin-bearing pegmatites of the Carolinas.

On the other hand, Singewald states in reference to Zinnwald : "All stages of transformation from granite to greisen are encountered and frequently the greisen areas include unaltered masses of granite." This is certainly not the case at Gunong

Bakau, for there is no general transition from the quartz-topaz rock to the granite and neither have any portions of unaltered or even partially altered granite been found in quartz-topaz veins.

If in the quartz-topaz rock the topaz is secondary as in "zwitter," which is an altered granite in which felspar has been replaced by topaz, it is strange that in no specimen of such rock from Gunong Bakau have remnants of unreplaced felspar been observed, or even has the outline of the replaced felspar been preserved, as is so commonly the case at Sadisdorf. On the other hand, crystal boundaries of the topaz itself are sometimes shown.

Again at Geyer, according to Singewald, "the main mass of the granite is traversed throughout by narrow bands of zwitter in which the fissures from which the impregnation has taken place are usually so narrow as to be scarcely visible. In addition to these small irregular zwitter bands, there are groups of veins also accompanied by zwitter zones." At Gunong Bakau, however, there is not the faintest trace of a fissure within the quartz-topaz veins themselves; nor anywhere in the area has the quartz-topaz rock been observed occurring as a wall rock to any other parallel vein.

From the above remarks it must appear obvious that instead of resembling the deposits of Erzgebirge, the dissimilarities are extremely pronounced. On the other hand, all the evidence tends to prove that at Gunong Bakau the quartz-topaz has been intruded into the granite, and that in this locality the topaz and cassiterite are primary minerals.

Future Prospects.—It can be confidently asserted that mineralization over this area is both intense and extensive. Although diverse types of stanniferous deposits have been exposed at Gunong Bakau it appears certain that the main source of tin ore in the future will be the veins of quartz-topaz rock, since these are of a widespread character and of a more persistent nature than other sporadic ore-bodies, despite the fact that these latter are often richer. Although mining has been carried out in this locality for over twenty years, only a very small proportion of the mineralized area has been removed. Since the values are variable the workings in the past have been confined to the richer patches which have been discovered, and little or no systematic prospecting has been done. The chief difficulty which has prevented large-scale operations is the lack of a plentiful supply of water necessary both for the removal of decomposed rock and to obtain cheap power for milling. Should such become available in the future by its introduction from higher ground along the range, the best method of prospecting appears to be by the removal of the topaz-aplite and decomposed granite by water power, thus uncovering the quartz-topaz veins. By this method not only would the high cost of underground mining become unnecessary, but the cassiterite recovered from the topaz-aplite would assist materially in the payment of such removal.

It is unfortunate that the political boundary between Selangor and Pahang passes across the mountain, dividing it into two halves. The mineralized area, however, extends into both these and the deposit from a geological or mining standpoint is indivisible. This artificial boundary is a distinct disadvantage in the case of large-scale operations being contemplated. Should these difficulties in the future be overcome, and if the price of tin remains at a reasonable figure, Gunong Bakau promises to be an important source of tin ore for several years.

Conclusion.—In conclusion my thanks are due to Messrs. J. A. Russell and Co. for their hospitality while on Gunong Bakau; to their manager, Mr. R. S. Opie, for accompanying me during my examination of the workings; and to Mr. J. B. Scrivenor for the loan of his plan of the area and the use of his additional specimens and slides.

Silicosis Committee.—The Medical Research Council has appointed a committee to advise upon the further investigation of pulmonary silicosis and of other pulmonary conditions associated with the inhalation of dusts arising from industrial processes. Professor A. J. Hall has been appointed chairman of the committee and the other members are: Dr. A. E. Barclay, Mr. J. C. Bridge, Professor S. L. Cummins, Professor E. H. Kettle, Dr. E. L. Middleton (secretary), Professor M. J. Stewart, and Dr. Cecil Wall. The committee will survey the present state of knowledge, advise upon new lines of enquiry, and supervise investigations, the work being directed towards obtaining more accurate knowledge of the causes and diagnosis of these disorders.

BOOK REVIEWS

Select Methods of Metallurgical Analysis. By Dr. W. A. Naish and J. E. Clennell. Cloth, octavo, 495 pages, illustrated. Price 30s. London: Chapman and Hall.

A book on assaying will appeal, principally, to two classes of persons—the student and the experienced analyst. To each class it may make a special claim, but it is not every book that will necessarily satisfy both. The student is fresh to the work and the author needs to present his information concisely and accurately, adding those touches from practical experience which will help the budding assayer over the many pitfalls of manipulation and technique. To the practitioner the author should offer a book of reference wherein may be found not only details of established methods, but also an account of those modern developments and improvements which reflect the advances that have recently been made, but which have not been published except in the transactions of scientific societies. Only in such a manner is it possible for disseminated information to become progressive.

Judged from the point of view of the student or the expert, and bearing in mind the above considerations, the present work does not satisfy. Its title of "Select Methods" raises hopes of records and achievements, processes and schemes, of the highest order and modernity. One hopes for something particularly new which will carry us a long way ahead of books which already exist and are well known. But it is disappointing to record disillusionment. So far as the requirements of the student are concerned there is a pronounced lack of manipulative detail; for the practising assayer there is insufficient of that critical survey and discrimination of modern methods which would have made this book different from, and in advance of, its predecessors. From the point of view of both, it is very much to be regretted that the work is not complete in itself; a student usually cannot afford to buy many books dealing with the same subject and to the experienced analyst it will be unnecessary as he will no doubt already possess those other books to which the present authors would refer us for complete information.

The book consists of six parts and an appendix. The contents of the former may be briefly given as follows. (1) Sampling, qualitative analysis, methods of solution and separation, the preparation of samples for quantitative work, and general notes on volumetric work; (2) the main part of the book, in which methods of analysis for all the elements are given. As the latter are taken in alphabetical order reference work is facilitated; (3) Analysis of commercial metals and technical alloys together with a short section on the assay of ferrous materials; (4) Methods for the complete analysis of ores, slags and metallurgical products; (5) Analysis of refractory materials and coal; (6) Electrometric titrations, mineral analysis and spectrographic methods. These three sections have been contributed by independent authors. They serve as introductions to the subjects with which they deal. Following the methods which have been chosen for each element a bibliography of work on that particular element is inserted. This would be distinctly more valuable if it were in all cases complete.

In the majority of instances the methods quoted are culled bodily from standard works previously published. Errors in manipulation and technique, and omissions of precise instructions which would be valuable to the student, and even to his more experienced colleagues, are frequent. These, and several other points, which have been noticed in a perusal of the book, have created a feeling of regret and disappointment. Nevertheless one hopes sincerely that the authors may be induced to take an early opportunity of self criticism and afterwards amend their work in the interests of the science which they both serve.

W. A. C. Newman.

Hydrogen Ions: Their Determination and Importance in Pure and Industrial Chemistry. By Dr. H. T. S. Britton. Cloth, octavo, 515 pages, illustrated. Price 25s. London: Chapman and Hall.

The importance of being able to measure and control the hydrogen ion concentration of solutions employed in many technical processes has been increasingly recognized in recent years, and the need of a book dealing with this subject on broad lines has been felt by workers in many fields. The present volume will be found to satisfy this need in a highly successful manner.

The earlier chapters are devoted to an exceptionally clear exposition of the theory and practice of hydrogen ion determinations by electrometric and colorimetric methods, and include an account of the oxygen electrode and the glass electrode which are now finding application under special conditions where hydrogen or quinhydrone electrodes cannot be employed. The applications of these determinations in general chemistry is next considered, particularly with reference to inorganic analytical methods. The results of the author's own extensive investigations on precipitation reactions form an important feature of this section. Finally, the last third of the book is concerned with the application of hydrogen ion determinations in various industries such as tanning, brewing, sugar manufacture, pulp and paper manufacture, water purification, agriculture, textile and dye industries, etc. Each industry is treated separately. Mention should be made here of sections dealing with the significance of hydrogen ion concentration in the electro-deposition of metals and in the corrosion of metals. The former contains a summary of the comparatively recent work which has led to improvements in the character of electro-deposits of base metals, especially nickel, by suitable control of hydrogen ion concentration. The latter is concerned almost entirely with the corrosion of iron and steel. The treatment of the whole question of metal corrosion might well have been made more extensive. In a later chapter a brief account is given of the possibilities of hydrogen ion control in ore flotation.

The text is illustrated by numerous clear and informative diagrams and adequate references are given to the wide range of scientific and technical literature which has been consulted.

H. J. T. ELLINGHAM.

The Physiographical Evolution of Britain. By Dr. L. J. WILLS. Cloth, octavo, viii + 376 pp., illustrated. Price 21s. London: Edward Arnold and Co.

Fragment by fragment the story of past life, of denudation, deposition and upheaval, has been collected by the use of geological hammers. This book pieces those fragments together and in it one sees not so much the gaps between the fragments as the continuous story.

The author starts with a summary of the basic principles of physiography generously illustrated with line drawings. Then follows a short chapter given to the principles of stratigraphy while the rest of the book is divided into two parts: (1) the Post-Carboniferous Systems and (2) the Pre-Cambrian and Palæozoic Systems with a final chapter on volcanic processes. It is unusual to begin a meal with the sweet and to have the hors d'œuvre after coffee, but one pardons this when the meal is so good and one's digestion is unimpaired.

The Post-Carboniferous record is more complete and less mutilated than that of the earlier rocks. It represents the continued rising of a continental area; this area becomes denuded, then partially submerged beneath an incoming sea, eventually to rise again with the earth movements which formed the Alps. The story of the Alpine region itself is told and illustrated in a most attractive and simple manner. Attention is next turned back to the events in Britain gradually culminating in the Quaternary Ice Age which, the author shows, had considerable effect upon present-day topography. The account succeeds in giving the reader a vivid picture in a balanced perspective.

From its nature, the Pre-Cambrian record can only be dealt with in very general terms, while the Palæozoic story, though profiting from its deferred treatment, is a little less "living" than is that of the Post-Palæozoic. Nevertheless the account is valuable, particularly that section dealing with Coal Measure times.

A few of the names used by Dr. Wills for stratigraphical units may not gain universal approval; the book, however, is one of which any geologist would be proud to be the writer, and one which all geologists would gladly read. The author has read widely and has weighed and incorporated here many modern conceptions of fact and theory and, except in a few cases, has avoided unwise speculation. References are full and cross references in the text are quite helpful, while the diagrams are always present where wanted, and are usually easy to understand.

C. J. STUBBLEFIELD.

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

NEWS LETTERS

JOHANNESBURG

February 6.

Mineral Output for 1929.—South Africa's mineral production for the past year is valued by the Ministry of Mines and Industries at £50,009,238, and is over half a million sterling in excess of the output for 1928. The figures mentioned do not include the diamond output, which has not yet been announced. Gold alone shows an improvement of £246,625 and the coal output has increased by over 500,000 tons in weight and £97,659 in value. The production of platinum has advanced from 17,827 oz. to 21,463 oz., but the total value of the output of this metal for the year is considerably lower owing to the fall in the market price. The output of copper is smaller, but the total value is higher, because the price of the metal advanced during the year. While there is very little change in regard to the weight of tin produced, the value of the output shows a decrease of £25,000.

Alluvial Diamond Slump.—The decline in production of alluvial diamonds in the Transvaal during the last quarter of 1929 was very rapid. The figures of weight and value of output and value per carat for the three months are :—

	Carats.	*Total value* £	*Value per carat.*
October	103,835	238,772	43/10
November	84,303	176,596	42/10
December	40,351	68,532	33/11

The number of diggers who registered sales in December was 2,207 as compared with 3,001 for November, and 3,165 for October.

Another Platinum Producing Mine.—The Potgietersrust Platinums Company's new reduction plant at Klipfontein-Kroondal, near Rustenburg, has been placed in commission and is running smoothly. The plant is capable of treating at least 6,000 tons of sulphide or 9,000 tons of oxidized ore per month. At present a preponderance of oxidized ore is being crushed, but it is anticipated that a mixed mill feed of both types of ore will give the best results. As the company has sufficient ore of both types developed it will be guided by the results obtained. The mill feed value is probably over 8 dwt. platinum group metals per ton, of which approximately 75% is platinum. The plant has been so designed that duplication or extension can be made quickly and at a low cost, and as the company has over £100,000 cash in hand no anxiety need be felt as regards finance. The concentrates will be treated at the company's chlorine treatment plant which has been erected at the Government Areas Gold Mine, on the Far East Rand.

The company is encountering very high values at a depth of 200 ft. in the Potgietersrust portion of its extensive property. In one cross-cut the reef assays 20 dwt. per ton platinoids, of which no less than 9·5 dwt. is platinum, over 12 ft., and in another cross-cut it carries 15·5 dwt., of which 7·4 dwt. is platinum, over 11 ft. During the three months ended December 31, 1929, the pilot plant on this section crushed 11,000 tons of ore and recovered 1,440 oz. of platinum, 611 oz. of palladium, 14 oz. of other platinum group metals, 80 oz. of gold, 3 tons of copper and 4 tons of nickel. The ore was of much lower grade than that which is now being exposed. During the quarter, 2,279 oz. of crude platinoids were realized for a sum of £14,844. The results mentioned above were obtained by means of a plant which has a capacity of 100 tons per day. It is quite probable that in view of the very gratifying development results, the capacity of the Potgietersrust plant will soon be doubled.

The ore in the Onverwacht Platinum Company's dunite " pipe " in the Lydenburg district is now exhausted, and developments and mining operations have been suspended. This company enjoyed the distinction of being the first South African platinum concern to pay a dividend. Its distributions total 30%.

Transvaal and Swaziland Asbestos.—Important decisions regarding the Turner and Newall groups asbestos properties in the Transvaal are announced. The rich Havelock mine in Swaziland which was recently acquired by the group, is to be incorporated in the New Amianthus Asbestos Co., Ltd., and will be administered by the same staff as the latter company. Operations on the Montana block on the Pietersburg amosite region, belonging to the associated company, the Dominions Blue Asbestos Co., Ltd., have been suspended, and all available labour is being concentrated on the development of the Havelock mine. The latter promises to become one of the most important chrysotile producers in the world, and plans

are being prepared to develop and equip it for production on a large scale. Mr. C. S. Bell, a director of Turner and Newall, Ltd., and Mr. R. Starkey, consulting engineer, have sailed for England, and on Mr. Starkey's return the equipment of the Havelock Mine will be taken in hand.

A Manganese Ore Shipment.—The Manganese Corporation has shipped to Europe 550 tons of Postmasburg ore containing 48·69 tons of metallic manganese. The ore sent by road to the railway at Koopmansfontein was made up of two distinct parcels, there being 250 tons of low-grade ore and 300 tons of high-grade ore. The low-grade ore was a test shipment for a Belgian consumer desirous of entering into a contract for ore of this type, probably for blending with a higher-grade ore of different composition. A remarkable feature of the analyses of this ore is the extremely low-moisture content (low-grade ore 0·13% ; high-grade ore 0·15%), a matter of great importance, particularly in transport. Some twenty-five miles of the branch railway have now been laid towards Postmasburg, so that fairly rapid progress has been made. It is doubtful if any further ore shipments will be made until railhead reaches the deposits.

New Manganese Field. — The Manganese Fields, Ltd., announces that it has secured an option on two farms on which manganese deposits have been discovered. Samples have been assayed and give a result of 58·24% metallic manganese. The line of strike has been followed for over ten miles. The property is situated on the railway line and approximately 150 miles from the nearest seaport.

Transvaal Emeralds.—A further extension of the beryl-emerald field in the Murchison Range, Northern Transvaal, is reported to have been discovered. It is stated that the strike of the occurrence is east and west, and has been traced for a quarter of a mile. Many crystals have been picked up in this area. Shafts are being sunk and indications are said to be promising.

A Kieselguhr Deposit.—A large deposit of kieselguhr has been located on the municipal commonage at Port Alfred. The matter is being investigated with a view to shipping large quantities overseas, where it is greatly in demand for sugar-refining and other industries. There is also a considerable local demand for this mineral in the manufacture of explosives.

BRISBANE

January 20.

The Coal Crisis.—The past month at the New South Wales coal mines has been marked by militant measures on the part of the miners such as have caused great uneasiness to the community and grave concern to the authorities. Following on the fatal raid on the Rothbury mine, the men who have refused to work except on their own terms have continued extreme measures to prevent others from filling their places. In defiance of the law, which prohibits such proceedings and massed picketing, large bodies of unionists, who are being enrolled in an organization called the Labour Defence Army, are being openly drilled on military lines. Led by avowed Communists, some thousands of men have made marches on two or three mines. In each case, however, the police have been able, by baton charges and without resort to arms, to disperse the crowds without much trouble, but there are now reports that a massed raid is threatened on the Rothbury mine by 30,000 men. The State Government has not only assembled a large body of constables where they are expected to be wanted, but is organizing a voluntary civilian constabulary, which can be called upon, if and when necessary, to assist the ordinary police. The Government has continued to work the Rothbury men with volunteer labour, and at least one train load of coal has been sent away. The railwaymen were asked not to move coal from this mine, which has been declared " black," but so far have not refused to do so. A move has been made for a general strike in the unassociated mines in the south and west of the State, where the men at work have been contributing 12½% of their wages to assist the men from the northern pits, which have been closed. Naturally, the idle men are against a general strike, and the proposal does not seem likely to meet with much support. An order has also been given for the withdrawal of the safety men from the associated collieries, where work has ceased. These men have gone out from one or two mines, but, as far as can be learned, no damage has yet resulted. It is stated, however, that if the men are withdrawn from certain specified pits, they will be ruined.

In the meantime an effort has been made to force a declaration that the dispute has extended to more than one State and, consequently, become a Federal matter. Actually, this action was instigated on behalf

of the unions because the Commonwealth Government is a labour administration, while that of the State is Nationalist. The question involved has been before the High Court for two or three weeks, and the hearing has just ended, but judgment not yet given. The State Premier (Mr. Bavin) is holding his hand with regard to the opening of other mines with volunteer labour until this judgment is delivered, and the Railway unions appear to be delaying a decision as to their future attitude for the same reason.

The coal stoppage has now lasted eleven months, and originated when 10,000 miners employed at 30 collieries on the New South Wales northern fields (Newcastle and Maitland) refused to accept a reduction in wages to help in rehabilitating the coal industry. It is estimated that the loss in wages amounts to over £2,000,000. The State Government has now stopped the unemployed allowance to idle men who are acting in defiance of the law, and it has already been stopped for 300 men who have been identified as having taken part in riotous or other illegal assemblies.

Mount Isa Activities.—The present is about the time for the beginning of the wet season in North Queensland, and this is now awaited at Mount Isa in order to fill the dam at Rifle Creek which was finished about a year ago. Yesterday news was received from the mines that up to two days previously 150 points of rain had fallen there, but no advice has since been received. In the meantime, the present supply is being augmented by the sinking of additional artesian wells near the mine. The pipe-line to connect the Rifle Creek dam with Mount Isa has been completed for about 11 of the total distance of 20 miles, and will doubtless be all laid by the time production commences about August next.

In the four-week period covered by the last report from the manager at Mount Isa, a total of 1,187 ft. of diamond drilling was carried out on the Black Star lode. The drives and cross-cuts in the grizzly and haulage levels were extended an aggregate distance of 500 ft. and sinking is being continued in two glory-holes. The Urquhart ore-hoisting shaft was further sunk to 403 ft. The excavations for the main power-house have been finished, and 260 tons of steel-work, including coal hoppers, has been erected. For the concentrating mill, all excavation work is done and 600 tons of steel-work has been put up. Other extensive foundation work has been in hand, the erection of steel bins is in progress, and practically all the plant and machinery is in the railway yard or on the ground ready for erection.

The Whitworth Company.—The Whitworth Mining and Finance Company, an English corporation which started operations some months ago in the Herberton tinfield, North Queensland, has of late been curtailing operations and has reduced the number of men employed from 90 to 40. At the Vulcan (Irvinebank), the first of the mines taken in hand, the company has suspended work, but has let the holding to a tribute party, who appear likely to make good wages, while at the same time keeping the mine free of water to the 600 ft. level. The company has acquired an option over a mine called the Lizzie, and is now practically confining its attention to the opening up of this property for production on a large scale. According to the local district Inspector of Mines, in this occurrence the greywacke has been more or less impregnated with tin over a width of 40 ft., and the company anticipates that bulk values will be high enough for a success to be made of the proposition. During this month it is proposed to begin crushing at the rate of about 60 tons a day.

Cloncurry Copper Ore.—For some years the Queensland Government has granted a rebate of 75% in railage freight on ore mined by copper "gougers" in the Cloncurry district and railed to the port of Townsville, where nearly all of it has been shipped to Port Kembla, in New South Wales, for treatment. This rebate, which was not granted to companies, was probably one reason why the Mount Elliott Company preferred letting its mines to tribute parties, consisting of gougers, rather than operating them itself. The mines have been let on terms such as were apparently satisfactory to the company and have admitted of the tributers making good money, especially since the rise in the price of copper. Now the Government Railway department, which has been carrying the ore at a heavy loss, has stopped this rebate, and has offered the miners such a tariff for their ore as was thought would induce them to rail the ore to the Chillagoe State smelters, which have lately been reopened. Those affected, however, point out that these smelters cannot produce refined copper, as at Port Kembla, and assert that they could not treat all the Cloncurry ore. They also contend that the

abolition of the rebate will result in the closing of several mines, including some of those worked on tribute and the Trekelano, a privately owned mine employing 60 men. The new scheme is already in force, but it is too early to judge what will be its actual effect.

The Bendigo Goldfield.—Another effort is being made to revive mining on the historical Bendigo goldfield in Victoria. The field has been visited by a geophysical expert (Mr. S. Anderson), whose investigations have served to attract considerable attention to the possibilities of further developing many sections of the field. Mr. Anderson is at present making tests in the New Red, White, and Blue mine, and should the results be confirmed by actual operations, they would have an important influence on the future extent of mining at Bendigo. In a preliminary report which Mr. Anderson has already submitted to this company, he refers to the existence of a large formation in the lower levels, which at present are under water. The amount of gold won on the field in 1929 was about 14,000 oz., compared with 18,693 oz. in 1928.

Broken Hill Statistics.—Some interesting statistics lately published concerning mining at Broken Hill, New South Wales, show the value of the production of the mines to date to total £142,000,000, while the dividends paid amounted to £32,500,000. The total ore raised is 44,000,000 tons. In 1909 ore reserves were estimated at 13,000,000 tons. Since then approximately 19,000,000 tons has been extracted, and it is estimated that another 10,000,000 tons is in sight. The average value of ore reserves at the Barrier are set down at 14% lead, 12% zinc, and 7·5 oz. silver per ton.

VANCOUVER

February 8.

A Company Failure.—The event of the week has been the assignment of Stobie, Forlong and Company and the cessation of work on all properties in British Columbia sponsored by them. The firm has been exceedingly active in the Province. It saw the opportunity the British Columbian mines offered and the interest that had been suddenly aroused in mining enterprises owing to the phenomenal success of the Consolidated Mining and Smelting Company of Canada and it was able to acquire a number of old properties at reasonable prices and on reasonable terms. The companies promoted by the firm were: Enterprise Mines, the name of which was later changed to Yankee Girl Consolidated Mines; Kootenay Florence Mining Company; Lorne Gold Mines; Slocan Rambler Mines and Utica Mines. Enterprise Mines acquired, either under option or in exchange for shares in the Enterprise mine, the following properties in the Slocan Lake district: Yankee Girl, Goodenough, and surrounding claims, near Ymir; and the Nugget-Motherlode mine in the Sheep Creek district. After some exploration the option on the Goodenough property was dropped. Kootenay Florence Mining Company acquired the Florence mine at Ainsworth, and later increased its capitalization, adding the adjoining Lakeshore property to its holdings. Lorne Gold Mines acquired the Lorne mine, at Cadwallader Creek, Bridge River district, part of the Coronation group, and a number of surrounding claims. Slocan-Rambler Mines acquired the Rambler-Cariboo mine, at Sandon, and Utica Mines acquired the Utica mine, in the Kaslo district.

With the exception of Utica Mines, operation on which was delayed for about a year owing to legal difficulties in getting title to the property, an ambitious plan for development of and equipment of each property was laid out and was carried out efficiently while funds lasted, but as the public's appetite for stocks became satiated and the stocks of the several companies dropped to below par on the exchanges, difficulty in financing the several concerns arose and development had to be curtailed. Had the original plans of campaign been on a less generous scale, funds would have gone further and better results might have been attained, but, on the other hand, would the public have subscribed for the stock as generously under those conditions? The investing public, taken as a whole, knows little about mining and it likes to see things going with what appears to be a healthy swing.

To take the several Stobie-Forlong properties individually, Yankee Girl and Lorne seem to be the most promising. Both are essentially gold properties, so that in the event of their being brought to production there will be no difficulty in marketing the product. The option on the Yankee Girl was taken over from a group of engineers who had been operating the mine for some

time under a hand-to-mouth policy, shipping the crude ore to Tadanac where it received a low-treatment rate on account of its fluxing property, and had been making the mine pay. When Yankee Girl Consolidated Mines took the property over, toward the end of 1928, it decided to rush through a main haulage tunnel, about 5,000 ft. long, from Wild Horse Canyon to develop the veins at some 800 ft. greater depth, without first ascertaining that the sizes and values of the ore-bodies persisted to that depth. There is nothing spectacular, nothing to interest the investing public, in diamond-drilling, though some drilling was done, but there was a good deal of the spectacular at the portal of the tunnel at Wild Horse Creek. A good camp, comprising 13 buildings, was erected; a trestle, 830 ft. long, was built across the canyon to the mill site on the opposite side to the portal; the West Kootenay Power and Light Company's transmission line was extended to the camp, and a transformer station was erected to step down the power. The tunnel has been driven 2,900 ft., so about 2,000 ft. more driving is needed to reach the downward extension of the ore-bodies. The Yankee Girl vein has been developed to a depth of 1,115 ft. and the ore shipped is said to have averaged between $14 and $15 per ton, of which about $12 is in gold. There is good ore on the floor of the present working, so it is reasonable to suppose that, even if mineralization does not extend to the level of the Wild Horse tunnel, raising from that tunnel, if continued, may be expected to open up considerable new ore.

Work by Lorne Gold Mines was started in the spring of 1928 on a similarly generous plan. Several acres of ground were cleared for camp buildings and a good deal of road work was done to connect the several parts of the property with the main road. A saw mill and a small power plant were erected and, with lumber cut on the spot, camp buildings were built. While this work was under way a crosscut was driven some 700 ft. from the bottom of the 200 ft. shaft in the Coronation mine. This exposed several new veins. A main haulage tunnel was then started to develop the veins exposed by shallow workings on the Lorne property at depths of 600 to 700 ft. A crosscut from this tunnel has opened what is believed to be the downward extension of the King vein, and driving and raising on the vein is said to have developed enough ore to warrant the erection of a small mill. Flumes have been cleaned and repaired and some 2,000 ft. of stave pipe has been laid for a hydro-electric plant capable of developing 2,000 h.p.

Kootenay Florence Mining Company was taken over by the Stobie-Forlong interests to continue the work of driving the lake-level tunnel at the Florence mine, near Ainsworth, which was started by A. G. Larson and associates, to develop the Florence fissure vein and its associated replacement veins at some 550 ft. greater depth. It was expected that the Florence vein would be cut at about 3,500 ft. from the portal, but, apparently owing to the flattening of the enclosing strata, it was not found until the tunnel had been driven 3,900 ft. When it was cut work was delayed for a time by an enormous inflow of water which at its height flooded the tunnel to a depth of two feet. Much ground caved with the inflow of water, which necessitated the removal of a large tonnage of muck. When the water had drained away, driving and raising was done on the fissure and exploration was done in the Lakeshore area, where some ore was found. A brief account of the mine superintendent's report for last year was contained in the last news letter.

Operations at the Rambler-Cariboo and Utica Mines have been continued on a much smaller scale and, as yet, sufficient development has not been done to allow of an intelligent appraisement of the properties.

"White Bulletin."—A recent issue of the *White Bulletin* telling shareholders of the work done on the properties of the companies promoted by J. B. White, of Spokane, for the quarter ended January 31, shows that only desultory development has been carried on during the period by companies operating in British Columbia. The bulletin reports that in 40 ft. of cross-cutting and 100 ft. of driving and open-cutting, a four-foot shoot, showing considerable clean ore, was found at the Leadsmith mine. In 173 ft. of driving, some clean ore, assaying 306 oz. of silver per ton and 68% lead, was found on No. 5 level in the Slocan King mine. Some additional ore was disclosed in 203 ft. of driving at the Silversmith mine.

Noble Five Mines.—The directors of Noble Five Mines have decided that during the depressed silver market further dividends will not be paid, but funds will be conserved for development purposes. Owing to the

usual mid-winter shortage of water, the output of the mill has been reduced to 50 tons daily. Paul Lincoln, general manager, expects to be able to maintain this rate of production during the remainder of the winter, and to increase it again when the spring thaw yields more water for power purposes.

Premier Border.—Angus McKenzie, mine superintendent for Premier Border Gold Mining Company, reports that during last year the company did 1,600 ft. of driving and a few hundred feet of surface exploration. Two definite porphyry zones were found, one at 1,283 ft., from the portal and the other about 200 ft. farther in. These zones will be explored by a diamond drill.

Exports of Concentrates.—According to a recent report issued by the harbour master at Tacoma, Washington, during 1929 ores and concentrates to the amount of 218,037 tons and to the value of $14,094,572 were received at the Tacoma from British Columbia mines. This roughly represents one-fifth of the total value of the mineral production of the Province and indicates that if the shippers of this material could get together and decide to retain it in the Province there is enough material to maintain a smelter. The concentrates were shipped chiefly from the Britannia, Allenby, and Premier mills and the crude ore from the Premier mine.

Smelter Fume.—Truly there is a wide divergence of opinion as to injury done by smelter fume. At the session of the International Joint Commission, held recently at Washington, D.C., to enquire into damage done to lands in Stevens County, Washington, by fume from the Tadanac smelter, the claims of the alleged injured persons aggregated approximately $4,500,000, and Professor F. G. Miller, Dean of the Department of Agriculture at the University of Idaho, and Professor E.A. Howes, Dean of the Department of Agriculture at the University of Alberta, agreed in a minimum estimate of damage done on the figure of $7,415.

TORONTO

February 12.

Brokerage Frauds.—Public confidence in mining investments, which had been rudely shaken by the crash in the price of securities, received a further shock during the latter part of January when it was discovered that many brokers had been carrying on illegal operations and defrauding their customers. A number of Toronto brokers were arrested and charged with conspiracy to defraud, several offices were closed, and others only permitted to continue business under strict Government supervision. Similar action was taken simultaneously in several other provinces and a general movement set on foot for the cleaning up of the brokerage business and the protection of investors. A conference by representatives of the leading Provinces is now in session with a view to securing concerted action in the matter. The Ontario Government, it is announced, will amend the Securities Frauds Prevention Act in the direction of greater stringency, and will in future subject the brokerage business to close supervision. The exposure, in addition to checking wild speculation, is likely considerably to increase the difficulty of finding funds for legitimate mining enterprises.

Coal in Ontario.—With the development of the extensive lignite coal deposits at Blacksmith Rapids on the Abitibi River, now being carried on by the Provincial Department of Mines, Northern Ontario will no longer be dependent for fuel on anthracite imported from Pennsylvania. These deposits have been proved by diamond drilling to contain many millions of tons of a good grade of lignite capable of being used, when pulverized, for industrial purposes, or, when made into briquettes, as domestic fuel. In order to enable this coal to be marketed, the Ontario Government has decided to extend the Timiskaming and Northern Ontario railway from the present end of steel at Coral Rapids northward to Moose Factory on James Bay, a distance of 85 miles. Tenders have been called for the first section of the line, 45 miles in length, which will tap the coal field, work on which will be proceeded with as soon as the weather will permit, and which is expected to be completed during the summer. The extent of the lignite beds has not yet been determined, the amount so far indicated being between 60,000,000 and 70,000,000 tons. Active exploration is being carried on by the Department of Mines in the belief that other coal deposits occur in this region.

Sudbury District.—The International Nickel Company is speeding up production in view of the increasing demand for nickel. Ore shipments from the lower levels of the Frood mine are now averaging close to 2,000 tons per day. On these levels the copper content is higher than on the upper horizons,

and the ore, on account of its richness, requires no rock separation but is shipped direct to the smelter. It is reported that there are 250 drills in operation and that development work is being advanced at the rate of one mile a month. The smelter of the Falconbridge, which has an initial capacity of 250 tons a day has been blown in and is now in operation. A total of 800 ft. of stoping has been completed on two levels, placing the mine in a position to keep the smelter steadily in operation for several years. Under ground there are 10 drills operating, most of them on stoping, but a few of them have been moved to the 1,000 ft. level for advancing the main drive northward.

Diamond drilling on the Sudbury Offsets encountered 66 ft. of nickel-copper ore at a depth of 24 ft. Drilling is being continued to determine the depth of the deposit. The McVittie-Graham has been for some time conducting a diamond drilling campaign on its property at Moose Lake, and, although some ore has been encountered, the results are not considered sufficient to warrant extensive development.

Porcupine.—Information in advance of the annual statement of the Hollinger Consolidated for 1929 places the value of production at something under $9,000,000, from the treatment of about 1,500,000 tons of ore, the recovery being less than $6 per ton. The ore reserves, although encroached upon to some extent, were estimated at $45,000,000 at the close of the year. Underground work during the year, according to a statement by Noah A. Timmins, has considerably improved the position of the mine, resulting in the discovery of new veins, which it is hoped will enable the company to maintain the output without drawing on the ore reserves. The Dome mines will continue underground development for at least six months pending provision for milling facilities to take the place of those destroyed by fire. The mill at Vipond Consolidated is treating upwards of 300 tons of ore a day, production for the month of December amounting to $70,500 from 9,477 tons of ore. Another important vein carrying high grade ore, coming in from the Hollinger, has been encountered and is being driven on.

At the Coniaurum diamond drilling from the 500 ft. level encountered a new vein with an indicated width of 6 ft. carrying good commercial ore. Two promising ore shoots have been discovered on the 1,750 ft. level. Development at the Ridgedome during the year has been attended with encouraging results, a porphyry intrusion in the shaft being regarded as a favourable indication. A 6 ft. vein has been cut by diamond drilling at a depth of 150 ft. The Hayden is cross-cutting on the 700 ft. level to reach the downward continuation of a vein which carries a good width of commercial ore on the 300 ft. level. March is producing at the rate of about $25,000 a month. High grade ore has recently been encountered, and diamond drilling to a depth of 1,000 ft. will be undertaken.

Kirkland.—The Lake Shore is making steady progress with its expansion programme, the completion of which will bring the tonnage handled up to about 2,300 tons daily. About 1,500 ft. of driving has been done on the 2,000 ft. level, with both faces still in high grade ore carrying between $25 and $40 to the ton in gold.

The gross income for the Teck Hughes for the year 1929, was approximately $5,078,000, from the treatment of 340,000 tons of ore, or an average of slightly over 900 tons per day. Development on the 19th level shows improvement in values at depth, and stoping is being carried out over widths said to exceed 60 ft. The Wright-Hargreaves is increasing the rate of production, encouraged by favourable underground developments. A new vein of good grade has been encountered on the 800 ft. level. On the 2,200 ft. level ore has been developed to a length of 1,000 ft. and preparations are being made for stoping. The Kirkland Lake Gold Mine is opening up a vein on the 4,000 ft. level, which carries a width of high grade ore. The vein is in the immediate neighbourhood of the diabase dyke, and operating costs are stated as being under $5 per ton. The Barry-Hollinger is treating about 85 tons daily with an average recovery of about $8 to the ton. Work on the 1,500 ft. horizon has indicated sufficient ore to keep the mill in operation for at least a year. A winze will be put down to a depth of 2,000 ft.

Patricia District.—The Howey, in the Red Lake area, is now receiving power from the hydro-electric plant at Ear Falls, and according to the latest accounts the mill was expected to go into production about the middle of this month. The mill will be started on a small tonnage which will be gradually stepped up to 500 tons daily. President J. E. Hammell states that there is enough ore in sight to keep the mill in operation for several years. It is estimated that,

with ore carrying $8 per ton and operating costs of $5, a moderate profit can be shown.

Manitoba.—Great activity is looked for in the copper area of Northern Manitoba as soon as the spring has fairly set in. Many large companies have become interested and are making preparations to begin work at an early date. Attention is largely centred on the Hudson Bay and Sherritt-Gordon properties, which will be the first to reach the production stage and both of which have extensive ore resources. Sherritt-Gordon has over 5,000,000 tons in sight, and a further tonnage indicated. The Flin Flon owned by Hudson Bay has about 18,000,000 tons of ore indicated, and in addition the company has the advantage of owning and operating the only smelter in the Canadian middle west and its power development will also be a source of revenue.

Diamond drilling by the Cold Lake company has encountered a mineralized zone under the bed of the lake, which is believed to be the continuation of the Sherritt-Gordon ore zone. The Consolidated Mining and Smelting Company has acquired large interests in the Manitoba field, including a number of claims in the Oxford Lake and Cross Lake section. The Gem Lake has encountered a vein carrying high gold values at the 500 ft. level, and has planned an extensive campaign of development. The vein will be opened up on the upper levels, and the shaft put down to a depth of 1,000 ft.

CAMBORNE

March 5.

Price of Tin.—During the last four weeks the price of tin metal has gradually receded a further £10 per ton, and yesterday's cash quotation of £166 15s. is the lowest point reached for 7 or 8 years, when the post-war general slump caused the practical suspension of the tin mining industry throughout Cornwall for over a year. Although this continued falling-away of prices, during the first few weeks of the output restriction scheme, creates a little surprise in some quarters—and, perhaps, a little disappointment—yet confidence in the future is generally evidenced by those chiefly interested in the industry, who recognize that it may require many months of restriction to accomplish the object in view.

Cornish Restriction.—As far as Cornwall is concerned, the restriction policy of the Tin Producers' Association is very loyally supported—an example to larger and richer tin-fields where the uniformity of support given to the policy is not yet so apparent. The South Crofty, East Pool, Geevor, Polhigey and Wheal Kitty companies, in accordance with their first announcements, are carefully observing their programmes of restriction. Jantar is following the plan outlined in the directors' statement made at the last meeting of shareholders. The only company temporarily to suspend operations is Wheal Reeth.

Labour.—Unfortunately the effect of the restriction scheme upon labour is only too plainly demonstrated. The numbers of unemployed men in Camborne, Redruth, St. Just and St. Agnes (the chief mining parishes of the county), according to the periodical returns of the local Employment Exchange, have increased by 50% since last September. A Cornish deputation, representing the Urban District Councils of Camborne, Redruth and Truro, succeeded in obtaining a modification of the conditions which had been attached to Government grants for public works, drainage, etc. It had been a condition in certain Cornish cases, that 50% of the workmen employed in such works should be transferred from South Wales to Cornwall. This has now been altered to 20%.

Prospecting. — Although prospecting work has naturally suffered a set-back, due to the fall in the price of tin, steady progress has been made in Wheal Buller, where there is every indication of the existence of a valuable tin deposit underneath the copper so successfully mined in shallower levels by the old company. Also, at Mount Wellington a limited number of men continue at work with satisfactory results.

Castle-an-Dinas.—Apart altogether from tin, operations have been resumed on the wolfram lode at the Castle-an-Dinas mine, owned by South Crofty, the concentration plant improved, and regular work is now in progress.

Lambriggan.—At Lambriggan lead and zinc mine, since the completion of the vertical engine shaft to a depth of 400 ft. and the crosscut to the main lode at that depth, good progress has been made in driving east. The productive section of the lode discovered at the two shallower levels should be reached in about a month. Meanwhile, sampling of the lode in the shallower levels has yielded very satisfactory results. Additional air-compressing power is being installed.

Dolcoath.—During the last month efforts have been continued to persuade the Government to consider favourably Cornish mining development in relation to the increasingly difficult problem of unemployment in the West. The Dolcoath company, through the chairman, made another attempt to get the Trades Facilities Committee to modify the conditions under which the loan was made, to enable the Roskear scheme to be carried on, but the attempt proved unsuccessful. Indeed, an official statement was made that the security held by the Trades Facilities Committee must be realized. It is conceivable that foreclosure might be advantageous if, in some way, it led to resumption of operations at Roskear and so reduced—to some little extent—the length of the unemployment roll. It is understood that further representations are to be made to the Trades Facilities Committee. A deputation from the Cornish Institute of Engineers and the Cornish Chamber of Mines was afforded an opportunity of discussing the scheme prepared by a joint committee of the two institutions at the Treasury, and were assured that the scheme should be given prompt attention. This scheme was outlined in the MAGAZINE of November last.

PERSONAL

E. B. BAILEY, professor of geology in the University of Glasgow, has been elected a fellow of the Royal Society.

C. A. BANKS is visiting New York and London.

W. H. BEASLEY is shortly returning from Northern Rhodesia.

A. O. BROWN is home from Morocco.

L. MAURICE COCKERELL has left for the Gold Coast Colony.

J. J. COLLINS has returned from Malaya.

G. S. DYER has left for California.

C. E. EDWARDS, principal and professor of metallurgy, University College, Swansea, has been elected a fellow of the Royal Society.

W. A. EDWARDS is now in Chile and is shortly proceeding to Bolivia.

J. M. FAIR has left for Malaya.

E. FURZE is home from the United States.

B. J. GILLARD has gone to the Gold Coast.

LEONARD HARVEY is returning from Namaqualand.

R. J. LEMMON has returned from the United States and Canada.

C. F. LLOYD JONES has left for Iraq.

E. NEWBOLD has left for the Straits Settlements.

M. A. NOVOMEYSKY has left for Palestine.

H. C. ROBSON has left for India.

R. R. SPEAR is home from Nigeria.

G. L. L. STONE has left for Mexico.

W. E. THORNE is returning from Colombia.

SCOTT TURNER, Director of the United States Bureau of Mines, has been elected Vice-President and Director of the American Institute of Mining and Metallurgical Engineers.

A. B. WATSON is home from Nigeria.

C. H. WRAY is here from Tasmania.

LIEUT.-COL. P. N. NISSEN died on March 2, aged 57. Col. Nissen was born in Canada and came to England prior to the War, being engaged in connexion with the stamp for crushing gold and other ores, which he invented and which bore his name and was subsequently installed on several of the leading mines in South Africa and Rhodesia. In the early days of the War Col. Nissen, who was in the Royal Engineers, was actively engaged in Belgium and later on designed the Nissen hut, being also responsible for other useful inventions. For his services he received the D.S.O. In 1921 Col. Nissen designed and executed the War memorial erected by the Institution of Mining and Metallurgy, which was unveiled by Earl Haig towards the end of that year.

TRADE PARAGRAPHS

Oerlikon, Ltd., inform us that their address in London has now been changed to Victoria House, Southampton Row, W.C. 1.

British Hacksaw Makers' Association, of King Street, Sheffield, issue a list of prices agreed internationally for hacksaw blades.

Leyland and Birmingham Rubber Co., Ltd., inform us that their London office will in future be at Grand Buildings, Trafalgar Square, W.C. 2. Their central sales organization is also being moved from Leyland to this office.

Sullivan Machinery Co., of Salisbury House, London, E.C. 2, issue further letters as to the relative advantages of scraper loading in general, and advocating the Sullivan 30 h.p. scraper loading unit with flame-proof electric motor, in particular.

Edgar Allen and Co., Ltd., of Imperial Steelworks, Sheffield, send us one of their attractively bound catalogues giving drill data which would be of interest in a machine shop. Another booklet is devoted to steels for motor cars and aircraft.

G. A. Harvey and Co. (London), Ltd., of Woolwich Road, London, S.E. 7, send us the first issue of a new house organ entitled *The Harco Magazine.* This is well printed and illustrated and follows conventional lines in publications of this description.

A.E.G. Electric Co., Ltd., of 131, Victoria Street, London, S.W. 1, in their *A.E.G. Progress* for February have an article describing the electrical equipment of bucket and grab hoist gear with details as to how these are controlled on mechanical excavators and cranes.

Demag A.G., of Duisburg, Germany, send us their *Demag News* for January which contains a long illustrated article on central compressed air stations with small units in which are described various air-compressors of their manufacture. There is also a section devoted to mechanical excavators and cranes.

Bureau of Information on Nickel of the Mond Nickel Co., Ltd., of Imperial Chemical House, London, S.W. 1, in the January issue of their *Nickel Bulletin* have a description of nickel-chromium heat-resisting alloys, particularly of cronite which is a material used for some of the furnace parts in the Coley zinc process. This alloy is also suitable for case-hardening boxes.

G. and J. Weir, Ltd., of Cathcart, Glasgow, send us booklets devoted respectively to the Weir turbo-feed, turbo-electric and electro feeder pumps and also to the reduction of running costs as exemplified by their pumps and auxiliary plant. Each is well produced and fully illustrated with examples of their products both by photographs and drawings.

Compressed Air Society, of 19, West Street, New York, send us the fourth edition of the trade standards of the Society, which contains sections devoted to nomenclature, definitions, installation and lubrication of air-compressors, tool standards, and other useful matter, notably a new formula for use in air-compressor testing as adopted by the Society.

Ruston-Bucyrus, Ltd., of Lincoln, issue a leaflet which, besides drawing attention to the newly consolidated working arrangements, gives details of different types of shovels, draglines, and other excavators, which as a united firm they are able to place on the market. These vary from ½ cu. yd. (the well-known Ruston No. 4) to enormous stripping shovels with bucket capacities of 12 to 16cu. yd.

Samuel Osborn and Co., Ltd., of Sheffield, issue a booklet describing castings and forgings of their manufacture for dredge plant. These include buckets, manganese steel lips and bushes, nickel-chrome steel pins, cast steel trays, toughened cast steel bottom tumbler with manganese steel shells, idlers of toughened cast steel with shafts of mild steel and plates also of manganese steel, steel chafers for the well of a dredge pontoon, ladder roller shells, pump liners and impellors.

Metropolitan-Vickers Electrical Co., Ltd., of Trafford Park, Manchester, in their *Gazette* for January have an article, fully illustrated, describing the work and progress of the organization during the past year. Beside reviewing progress in turbo-generating sets, frequency changers, converters, transformers and induction motors, this includes a section devoted to electric winders for South Africa and Rhodesia, to which detailed reference has been made in these columns already.

Evershed and Vignoles, Ltd., of Acton Lane Works, Chiswick, London, W. 4, have issued a new edition of their catalogue No. 7/162 describing the Midworth distant repeater which, as has been pointed out in these columns before, is an electrical system designed both to transmit information to a distance and to control distant appliances and equipment. The present catalogue is fully illustrated with photographs and diagrammatic sketches which with the accompanying text serve to give a clear idea of the manner of the operation.

Holman Bros., Ltd., of Camborne and Broad Street House, London, E.C. 2, have published, in the name of their South African subsidiary company in Johannesburg, a handsomely prepared souvenir of the coming Mining and Metallurgical Congress. This covers some fifty odd pages of heavy art paper and places on record in pictures and text the major achievements of this well known Cornish firm, both in peace and war. Recent developments in rock drills and hoists and haulages are also specially dealt with.

International Combustion, Ltd., of Africa House, Kingsway, London, W.C. 2, inform us that contracts have been secured for Wood type steam generators by their associated French company as follows:—The order for Quaregnon Power Station, comprising three generators having an evaporation of 190,000 to 225,000 lb. per hour at 950 lb. pressure and 840° F. final temperature. The boilers are normally fired with pulverized coal, provision being made for using as alternative fuel de-hydrogenated coke-oven gas. The second contract is for a steam generator of a similar design evaporating 80,000 to 90,000 lb. per hour at a pressure of 400 lb. per square inch and a final temperature of 800° F. which will also be fired with pulverized fuel.

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 No. 00 Raymond Pulverizer for clay; one 3 ft. Raymond separating plant for carbonate of magnesia; two tubular dust collectors; one 3 ft. by 5 ft., type 39, screen for slag; one 5-roller Raymond mill for oxide and two 3 ft., type 31, screens. For Germany: Two 4 ft. by 7 ft. screens for coal. For Australia: Three No. 70 Impax mills for coal, and one R.L.7 Raymond-Lopulco mill for phosphate. For Portugal: One 3 ft. by 8 ft. ball-mill for tin ore. For France: Two 5-roller Raymond mills for phosphate; one 3-roller Raymond mill for ochre; eight 8 ft. by 60 in. Hardinge mills for coal; four 10 ft. by 48 in. Hardinge mills for coal; one 5 ft. by 10 in. rod mill, and one No. 00 Raymond pulverizer.

Westinghouse Electric International Co., of 2, Norfolk Street, Strand, London, W.C. 2, issue a number of leaflets devoted respectively to electric plant for rotary drilling; motors and control for pipeline pumping; 2 speed wound rotor motors and control for oilfields; 1½ and 3 kw. turbine generator units; and electrical equipment for cable tool drilling. The company also issue their customary publication describing their major achievements during the past year. This is, as usual, a comprehensive review divided into sub-sections and fully illustrated. Among mining specialities may be noticed two six-ton 56 h.p. mining locomotives for coal haulage, having a height of only 24¾ in. (excluding the trolley). It is said to be the lowest ever achieved in an engine of this weight. Another operation to which attention is drawn is an automatic electrically operated mine hoist which is in use at Kimberley, Nevada. It is designed for an ultimate depth of 835 ft. for control from either one or two mine levels or from the surface. Two skips of 12 ton capacity are operated in balance at a maximum speed of 900 ft. per minute, the winding being by a d.c. hoist motor rated at 900 h.p., 560 volts, at 300 r.p.m.

BRITISH INDUSTRIES FAIR

The British Industries Fair was held simultaneously at Birmingham and in London from February 17–28, the heavy or engineering section being entirely concentrated at Birmingham. Of interest to engineers in the London section is the chemical group. Among exhibits in the engineering section, the following may be taken as being of more particular interest to mining men:

Davidson and Co., Ltd., of Belfast, among models of fans, etc., were making a feature of the Sirocco mine fan.

W. and T. Avery, Ltd., of Birmingham, were showing weighing, counting, testing and measuring machines for all purposes.

British Thomson-Houston Co., Ltd., of Rugby, were represented by examples of electric plant for all industrial requirements.

Arthur Balfour and Co., Ltd., of Sheffield, were exhibiting a wide range of their steels including magnet steel and products therefrom.

Oldham and Son, Ltd., of Manchester, were showing miners' safety lamps, stone dusting machines and gas testing apparatus.

Fielding and Platt, Ltd., of Atlas Works, Gloucester, had running exhibits of various types of low pressure, cold starter, crude oil engines.

Cassel Cyanide Co., Ltd., of 19, St. Vincent Place, Glasgow, had a plant for demonstrating case hardening by means of molten sodium cyanide.

R. A. Lister and Co., Ltd., of Dursley, Gloucester, were showing running engines both petrol and petrol-paraffin, in hopper and tank-cooled models.

N. Hingley and Sons, Ltd., of Dudley, were showing a variety of coal and other mining specialities such as chains, tub couplings, draw bars, rope clips, and such like.

Gandy Belt Manufacturing Co., Ltd., of Seacombe, Cheshire, were displaying belts and brake linings, comprising every type of belt for conveying and power transmission.

Electric Furnace Co., Ltd., of 17, Victoria Street, London, S.W. 1, were showing examples of their electric furnaces for all purposes, e.g. melting and heat treatment of metals.

Rapid Magnetting Machine Co., Ltd., of Lombard Street, Birmingham, were showing and demonstrating all their recent types of magnetic separators, lifting magnets, clutches and chucks.

W. G. Allen and Sons (Tipton), Ltd., of Tipton, Staffs, were displaying examples of colliery and mine tubs and sectional tipping wagons, underframes, axle greasers, haulage clips and such like.

Goodwin, Barsby and Co., Ltd., of Leicester, were showing examples of their stone crushers, screens, granulators and loaders, the former are made in portable form, 15 in. by 7 in. and 12 in. by 5 in.

Coventry Chain Co., Ltd., of Coventry, were showing roller and inverted tooth chains for power transmission, complete chain drives and self contained chain reduction gears, also examples of elevators.

Ewart Chainbelt Co., Ltd., of Derby, were showing examples of their chains, also sprocket wheels and elevator buckets. The firm manufacture all types of conveying and elevating plant for mines, etc.

Bromford Tube Co., Ltd., of Birmingham, were showing hot-finished weldless steel tubes in bores of from 10 to $\frac{3}{4}$ in. and lengths up to 50 ft., various types of gas and water mains, spigot and faucet tubes, etc.

Drayton Regulator and Instrument Co., Ltd., of West Drayton, Middlesex, were showing examples of instruments which they manufacture, such as temperature regulators, indicators, and recorders of many types.

Harland Engineering Co., Ltd., of Manchester and Alloa, Scotiand, in addition to switchgear of different types were demonstrating an interlock drive suitable for bore-hole, deep-well, dewatering, sinking, and boiler-feed pumps.

Victory Valves, Ltd., of Stockport, were showing wrought steel and other valves which are manufactured in sizes from $\frac{1}{4}$ in. to 24 in. bore in parallel slide, junction, safety, feed, blow-off, and vertical and horizontal isolating types.

Ross Patents, Ltd., of Abbey House, Victoria Street, London, S.W. 1, were demonstrating with models the Ross feeder, Ross feeder screen, Ross curtain screen and the Ross wagon loader, which have already been described in these columns.

George Ellison, Ltd., of Birmingham, were exhibiting switchgear for the control of electric power and machinery in mines and elsewhere in ranges extending from 11,000 supply substation switchgear to starting and control gear for small motors.

A Reyrolle and Co., Ltd., of Hebburn-on-Tyne, were showing metalclad, oil-immersed circuit breakers for industrial and mining apparatus, air break switches in metal boxes combined with various accessories, also plugs and sockets for mining and other uses.

Premier Electric Welding Co., Ltd., of Abbey Wood, London, S.E. 2, were showing and demonstrating arc and other types of welding plant, transformers, and choke coils, electrodes for steel and cast iron and the " Flexin " continuous welding for iron and steel.

Stewarts and Lloyds, Ltd., of Glasgow, were showing lapwelded wrought iron and steel and weldless steel fittings, bitumen lined steel tubes, concrete lined tubes, " Long Sleeve " welded joint tubes, Victaulic joint tubes and iron and steel chains and castings.

Thomas Firth and Sons, Ltd., of Norfolk Works, Sheffield, were exhibiting a wide range of products made from Firth stainless and " Staybrite " steels, including polished sheets, wire, foil, sections, castings, forgings, etc. Machine tools were also included in the exhibit.

Monel-Weir, Ltd., of Cathcart, Glasgow, were showing varieties of Monel metal and malleable nickel in the form of hot-rolled rod and sheet, solid drawn tubing, turbine blading, valves, castings, forgings and also nickel-chromium-iron in the form of a variety of fabricated parts.

Tangyes, Ltd., of Birmingham, were showing a twin-cylinder heavy fuel oil engine of 144 b.h.p. cold starting, a 19 b.h.p. fuel oil engine, and a smaller engine; also centrifugal, turbine, single and treble ram pumps, and examples of their vertical two-stroke engines, lifting jacks and pulley blocks.

United Steel Companies, Ltd., of Sheffield, were showing alloy steels, billets and bars. They have also issued catalogues of drop stampings made by Daniel Doncaster and Sons, Ltd., one of their associated companies, and also a general catalogue of examples of the products of all their subsidiary companies.

Sunderland Forge and Engineering Co., Ltd., of Sunderland, were showing their patent vibratory screen suitable for grading ores, described in the MAGAZINE for December, 1929, and in addition, electrically driven drills for medium hard stone, of which more particulars will be given in these columns later.

Broom and Wade, Ltd., of High Wycombe, Bucks., had outdoor exhibits of air-compressors, a portable type with a capacity of 55 cubic feet per minute, another with a capacity of 100/110 cubic feet per minute, and others with capacities of 150 and 200 cubic feet per minute; also a rotary type compressor.

Bureau of Information on Nickel of the Mond Nickel Co., Ltd., of Imperial Chemical House, London, S.W. 1, in addition to the exhibit already referred to under the Canadian Government had a separate stand on which were displayed examples of the various applications of nickel in modern alloy work.

Canadian Government Exhibit.—Occupying a large stand in the centre of the Exhibition, the Canadian Government allocated space to a number of important Canadian manufacturers and business houses. Space was occupied here, for example, by the Canadian National Railways and the International Nickel Co.

National Gas Engine Co., Ltd., of Ashton-under-Lyne, had a representative display of their products, consisting of vertical and horizontal gas, crude oil, petrol and paraffin engines in various sizes from 75 to 2 h.p. These engines are made in all sizes from 2 to 3,000 h.p. and will work on any combustible fuel, waste or otherwise.

W. H. Allen, Sons and Co., Ltd., of Bedford, were showing their 3-cylinder airless injection Diesel engine of 200 b.h.p. at 400 r.p.m. direct coupled to a d.c. generator of 132 kw. at 220 volts and, in addition, a 3-cylinder airless injection Diesel engine of 100 b.h.p. at 500 r.p.m. direct coupled to a 65 kw. 220 volt d.c. generator, also a 15 b.h.p., 2 cycle, heavy-oil engine.

L. Gardner and Sons, Ltd., of Patricroft, Manchester, had running exhibits of their high speed Diesel engine developing 38 b.h.p. at 1,000 r.p.m., direct coupled respectively to a dynamo and an air-compressor, also a spirit engine developing 20 b.h.p. at 1,000 r.p.m., belt driving a dynamo. Also exhibits of horizontal cold starting types—29/31 b.h.p. at 250 and 7/8 b.h.p. at 340 r.p.m.

Crossley Bros., Ltd., of Openshaw, Manchester, had a working exhibit of a 4-cylinder vertical compressorless Diesel engine with normal rating of 200 b.h.p. with direct coupled generator, also a similar 3-cylinder engine with normal rating 82 b.h.p. at 450 r.p.m. The outstanding feature of these engines is that they are totally enclosed. The consumption of cheap fuel oil by these engines is given as 0·4 lb. per b.h.p. per hour.

G. A. Harvey and Co. (London), Ltd., of Woolwich Road, London, S.E. 7, were showing samples of their perforated metal and woven wire in a variety of patterns and metals. Other manufactured articles included steel furniture, equipment for offices, works, etc., such as cupboards, shelves, tables, cases and boxes. Steel plate work was exemplified in storage vessels, bunkers, and similar material for chemical and metallurgical works.

Hadfields, Ltd., of East Hecla Works, Sheffield, in addition to showing samples of "Era" H.R. heat-resisting steels, remarkable for their strength and non-scaling qualities at high temperatures, and "Era" C.R. non-corroding steels, which are highly resistant to a large number of chemical agents, were also showing articles made with manganese steel, such as lips for dredging buckets and various other dredge bucket parts made in nickel and other steels.

Cambridge Instrument Co., Ltd., of 45 Grosvenor Place, London, S.W. 1, were showing temperature, measuring, engineering and electrical instruments, including pyrometers and thermometers for temperatures between 200° C. and 4,000° C., automatic temperature regulators, and apparatus for measuring CO_2, CO, oxygen and other gases. Indicating and recording draught and pressure gauges, and various types of galvanometers, electrical testing sets, etc.

Imperial Chemical Industries, Ltd., of Imperial Chemical House, London, S.W. 1.—This organization was extensively represented at each section of the Fair. At the London section, in the chemical group, they had a large stand setting forth the many and varied applications of their products, notably a section devoted to explosives, mining, quarrying, and so forth. At the Birmingham section was a similar stand with corresponding sub-sections devoted to different branches.

P.B. Sillimanite Co., Ltd., of 791 Salisbury House, London, E.C. 2, and **Lucas Furnaces, Ltd.,** of Broad Street, Birmingham, were exhibiting on adjoining stands. The former had a wide variety of their refractory material in the form of bricks of various shapes such as are used by a number of industries, and the latter were showing gas fired muffle type furnaces for heat treatment purposes lined with this material. It is a feature of these furnaces that when open for the insertion or extraction of an article there is said to be no cooling whatsoever, on account of the system of flues adopted.

Ruston and Hornsby, Ltd., of Lincoln.—Of outstanding interest in this exhibit was the first successful oil engine sent out by the firm's works at Grantham of 9½ b.h.p., which has been in constant service since 1892. By way of comparison they were also showing a 3-cylinder airless injection oil engine fitted with stream line filter to economize on lubricating oil and two other oil engines—a 22 b.h.p. on crude oil and a 10 b.h.p. running on petrol/paraffin. **Ruston-Bucyrus, Ltd.,** had a stand adjoining that of Ruston and Hornsby, Ltd., the newly-formed alliance being represented with an exhibit of a Ruston No. 4 excavator, demonstrated working and powered by a Diesel engine.

Petters, Ltd., of Yeovil, had on their stand a comprehensive exhibit of their oil and paraffin engines and were making a special feature of the Atomic Diesel cold starter oil engine. These are made in sizes ranging from 1½ to 260 b.h.p., and in both horizontal and vertical types. This engine is of the two cycle cold starter airless injection type with a particularly low fuel consumption and is simple in design, being without valves in the combustion chamber, or valve operating gear, injection air compressor or other such devices. It should be borne in mind that this firm used to manufacture engines of the 4 cycle type, but once it was demonstrated to their satisfaction that their 2 cycle type was to be preferred they have been manufacturing these instead, and one of the booklets published by themselves gives much detail as to the relative advantages of this type.

Agricultural and General Engineers, Ltd., Aldwych House, London, W.C. 2.—Various of the subsidiary companies of this concern were represented at this Exhibition, of which the following are of more particular interest. **Blackstone and Co., Ltd.,** of Stamford, were showing running exhibits of five of their horizontal spring injection oil engines. In addition three examples of the petrol and petrol-paraffin engines were shown with respective h.p. of 2½, 3¾, and 6. A further exhibit was the unchokeable pump which may be

belt driven or direct connected to a motor. These are made in sizes of from 1 to 8 in. with corresponding capacities of 10/35 gallons per minute to 11/2,200 gallons per minute. **Davey, Paxman and Co., Ltd.,** of Colchester, were showing one of their vertical heavy fuel oil engines with normal power of 265 b.h.p. at 333 r.p.m. and overload for an hour's duration of 305 b.h.p. The engine is of the enclosed forced lubrication type with exterior oil sump, and incorporates a spring injection system of fuel injection referred to above under the heading of Blackstone and Co., Ltd., in connection with horizontal engines. They were also exhibiting a Paxman all steel boiler which is manufactured of mild steel plates. The risk of fracture is avoided and the life of the boiler increased. **J. and F. Howard, Ltd.,** of Bedford, were showing two of their smaller sizes of petrol locomotives, respectively of two and three tons capacity, representing a range of from two to twelve tons. The purpose of these smaller machines, for 24 in. gauge, is for internal transport in works. The power unit is a 4-cylinder petrol engine, developing 20/28 b.h.p. in the two ton size and 25/36 b.h.p. in the three ton. **Bull Motors, Ltd.,** of Ipswich, were showing d.c. generators for coupling to a Paxman oil engine, having an output of 120 kw. 220 volts, running at 300 r.p.m. and the other 52 kw. 260 volts. Arc welding plants were also shown.

METAL MARKETS

Copper.—Apart from a certain amount of manipulation in the early part of the month, mainly on American account, the standard copper market in London during February showed few interesting features. The tendency, on balance, was rather easier, especially as regards the early positions. In America, despite the fact that the statistical position has not yet begun to reflect the effects of their policy of output-curtailment, producers have maintained the price of electrolytic metal at 18 cents per lb. Consumers, meanwhile, are buying only from hand to mouth, as they are distrustful of the present level of prices.

Average price of cash standard copper: February, 1930, £71 10s. 3d.; January, 1930, £71 11s. 1d.; February, 1929, £78 5s. 10d.; January, 1929, £75 11s. 11d.

Tin.—The London tin market was fairly steady during February until towards the end of the month when values receded somewhat, possibly partly in anticipation of the monthly statistics, which proved to be bad, with a further heavy increase in world "visible supplies." Consumers did not take very much interest, and there was no general disposition to support the market despite the measures which certain producers were taking to reduce production. Buyers are not likely to take a more optimistic view until "visible supplies" definitely begin to shrink, which may not be for some time to come, especially as the important Dutch smelters are chary of joining the scheme of the Tin Producers' Association.

Average price of cash standard tin: February, 1930, £173 16s. 6d.; January, 1930, £175 10s. 10d.; February, 1929, £223 4s. 8d.; January, 1929, £222 16s. 3d.

Lead.—Prices broke badly last month, as the Lead Producers' Association apparently found it impossible, owing to heavy stocks, American competition and a poor demand, to maintain its quotations. So far consumers have not been attracted into the market on a very large scale as they are waiting to see whether prices will go any lower. The quotation is, of course, very cheap now, but with industrial conditions so gloomy and ample supplies of fresh lead coming forward, it would be hazardous, despite the existence of the Producers' Association, to affirm that the market has now touched bottom.

Average mean price of soft foreign lead: February, 1930, £21 2s. 10d.; January, 1930, £21 11s. 1d.; February, 1929, £23 2s. 10d.; January, 1929, £22 4s. 6d.

Spelter.—Quotations collapsed further last month and are now lower than have ruled for over two decades. The market has continued to be dominated by a marked excess of supply over demand, and although it is to be anticipated that the drop in prices will result in a drastic curtailment of output, some time may elapse before the market can begin to react. Fresh efforts are being made to re-establish the Continental Zinc Cartel.

Average mean price of spelter: February, 1930, £19 9s. 10d.; January, 1930, £19 18s. 9d.; February, 1929, £26 5s. 11d.; January, 1929, £26 4s. 3d.

Iron and Steel.—Conditions became distinctly gloomy on the Cleveland pig-iron market last month, as consumers were inclined to hold off in the hope of securing material at lower figures later on. For the time being, makers, however, are not inclined to make concessions, despite the drop in their production-costs, but there is no doubt that they are getting somewhat anxious at the outlook. Meanwhile, they are maintaining their minimum quotations as follows: No. 1 Cleveland foundry, 75s.; No. 3 G.M.B., 72s. 6d.; No. 4 foundry, 71s. 6d.; and No. 4 forge, 71s. Makers' stocks are increasing. Conditions are also rather unsatisfactory in the hematite market, and East Coast Mixed Nos. are not realizing more than 78s. per ton. In the finished iron and steel market, fresh business has been dull, especially as regards export. Demand from the shipyards has fallen off very appreciably and although many works are still well employed on current business, they must get more orders or they will be unable to maintain operations on the present scale. Prices of Continental steel have been raised by 2s. 6d. to 4s. per ton, and exporters have been brought under the control of the Cartel, their commission varying according to their importance.

Antimony.—At the close of February demand was quiet, with English regulus unaltered on the month at £42 10s. to £50 per ton. Chinese, on spot, was quoted at £30 to £30 10s. ex warehouse, with shipment metal priced at about £25 15s. per ton c.i.f.

Iron Ore.—There has been practically no new business done during the past month, and a good many ironmasters have found their contracts provided more ore than they require at present, with the result that deliveries against contracts have, in a good many cases, been delayed. Best Bilbao rubio is still nominally held for 22s. 6d. per ton c.i.f.

Arsenic.—Only a very quiet business is passing, Cornish 99% white remaining at £15 17s. 6d. to £16 per ton f.o.r. mines, with Mexican about £17 c.i.f. Liverpool.

Bismuth.—The official price is unchanged at 7s. 6d. per lb. for 5 cwt. lots and over.

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.	
Feb.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	d.	d.	s. d.
11	74 13 9	69 18 9	83 17 6	78 10 0	174 16 3	177 16 3	19 12 6	21 12 6	23 0 0	20 3/8	20 1/16	84 10 7/8
12	74 6 3	69 13 9	83 17 6	—	174 8 9	177 8 9	19 13 9	21 13 9	23 0 0	20 1/4	20 3/8	84 11 1/4
13	71 17 6	69 0 0	83 17 6	—	173 16 3	176 13 9	19 11 3	21 13 9	23 0 0	20 3/8	20 1/4	84 11 1/4
14	70 15 0	68 6 3	83 17 6	77 15 0	172 16 3	175 15 0	19 11 3	21 13 9	23 0 0	20 3/16	20 1/16	84 11 1/2
17	69 12 6	67 18 9	83 17 6	—	174 6 3	177 7 6	19 7 6	21 13 9	23 0 0	20	19 7/8	84 11 1/4
18	70 6 3	68 1 3	83 17 6	77 5 0	173 12 6	176 11 3	19 5 0	21 12 6	23 0 0	20 1/16	20	84 10 5/8
19	70 1 3	68 3 9	83 17 6	—	174 6 3	177 7 6	18 16 3	21 5 0	22 15 0	19 15/16	19 13/16	84 10 3/4
20	69 18 9	68 16 3	83 17 6	—	174 17 6	177 16 3	18 17 6	20 13 9	22 5 0	19 15/16	19 13/16	84 11
21	69 16 3	68 13 9	83 17 6	77 5 0	173 13 9	176 11 3	18 16 3	21 3 9	22 5 0	20	19 7/8	84 11 1/2
24	69 11 3	68 16 3	83 17 6	—	172 1 3	175 1 3	19 0 0	21 3 9	22 10 0	19 7/8	19 3/4	84 11 3/8
25	69 7 6	68 16 3	83 17 6	77 5 0	170 11 3	173 11 3	18 15 0	20 3 9	21 15 0	19 13/16	19 11/16	84 11
26	69 11 3	68 16 3	83 17 6	—	171 6 3	173 18 9	18 6 3	20 3 9	21 15 0	19 3/4	19 5/8	84 11 3/8
27	69 3 9	68 11 3	83 17 6	—	171 3 9	173 16 3	18 6 3	19 15 0	21 5 0	19 11/16	19 9/16	84 11 1/4
28	69 1 3	68 8 1 1/2	83 17 6	77 5 0	168 1 3	170 11 3	18 7 6	20 1 3	21 5 0	19 5/8	19 1/2	84 11 1/2
Mar.												
3	68 6 3	68 3 1 3/8	83 17 6	—	167 13 9	170 6 3	18 10 0	19 15 0	21 5 0	18 15/16	18 13/16	84 11 1/2
4	67 18 1 1/2	67 16 10 1/2	83 17 6	76 10 0	166 11 3	169 2 6	18 10 0	19 15 0	21 5 0	18 7/8	18 3/4	84 11 3/8
5	67 5 0	67 1 10 1/2	83 17 6	—	162 16 3	165 3 9	18 7 6	19 13 9	21 5 0	18 15/16	18 13/16	84 11 1/4
6	68 2 6	67 16 3	83 17 6	—	161 12 6	163 17 6	18 1 3	19 2 6	20 10 0	18 3/4	18 5/8	84 10 1/2
7	67 8 9	66 13 9	83 17 6	75 15 0	159 7 6	161 12 6	17 15 0	18 10 0	20 10 0	19 1/16	18 15/16	84 10 1/4
10	67 19 4 1/2	66 13 9	83 17 6	—	161 12 6	163 17 6	18 1 3	18 8 9	20 0 0	19 1/16	18 15/16	84 11 1/2
11	69 16 3	67 11 3	83 17 6	76 5 0	163 17 6	165 17 6	17 18 9	18 8 9	20 0 0	19 1/16	18 15/16	84 11

CADMIUM.—Quite a good demand is reported at about 3s. 11d. to 4s. per lb. Less Continental competition is now in evidence

COBALT METAL.—With the high speed steel trade slack, there has been a slowing down in the demand for cobalt, but the official price is pegged at 10s. per lb., although less is taken for substantial contracts.

COBALT OXIDES.—Steady conditions prevail here, with quotations unchanged at 8s. per lb. for black and 8s. 10d. for grey.

PLATINUM.—Plentiful supplies have been forthcoming, including a large shipment to Germany from the Russian State Bank of Platinum which had been held as currency reserve. Quotations have eased owing to the lack of demand, and at present refined metal stands at about £11 10s. to £12 per oz.

PALLADIUM.—Very little interest is shown in this metal, quotations now standing at about £5 15s. to £6 10s. per oz.

IRIDIUM.—Although quiet the market has kept steady, sponge and powder being priced at £36 to £39 per oz.

TELLURIUM.—Business is at a standstill and prices nominal at 12s. 6d. to 15s. per lb.

SELENIUM.—A steady demand continues in evidence, with high grade black powder unchanged at 7s. 8d. to 7s. 9d. per lb. ex warehouse.

MANGANESE ORE.—Buyers are still fully covered for some little time to come and no fresh business of any importance has been placed recently. In the absence of sales, quotations are nominal at about 1s. 1½d. per unit c.i.f. for best Indian and 1s. 0½d. to 1s. 1d. c.i.f. for washed Caucasian ore.

ALUMINIUM.—Business has been on a rather small scale recently, aluminium suffering in common with most of the other non-ferrous metals. Prices, however, are maintained at £95 delivered, less 2% for ingots and bars. An interesting development during February was the initiation of negotiations for an agreement between European aluminium rollers in order to lessen competition in the Indian market so that more remunerative prices may be obtained.

SULPHATE OF COPPER.—English material is still quoted at £27 to £27 10s. per ton, less 5%.

NICKEL.—Business has been very well maintained on the whole, and quotations are without change at £170 to £175 per ton.

CHROME ORE.—Although supplies are plentiful they are not pressing on the market, and quotations are well maintained at around £4 to £4 7s. 6d. per ton c.i.f. for good average 48% ore.

QUICKSILVER.—This market during the past month has been characterized by the extreme quietness of demand. Prices are fractionally easier at £23 per bottle, for spot material.

TUNGSTEN ORE.—Buyers have continued their policy of holding off as much as possible and with the demand for ferro-tungsten at a low ebb their requirements have been distinctly small. Quotations have eased in the absence of any appreciable demand and the current value of forward shipment from China is about 29s. to 30s. per unit c.i.f.

MOLYBDENUM.—Easier conditions have ruled in this market recently, 80% concentrates now being offered at about 35s., while buyers are bidding only about 32s. 6d. per unit c.i.f.

GRAPHITE.—Madagascar 85 to 90% flake remains at around £25 to £28 per ton c.i.f., and 90% Ceylon lumps in the neighbourhood of £25 to £26 c.i.f.

SILVER.—February proved anything but a favourable month for the silver industry. On February 1 spot bars stood at the low level of 20⅛d., but although during the first half of the month quotations were fairly well maintained, there was no appreciable confidence on the part of buyers, and later in the month easier conditions developed, culminating with a drop of 9/16d. in the price of spot bars on 28th ult. owing to Eastern selling on news of the new Indian duties. This brought the price down to 19⅛d. per oz., which was easily the lowest figure ever recorded for the metal.

STATISTICS

PRODUCTION OF GOLD IN THE TRANSVAAL.

	Rand.	Elsewhere.	Total.
	Oz.	Oz.	Oz.
February, 1929	778,559	36,725	815,284
March	830,829	35,700	866,529
April	836,474	35,649	872,123
May	858,991	38,607	897,598
June	821,352	34,677	856,029
July	853,370	36,110	889,480
August	850,952	38,649	889,601
September	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

TRANSVAAL GOLD OUTPUTS.

	January.		February.	
	Treated Tons.	Yield Oz.	Treated Tons.	Yield Oz.
Brakpan	82,000	£134,153	74,000	£122,977
City Deep	99,000	24,760	88,000	22,968
Cons. Main Reef	59,300	21,077	54,600	19,546
Crown Mines	228,000	72,669	216,000	68,837
D'rb'n Roodepoort Deep	41,700	13,939	38,500	12,690
East Rand P.M.	147,000	39,620	137,000	37,135
Geduld	85,000	27,114	80,000	25,577
Geldenhuis Deep	66,000	15,588	58,700	14,111
Glynn's Lydenburg	6,200	2,100	6,000	2,107
Government G.M. Areas	210,000	£400,792	189,000	£359,371
Kleinfontein	52,200	11,956	48,200	£11,042
Langlaagte Estate	81,500	£116,790	75,000	£111,134
Luipaard's Vlei	23,000	5,851	23,000	5,775
Meyer and Charlton	17,500	£19,150	16,500	£18,014
Modderfontein New	155,000	74,574	140,000	67,437
Modderfontein B	71,500	25,562	66,000	24,079
Modderfontein Deep	45,900	23,670	41,400	21,323
Modderfontein East	70,000	20,622	63,500	18,615
New State Areas	78,000	£148,185	72,000	£138,183
Nourse	54,500	16,587	57,000	16,774
Randfontein	204,000	£216,679	191,000	£202,830
Robinson Deep	80,500	20,840	123,800	33,395
Rose Deep	58,500	12,205	55,500	11,431
Simmer and Jack	73,800	19,528	69,500	19,128
Springs	70,000	£143,387	64,000	£133,055
Sub Nigel	27,400	21,430	26,500	20,670
Transvaal G.M. Estates	15,000	4,700	13,400	4,735
Van Ryn	42,000	£41,185	38,000	£38,670
Van Ryn Deep	62,000	£105,948	60,000	£102,741
Village Deep	57,000	15,381	—	—
West Rand Consolidated	90,000	£98,342	82,000	£91,755
West Springs	66,800	£76,994	63,000	£72,543
Witw'tersr'nd (Knights')	50,000	£53,405	51,000	£48,692
Witwatersrand Deep	42,300	9,370	39,000	11,548

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.	£
Dec., 1928	2,505,500	27 10	19 8	8 2	1,024,654
January, 1929	2,627,320	28 1	19 9	8 4	1,095,070
February	2,403,720	28 6	20 3	8 3	990,942
March	2,581,600	28 3	20 0	8 3	1,062,331
April	2,606,420	28 1	19 11	8 2	1,068,103
May	2,694,610	28 0	19 10	8 2	1,100,461
June	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	2,580,370	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	—	—	—	—	1,103,718

NATIVES EMPLOYED IN THE TRANSVAAL MINES.

	Gold Mines.	Coal Mines.	Diamond Mines.	Total.
February 28, 1929	196,150	15,940	5,635	217,725
March 30	197,646	16,065	5,787	219,498
April 30	197,412	15,900	5,554	218,866
May 31	195,733	15,852	5,473	217,058
June 30	192,595	15,928	5,029	213,552
July 31	190,031	15,914	4,845	210,790
August 31	190,062	15,867	5,071	211,000
September 30	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	190,638	15,283	5,889	211,840
February 28	196,752	15,495	6,584	218,831

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	—
March	50,407	48,017	47,388	—
April	48,290	48,549	48,210	—
May	48,992	47,323	48,189	—
June	52,910	51,762	48,406	—
July	49,116	48,960	46,369	—
August	47,288	50,611	46,473	—
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.

	January.		February.	
	Tons.	Oz.	Tons.	Oz.
Cam and Motor	24,000	10,986	22,400	10,218
Globe and Phœnix	6,022	5,797	5,751	5,753
Lonely Reef	6,000	4,140	5,500	3,847
Luiri Gold	—	—	1,056	£2,637
Mayfair	—	—	—	—
Rezende	6,400	2,722	6 000	2,537
Sherwood Starr	4,800	£11,184	4,600	£10 525
Wanderer Consolidated	12,040	3,017	10,670	2,667

WEST AFRICAN GOLD OUTPUTS.

	January.		February.	
	Tons.	Oz.	Tons.	Oz.
Ariston Gold Mines	8,051	£13,658	—	—
Ashanti Goldfields	10,367	11,458	9,979	11,484
Taquah and Abosso	8,810	£14,633	8,750	£14,719

AUSTRALIAN GOLD OUTPUTS BY STATES.

	Western Australia.	Victoria.	Queensland.	New South Wales.
	Oz.	Oz.	Oz.	Oz.
February, 1929	28,177	1,997	117	474
March	25,848	2,974	816	—
April	39,166	—	617	—
May	28,026	3,018	493	467
June	33,139	2,368	465	8
July	28,086	1,421	1,203	—
August	37,032	2,178	567	—
September	32,751	1,739	381	—
October	35,445	—	789	—
November	28,460	—	—	—
December	33,650	2,736	1,636	—
January, 1930	25,472	—	—	—
February	31,307	—	—	—

AUSTRALASIAN GOLD OUTPUTS.

	January.		February.	
	Tons	Value £	Tons	Value £
Associated G.M. (W.A.)	4,353	7,570	4,859	8,400
Blackwater (N.Z.)	1,364	5,790	2,935	5,575
Boulder Persev'ce (W.A.)	5,262	12,019	6,404	14,618
Grt. Boulder Pro. (W.A.)	7,632	21,131	9,146	21,871
Lake View & Star (W.A.)	12,230‡	31,132‡	6,987	19,248
Sons of Gwalia (W.A.)	12 554	11,119	12,960	11,116
South Kalgurli (W.A.)	7,316	15,029	8,055	14,292
Waihi (N.Z.)	22,244	{ 7,889* 47,335†	—	{ — —

* Oz. gold. † Oz. silver. ‡ Dec. and Jan.

GOLD OUTPUTS, KOLAR DISTRICT, INDIA.

	January.		February.	
	Tons Ore	Total Oz.	Tons Ore	Total Oz.
Balaghat	3,250	2,303	3,800	2,153
Champion Reef	7,700	5,591	7,310	5,136
Mysore	17,205	8,456	16,482	8,023
Nundydroog	11,500	6,953	11,000	6,907
Oregum	13,544	6,231	13,500	6,168

MISCELLANEOUS GOLD, SILVER, AND PLATINUM OUTPUTS.

	January.		February.	
	Tons	Value £	Tons	Value £
Chosen Corp. (Korea)	11,240	11,227	9,030	10,039
Frontino & Bolivia (C'lbia)	1,480	6,653	1,770	5,079
Lena (Siberia)	—	12,469	—	11,065
Lydenburg Plat. (Trans.)	3,630	786*p*	3,230	818*p*
Marmajito (Colombia)	862	3,274	630	2,505
Fresnillo	90,489	80,301*d*	—	—
Onverwacht Platinum	2,850	452*p*	2,900	554*p*
Oriental Cons. (Korea)	—	97,635*d*	20,809	98,141*d*
St. John del Rey (Brazil)	—	44,300	—	43,000
Santa Gertrudis (Mexico)	49,328	109,990*d*	46,186	93,067*d*

d Dollars. *p* Oz. platinoids.

PRODUCTION OF TIN IN FEDERATED MALAY STATES.

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

July, 1929	5,802	January, 1930	6,128
August	5,610	February	4,768
September	5,332	March	—
October	5,966	April	—
November	6,135	May	—
December	5,849	June	—

OUTPUTS OF MALAYAN TIN COMPANIES.

In Long Tons of Concentrate.

	Dec.	Jan.	Feb.
Ayer Hitam	—	50½	65½
Batu Caves	31	26	16
Changkat	95	55	42
Chenderiang	29⅞	27⅞	28
Gopeng	86	77½	68½
Hongkong Tin	184½	137	113
Idris Hydraulic	38⅜	32¾	26⅞
Ipoh	51⅜	31	29½
Jelapang	34	34	29
Kampar Malaya	70	55	45
Kampong Lanjut	70	60	35
Kamunting	73½	89½	70
Kent (F.M.S.)	45	33	30
Kepong	37	40	37
Kinta	38⅜	30	24
Kinta Kellas	65½	53½	29¾
Kuala Kampar	90	75	45
Kundang	20	23	15
Lahat	16⅜	14½	—
Larut Tinfields	75	42	40
Malaya Consolidated	73	59	44½
Malayan Tin	142⅜	148¾	142¾
Meru	24½	19¼	20⅜
Pahang	222	222	222
Penawat	82½	77	69¼
Pengkalen	65½	51	48
Petaling	178	202½	202½
Rahman	65½	65½	65¼
Rambutan	11	10½	9½
Rantau	50	31	15
Rawang	90	100	80
Rawang Concessions	90	70	15
Renong	108	93	76½
Selayang	25	31	26
Southern Malayan	178½	172½	154⅜
Southern Perak	59¼	68½	56½
Southern Tronoh	48	54	38½
Sungei Besi	53	48	43
Sungei Kinta	49½	33½	20½
Sungei Way	77¼	83½	83½
Taiping	33	24	15
Tanjong	44½	38⅜	33
Teja Malaya	35	15¾	21¼
Tekka	45	42	46
Tekka-Taiping	31	31	33
Temoh	51⅜	37½	31½
Tronoh	122	107	95½

OUTPUTS OF NIGERIAN TIN MINING COMPANIES.

In Long Tons of Concentrate.

	Dec.	Jan.	Feb.
Amari	7	6	—
Anglo-Nigerian	67	103½	82½
Associated Tin Mines	274	200	200
Baba River	2½	3½	4
Batura Monguna	2	2½	—
Bisichi	112	122	120
Daffo	9	6	—
Ex-Lands	65	55	55
Filani	5½	4½	—
Jantar	42	35	—
Jos	26⅜	21¾	22½
Juga Valley	24	20	16
Junction	4½	6	6
Kaduna	40½	40	—
Kaduna Prospectors	24	26	—
Kassa	19	18	15½
London Tin	251	270	260
Lower Bisichi	6¾	6½	4½
Naraguta	18½	21	—
Naraguta Durumi	18½	21	19
Naraguta Extended	15	10	7
Naraguta Karama	27½	29½	—
Naraguta Korot	20	13	—
Nigerian Base Metals	—	—	—
Nigerian Consolidated	20	18	18
Offin River	7½	8½	7½
Ribon Valley	15	20½	15¾
South Bukeru	13	13	10
Tin Fields	2⅝	2¾	2⅝
Tin Properties	23	17	16
United Tin Areas	20	23½	20
Yarde Kerri	5	8	9

OUTPUTS OF OTHER TIN MINING COMPANIES.

In Long Tons of Concentrate.

	Dec.	Jan.	Feb.
Anglo-Burma (Burma)	19½	15	—
Aramayo Mines (Bolivia)	365	240	—
Bangrin (Siam)	48	59½	64¼
Berenguela (Bolivia)	35	33	—
C'nsolidated Tin Mines (Burma)	100	100	90
East Pool (Cornwall)	87½	82½	82½
Fabulosa (Bolivia)	290	177	177
Geevor (Cornwall)	65	65	56
Jantar (Cornwall)	24½	26	—
Kagera (Uganda)	30	25	20
Northern Tavoy	40	40	25
Polhigey (Cornwall)	34	31	28
San Finx (Spain)	16½*	21½*	24*
Siamese Tin (Siam)	145½	138	134½
South Crofty (Cornwall)	67¾	55½	54¾
Tavoy Tin (Burma)	47	25	20
Theindaw (Burma)	6	4	5
Tongkah Harbour (Siam)	67	50	40
Toyo (Japan)	30½	27½	20
Wheal Kitty (Cornwall)	45½	40	36
Zaai Plaats	—	—	35

* Tin and Wolfram.

COPPER, LEAD, AND ZINC OUTPUTS.

		Jan.	Dec.
Broken Hill South	Tons lead conc.	7,484†	—
	Tons zinc conc.	7,662†	—
Burma Corporation	Tons refined lead	6,750	6,750
	Oz. refined silver	608,741	607,945
Bwana M'Kubwa	Tons copper oxide	612	665
Electrolytic Zinc	Tons zinc	8,481*	—
Indian Copper	Tons copper	243	206
Messina	Tons copper	641	495
Mount Lyell	Tons concentrates	3,671	4,023
Namaqua	Tons copper	169	150
North Broken Hill	Tons lead conc.	8,470	—
	Tons zinc conc.	6,650	—
Poderosa	Tons copper ore	990	—
Rhodesia Broken Hill	Tons lead	—	—
	Tons slab zinc	1,502	1,461
San Francisco Mexico	Tons lead conc.	3,716	3,637
	Tons zinc conc.	3,699	3,201
Sulphide Corporation	Tons lead conc.	1,553	1,880
	Tons zinc conc.	2,156	2,517
Tetiuhe	Tons lead conc.	1,151	1,245
	Tons zinc conc.	2,293	2,215
Union Minière	Tons copper	—	—
Zinc Corporation	Tons lead conc.	7,310‡	—
	Tons zinc conc.	6,268‡	—

* Eight weeks to Feb. 5. † Four weeks to Feb. 8.
‡ To February 8.

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

		Dec.	Feb.
Iron Ore	Tons	491,630	419,137
Manganese Ore	Tons	25,923	32,663
Iron and Steel	Tons	256,429	310,316
Copper and Iron Pyrites	Tons	21,456	35,721
Copper Ore, Matte, and Prec.	Tons	4,254	7,696
Copper Metal	Tons	15,985	11,114
Tin Concentrate	Tons	8,340	7,357
Tin Metal	Tons	2,440	1,917
Lead Pig and Sheet	Tons	29,606	35,868
Zinc (Spelter)	Tons	14,437	12,991
Zinc Sheets, etc.	Tons	3,005	3,167
Aluminium	Tons	3,911	1,839
Quicksilver	Lb.	177,709	96,299
Zinc Oxide	Tons	583	1,014
White Lead	Cwt.	17,141	12,300
Red and Orange Lead	Cwt.	3,559	4,090
Barytes, ground	Cwt.	58,525	49,747
Asbestos	Tons	2,281	3,044
Boron Minerals	Tons	295	1,292
Borax	Cwt.	39,787	24,600
Basic Slag	Tons	2,454	2,626
Superphosphates	Tons	6,876	6,947
Phosphate of Lime	Tons	50,124	46,711
Mica	Tons	221	266
Sulphur	Tons	5,134	13,655
Nitrate of Soda	Cwt.	79,822	142,767
Potash Salts	Cwt.	268,853	264,312
Petroleum: Crude	Gallons	31,184,141	30,719,872
Lamp Oil	Gallons	17,232,033	29,970,808
Motor Spirit	Gallons	58,904,030	89,954,539
Lubricating Oil	Gallons	4,633,394	8,855,071
Gas Oil	Gallons	8,829,531	11,293,539
Fuel Oil	Gallons	27,528,856	40,383,333
Asphalt and Bitumen	Tons	13,166	13,055
Paraffin Wax	Cwt.	141,202	158,711
Turpentine	Cwt.	46,390	50,681

OUTPUTS REPORTED BY OIL-PRODUCING COMPANIES

In Tons.

	Dec.	Jan.	Feb.
Anglo-Ecuadorian	14,338	14,805	14,583
Apex Trinidad	33,530	34,760	21,370
Attock	3,238	3,111	2,921
British Burmah	5,518	5,359	5,030
British Controlled	30,487	32,220	23,293
Kern Mex	765	753	655
Kern River (Cal.)	1,118	932	1,100
Kern Romana	3,194	2,768	2,600
Kern Trinidad	5,030	4,726	4,987
Lobitos	29,817	28,815	25,681
Phœnix	48,618	50,110	45,612
St. Helen's Petroleum	8,372	6,107	6,352
Steaua Romana	70,150	71,890	64,870
Tampico	2,989	2,936	2,546
Trinidad Leaseholds	39,700	32,100	28,300
Venezuelan Consolidated	7,595	7,288	4,876

QUOTATIONS OF OIL COMPANIES SHARES.

Denomination of Shares £1 unless otherwise noted.

	Feb. 10, 1930	Mar. 10, 1930
	£ s. d.	£ s. d.
Anglo-American	3 2 6	3 12 6
Anglo-Ecuadorian	16 3	13 9
Anglo-Egyptian B	2 10 6	2 6 3
Anglo-Persian 1st Pref.	1 6 3	1 5 9
„ „ Ord.	4 1 9	3 18 0
Apex Trinidad (5s.)	1 5 0	1 3 0
Attock	1 18 9	1 12 6
British Burmah (8s.)	6 6	5 9
British Controlled ($5)	4 0	3 6
Burmah Oil	4 3 0	3 16 9
Kern River, Cal. (10s.)	5 9	5 0
Lobitos, Peru	2 0 0	1 16 3
Mexican Eagle, Ord. (4 pesos)	13 6	11 6
„ „ 8% Pref. (4 pesos)	13 3	11 3
Phœnix, Roumania	13 0	11 9
Royal Dutch (100 fl.)	32 15 0	31 10 0
Shell Transport, Ord.	4 15 6	4 11 3
„ „ 5% Pref. (£10)	9 15 0	9 15 0
Steaua Romana	9 0	8 0
Trinidad Leaseholds	3 17 6	3 15 0
United British of Trinidad (6s. 8d.)	7 0	6 3
V.O.C. Holding	3 0 0	2 13 0

PRICES OF CHEMICALS. March 7.

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	6
„ Glacial	per ton	66	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	„	24	0	0
„ Phosphate	„	40	0	0
„ Sulphate, 20·6% N.	„	10	2	0
Antimony, Tartar Emetic	per lb.			10½
„ Sulphide, Golden	„			7
Arsenic, White	per ton	16	0	0
Barium Carbonate, 94%	„	5	10	0
„ Chloride	per ton	11	0	0
„ Sulphate, 94%	„	5	0	0
Benzol, standard motor	per gal.		1	7
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.		2	5
„ „ crystallized, 40°	per lb.			7½
Carbon Disulphide	per ton	24	0	0
Citric Acid	per lb.		1	10½
Copper Sulphate	per ton	26	5	0
Hydrofluoric Acid	„			6
Iodine	per oz.		1	0
Iron, Nitrate	per ton	6	0	0
„ Sulphate	„	1	15	0
Lead, Acetate, white	„	39	0	0
„ Nitrate	„	32	0	0
„ Oxide, Litharge	„	35	10	0
„ White	„	36	10	0
Lime, Acetate, brown	„	7	5	0
„ „ grey, 80%	„	16	0	0
Magnesite, Calcined	„	9	10	0
Magnesium, Chloride	„	6	15	0
„ Sulphate, comml.	„	3	5	0
Methylated Spirit 64° Industrial	per gal.		1	5
Nitric Acid, 80° Tw.	per ton	21	0	0
Oxalic Acid	per cwt.	1	13	0
Phosphoric Acid	per ton	29	15	0
Potassium Bichromate	per lb.			4⅝
„ Carbonate	per ton	26	2	6
„ Chlorate	per ton	26	15	0
„ Chloride 80%	per ton	9	15	0
„ Hydrate (Caustic) 90%	„	31	0	0
„ Nitrate, refined	„	20	10	0
„ Permanganate	per lb.			5½
„ Prussiate, Yellow	„			6½
„ „ Red	„		1	9
„ Sulphate, 90%	per ton	11	0	0
Sodium Acetate	per ton	20	10	0
„ Arsenate, 45%	„	26	0	0
„ Bicarbonate	„	10	10	0
„ Bichromate	per lb.			3½
„ Carbonate (Soda Ash)	per ton	6	0	0
„ „ (Crystals)	„	5	5	0
„ Chlorate	per ton	25	15	0
„ Cyanide, 100% KCN basis	per lb.			7
„ Hydrate, 76%	per ton	14	10	0
„ Hyposulphite	„	9	0	0
„ Nitrate, 96%	„	10	2	0
„ Phosphate, comml.	per cwt.		11	0
„ Prussiate	per lb.			4½
„ Silicate	per ton	9	10	0
„ Sulphate (Glauber's Salt)	„	2	12	6
„ „ (Salt-cake)	„	2	15	0
„ Sulphide	„	9	10	0
Sulphur, Roll	„	10	0	0
„ Flowers	„	12	0	0
Sulphuric Acid, 168°	„	5	7	6
„ „ free from Arsenic, 144°	„	4	0	0
Superphosphate of Lime, 33%	„	3	9	0
Tartaric Acid	per lb.		1	3½
Turpentine	per ton	46	0	0
Tin Crystals	per lb.		1	3½
Titanous Chloride	„			10
Zinc Chloride	per ton	12	0	0
Zinc Dust	„	27	10	0
Zinc Oxide	„	39	0	0
Zinc Sulphate	„	10	10	0

SHARE QUOTATIONS

Shares are £1 par value except where otherwise noted.

GOLD AND SILVER:	Feb. 10, 1930. £ s. d.	Mar. 10, 1930. £ s. d.
SOUTH AFRICA:		
Brakpan	2 17 6	2 11 3
City Deep	7 6	5 0
Consolidated Main Reef	15 6	14 6
Crown Mines (10s.)	3 3 0	3 2 6
Daggafontein	1 3 0	1 1 3
Durban Roodepoort Deep	10 6	10 0
East Geduld	1 17 6	1 16 9
East Rand Proprietary (10s.)	11 0	9 0
Geduld	3 6 3	3 5 0
Geldenhuis Deep	5 6	5 3
Glyon's Lydenburg	2 6	3 6
Government Gold Mining Areas (5s.)	1 18 9	1 13 0
Langlaagte Estate	1 1 0	1 0 6
Meyer & Charlton	10 0	10 0
Modderfontein New (10s.)	4 3 9	4 0 0
Modderfontein B (5s.)	15 0	14 0
Modderfontein Deep (5s.)	1 5 0	1 3 9
Modderfontein East	1 5 0	1 3 9
New State Areas	1 11 3	1 11 9
Nourse	8 3	8 9
Randfontein	6 0	5 6
Robinson Deep A (1s.)	15 0	13 9
„ „ B	7 9	7 6
Rose Deep	4 3	4 0
Simmer & Jack (2s. 6d.)	3 3	2 9
Springs	3 5 6	3 1 9
Sub Nigel (10s.)	1 18 9	1 16 3
Van Ryn	6 6	6 3
Van Ryn Deep	1 18 9	1 10 6
Village Deep	7 3	7 9
West Rand Consolidated (10s.)	6 3	5 3
West Springs	15 3	12 9
Witwatersrand (Knight's)	9 0	9 0
Witwatersrand Deep	3 9	3 6
RHODESIA:		
Cam and Motor	1 0 6	1 1 9
Gaika	4 0	4 0
Globe and Phœnix (5s.)	14 3	16 0
Lonely Reef	16 3	16 9
Mayfair	12 6	12 6
Rezende	1 2 6	1 2 6
Shamva	2 0	1 6
Sherwood Starr	1 0 6	1 0 0
GOLD COAST:		
Ashanti (4s.)	1 6 6	1 6 6
Taquah and Abosso (5s.)	1 9	2 6
AUSTRALASIA:		
Golden Horseshoe (4s.), W.A.	2 9	2 6
Great Boulder Proprietary (2s.), W.A.	1 6	1 6
Lake View and Star (4s.), W.A.	13 0	11 6
Sons of Gwalia, W.A.	1 6	1 3
South Kalgurli (10s.), W.A.	13 0	13 0
Waihi (5s.), N.Z.	13 0	12 9
Wiluna Gold, W.A.	17 0	17 0
INDIA:		
Balaghat (10s.)	4 0	4 0
Champion Reef (10s).	9 0	9 0
Mysore (10s.)	13 0	12 0
Nundydroog (10s.)	16 0	16 9
Ooregum (10s.)	6 3	6 0
AMERICA:		
Camp Bird (2s.), Colorado	1 0	1 0
Exploration (10s.)	7 6	6 0
Frontino and Bolivia, Colombia	7 6	7 6
Mexican Corporation, Mexico	9 0	7 3
Mexico Mines of El Oro, Mexico	3 9	1 6
Panama Corporation	1 0 0	19 6
St. John del Rey, Brazil	18 6	18 6
Santa Gertrudis, Mexico	8 3	8 0
Selukwe (2s. 6d.), British Columbia	4 0	3 9
MISCELLANEOUS:		
Chosen, Korea	8 9	6 3
Edie (5s.), New Guinea	15 0	14 0
Lena Goldfields, Russia	6	6
COPPER:		
Bwana M'Kubwa (5s.) Rhodesia	1 2 0	1 1 0
Esperanza Copper, Spain	1 1 6	1 1 3
Indian (2s.)	1 9	1 9
Loangwa (5s.), Rhodesia	6 3	5 3
Luiri (5s.), Rhodesia	5 0	4 9
Messina (5s.), Transvaal	16 6	16 0
Mount Lyell, Tasmania	1 13 9	1 10 6
Namaqua (£2), Cape Province	16 3	13 0
N'Changa, Rhodesia	3 0 0	2 12 6
Rhodesia-Katanga	1 15 0	1 18 9
Rio Tinto (£5), Spain	46 5 0	43 12 6
Roan Antelope (5s.), Rhodesia	1 10 0	1 8 0
Tanganyika, Congo and Rhodesia	1 18 9	1 17 6
Tharsis (£2), Spain	4 18 9	4 11 3

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

In *Industrial and Engineering Chemistry* for February there is an article by H. A. Doerner of the Rare and Precious Metals Station, U.S. Bureau of Mines on the possibilities of the production of radium and vanadium from carnotite. The writer states that the carnotite ores of Colorado and Utah were the chief source of radium for many years. Originally these ores were worked only for their vanadium content, and were temporarily abandoned when the rich vanadium deposits in Peru were discovered. Later, about 1912, the presence and value of radium in those ores became appreciated, and carnotite was treated principally for its radium content, the vanadium and uranium being considered as by-products.

At the end of 1922 news of the very rich deposits of radium ore discovered in the Belgian Congo caused almost complete cessation of production in the U.S. The Congo ore contains pitchblende and a number of alteration products, including the new minerals bequerelite, curite, kasolite, stasite, and dewindite. Reports indicate that a considerable amount of ore containing over 50% U_3O_8 has been produced. It seemed certain that radium could be extracted from the Congo ore at a much lower cost than from the relatively low-grade carnotite; and in order to preserve their elaborate marketing organizations, the larger American producers made agreements with the Belgian syndicate to market the foreign product in this country. The price of radium has been held at $70 per milligram. Extraction of radium from carnotite by the usual methods does not appear to be profitable at that price. With one exception, all American firms ceased production after their accumulated stocks of ore had been treated. The United States Radium Company, which continued to treat carnotite for several years, has recently shut down its plant.

Although there is probably a large profit derivable from the treatment of Congo ore, it is not likely that the Belgian syndicate will meet sufficient competition to cause any reduction in the present quotations. It is not known how long the high-grade ore will last, but when it is exhausted the price of radium may be expected to advance. Carnotite contains the valuable element vanadium, which is not present in the Congo ore. The recovery of vanadium is an important factor in the cost of extracting radium from carnotite, and under favourable conditions carnotite can be profitably treated for the vanadium alone. Vanadiferous sandstones are found ranging from roscoelite (vanadium mica), containing little or no uranium, to a high-uranium and low-vanadium carnotite. Ores containing 2% or more U_3O_8 are classed as radium ore and are sold on the basis of the uranium content, which is proportional to the radium content. Only in exceptional cases have ores been evaluated on the basis of both the radium and vanadium contents, although the presence of vanadium has undoubtedly influenced the price of radium ore.

Since the advent of radium from Congo ore, a large quantity of carnotite has been treated for the vanadium alone, the radium being discarded with the tailing. Since the entire cost of mining, transport, and milling of this ore is thus covered by the value of the vanadium, the question arises as to whether the radium and uranium cannot also be recovered at a profit, or at least saved in such a concentrated form as to be available when market conditions justify further refining.

The National Radium Institute, under the technical management of the U. S. Bureau of Mines, produced over eight grams of radium by the nitric acid process. Published data show that the total cost of production was $37·60 per milligram of radium, of which $17 represented the cost of the ore at about $96 per ton, the balance being a treatment charge of $118 per ton of ore. These figures take no account of the value of the vanadium or uranium by-products or the cost of recovering them. The general level of wages and commodity prices has increased about 50% since 1915, when the operations covered by the Bureau of Mines report were completed. Moreover, it has been stated that "the mining costs resulting from the first systematic mining operations were faulty and erroneous, as they were based upon favourable physical conditions that were bound to disappear rapidly".

Barker estimated that $62 per milligram of radium extracted represents the bare costs of mining and processing a 2% U_3O_8 ore, and that after adding selling costs and a legitimate profit a selling price of $100 is not unreasonable. The fact that domestic production of radium ceased when the Belgian product came on the market at $70 is very strong evidence that Barker's estimate is close to actual operating costs. Evidently the methods used in the past are not adequate to meet present conditions.

To one not familiar with the mining of carnotite, costs ranging from $100 to $200 per ton of ore for mining and transport seem high. Detailed figures of actual operations are summarized in the Table, column 1. The value of the by-products vanadium and uranium, as well as the expense of recovering them, is not included in these cost data. The high mining costs are due to the necessity for careful selection and sorting of the ore from small scattered ore bodies. The isolated situation of the deposits makes transport costs high. In column 2 are data obtained from the same source relating to the milling of low-grade (0·85% U_3O_8 average) ore obtained as a by-product in the mining of shipping ore. The dust concentrates produced by milling are more difficult to treat than the shipping ore and treatment costs for these are not available. However, subsequent research has shown

that by a modification of the original Bureau of Mines methods high recoveries of not only the radium, but also of vanadium and uranium, can be obtained from either a shipping ore or dust concentrate with little if any increase in operating costs. Estimates based upon the modified procedure (indicated by column 2, see Table) are used to supplement the other data.

The higher costs per milligram of radium in subsequent operations have been due primarily to a lower average grade of ore and high expense for exploration and development of the more deeply buried ore bodies. Column 3 is based upon Barker's estimate of $150 per ton of 2% U_3O_8 ore and $125 for treatment to recover the radium only.

The effect of grade of ore upon the cost of radium is further shown in column 4, in which the cost of radium from a 1% ore is 63% higher than from a 2% ore, although the costs assumed for mining operations are less than one-third. If, however, tion and recoveries are based upon tests which will be described. It should be emphasized that the figures in the Table, with the exception of columns 1 and 2, are not to be taken as representing actual costs, which obviously will vary for different deposits and methods of operation. They merely illustrate the relations between grade of ore, cost of mining, and cost of radium, and especially the possibilities in concentration of low-grade ores. These possibilities have been somewhat neglected because of filtration difficulties, higher costs, and lower recoveries, when processing a dust concentrate by the usual methods of treating an ore.

Carnotite ore is a sandstone that has been impregnated with carnotite and related minerals. Organic matter such as the remains of trees often caused deposition of "bug holes" of nearly pure mineral, but as a rule the carnotite forms incrustations on the sand grains on exposed faces, in joints and fractures of the rock, and less abundantly as

Costs and Yields of Vanadium and Radium from Carnotite.

	(1)	(2)	(3)	(4)	(5) *b*	(6) *b*	(7) *b*
U_3O_8 in ore or concentrate, %	2·66	3·00	2·00	1·00	2·50	3·00	2·75
V_2O_5 in ore or concentrate, %	4·30	5·00 *a*	4·00	4·00	5·00	5·50	5·00
			Cost per ton.				
Development	$5·00	—	$45·00	$5·00	$15·00	$20·00	$15·00
Mining	36·00	$7·15	50·00	25·00	75·00	100·00	100·00
Transport	35·00	35·00	35·00	35·00	35·00	35·00	35·00
Milling	—	20·40	—	—	15·00	20·00	25·00
Overhead, royalty, etc.	20·00	21·75	20·00	5·00	5·00	5·00	5·00
Total cost of ore or concentrate	96·00	84·30	150·00	70·00	145·00	180·00	180·00
Treatment	118·00	125·00 *a*	125·00	125·00	150·00	150·00	150·00
Total	214·00	209·30	275·00	195·00	295·00	330·00	330·00
			Recovery.				
Radium, mg.	5·7	6·7 *a*	4·45	2·00	5·56	6·7	6·1
V_2O_5, lb.	25·0	85·0 *a*	68·0	68·0	85·00	93·00	89·00
U_3O_8, lb.	45·0	50·0 *a*	34·0	17·0	42·00	46·00	44·00
Cost per mg. radium	$37·60	$31·30	$61·80	$97·50	$53·00	$49·25	$54·20

a Assumed. *b* Costs per ton of concentrate.

an ore containing as much as 1% U_3O_8 carries sufficient vanadium, and is so favourably located that the ore can be profitably treated for the vanadium alone, then the radium can also be recovered at a cost considerably below the present market price, as part of the treatment cost and all of the ore costs are covered by the value of the vanadium.

As high as 10 tons of milling ore may be exposed in the development of 1 ton of shipping ore, and this ratio tends to increase as the richer ore bodies become depleted. If production from a given area is increased tenfold the mining cost per ton will be lower and development and other overhead charges may be divided by 10. From these considerations the costs per ton for 1% ore are as listed in column 4. The concentration costs $5 per ton, and the cost of processing a slime concentrate is $150, or 20% more than for an ore. If milling gives 83% recovery at a concentration ratio of 3, other costs being fixed as in columns 3 and 4, the cost per milligram of radium will be $53 (column 5). At 75% recovery and a concentration ratio of 4 the still lower cost of $49·25 is obtained (column 6). Assuming development, mining, and milling costs for 0·75% ore to be $3, $20, and $5, respectively, 73% recovery and concentration ratio of 5 shows a cost of $54.20 per milligram (column 7). These ratios of concentra-

individual grains. As the carnotite is relatively soft, most ores are easily crushed to the size of the sand grains. These ores are concentrated by a mechanical separation of the dust from the coarser sand grains. This may be accomplished either wet or dry. Wet methods are more effective, but scarcity of water in the carnotite areas makes the use of wet methods impractical in most cases. By the dry method the dry, crushed ore is agitated in a current of air to separate the dust from the sand. For good results the sand grains must be scoured clean from adhering mineral, with the minimum crushing of the barren grains. Ordinary crushing or grinding equipment is not well adapted to this operation, because it is designed to crush or pulverize but not for scouring through attrition. The impact or beater mill used in the Bureau of Mines work is probably the best standard type for this purpose.

Early in 1921 the author completed semi-commercial tests on the dry concentration of low-grade carbonaceous ores from the Temple Mountain area near Green River, Utah. Because of the large amount of organic material present, these ores are among the most difficult to treat by either mechanical or chemical methods. Much of the organic substance resembles a tough asphalt and is so closely associated with the valuable minerals

that both mechanical and chemical disintegration are obstructed. It was found that the difficulty could be overcome by roasting, which not only removes all organic matter and moisture, but also causes chemical changes which disintegrate the physical structure of the valuable minerals, reducing their powers of cohesion and adhesion so that they are more easily reduced to a dust. A special machine was designed and constructed to scour the sand and separate the dust. It consisted of a long metal trough provided with a tight hood and had a double row of agitating paddles. The latter were mounted on parallel, horizontal shafts revolving in opposite directions. The roasted ore was fed continuously into one end of the machine through a sealed hopper and subjected to the action of the paddles which tossed it about. Jets of compressed air in the bottom of the trough blew off the dust which was collected in the usual arrangement of cyclone dust collector and bags. The clean scoured sand was discharged through a sealed overflow at the end of the trough opposite the feed hopper. This equipment and procedure gave much better results than had been previously attained. The ratios of concentration and recoveries used in the Table, columns 5, 6, and 7, are representative of these tests. Mechanical concentration of the ore before shipment appears to be the most promising means of lowering costs. As previously noted, it is more difficult to extract radium from a concentrate than from an ore.

The methods of extracting radium from carnotite ore may be classified as follows:

(1) Solution of the radium by an acid, with or without a preliminary treatment.

(2) Chemical disintegration of the gangue and its removal by leaching or volatilization, leaving the radium concentrated in a small residue.

(3) A sulphating treatment (fusion with nitre cake or digestion with sulphuric acid) followed by leaching to dissolve the soluble sulphates, and then a separation of the sand, slime, and solution by classification (or decanting) and filtration (or settling), and finally the recovery of radium from the slime by some method covered by 1 or 2. This procedure cannot be applied to a dust concentrate because the sandy portion of the ore has already been eliminated.

Sulphuric Acid Extraction.—Hot concentrated sulphuric acid has been used to extract radium from a slime concentrate (obtained by method 3), but the large amount of acid required (two or three times the weight of ore slime) and the difficulties in handling the acid (especially filtration) have made this method unattractive. The whole is filtered and from the filtrate a high-grade radium-barium sulphate is precipitated by dilution and boiling, and the other valuable constituents of the ore may be recovered from the solution. Recovery of the excess acid might make this method economical.

Hydrochloric Acid Extraction.—Most ores require a preliminary treatment before a satisfactory extraction of the radium can be obtained with hydrochloric acid. The usual procedure is to boil or autoclave the ore with a solution of sodium carbonate (plus caustic), then filter and wash thoroughly. By this treatment the radium is converted to the acid-soluble carbonate, and soluble sulphates, which might cause premature precipitation and loss, are removed. The average ore requires its own weight of 20% acid and 40% of its weight of soda ash. A dust concentrate will consume and require much more reagent than an ore, and filtrations are more difficult. These disadvantages are reduced by a preliminary roast.

Nitric Acid Extraction.—Since even radium sulphate is quite soluble in hot 38% nitric acid, a direct treatment with this reagent will obtain a high extraction of radium from most ores. By regeneration of nitric acid from the sodium nitrate recovered as a by-product, the acid cost is as low as or lower than that for hydrochloric acid. The limitations of this method as applied by the National Radium Institute are as follows:

(1) It is not effective on ores containing considerable gypsum or carbonaceous matter.

(2) The recovery of vanadium is very poor.

(3) Handling and filtration of hot 38% nitric acid are difficult and expensive.

(4) Slow filtration may cause precipitation and excessive loss of both radium and vanadium. This difficulty makes the treatment of a dust concentrate by this method very unsatisfactory.

Although certain types of carnotite have in the past been roasted as a preliminary to the usual methods of treatment, some important results which may be obtained by roasting have not been recognized. As applied to the nitric acid process, roasting followed by a wash with sodium carbonate solution makes possible the following benefits:

(1) Exceptionally high recoveries of both radium and vanadium are obtained, even from the most refractory ores.

(2) Roasting eliminates carbonaceous material which otherwise would consume nitric acid, cause excessive frothing and slow filtration, and prevent dissolution of occluded minerals. Acid which reacts with inorganic minerals is finally recovered as sodium nitrate, but the acid reduced by organic material is destroyed and unrecoverable.

(3) Roasting converts the iron content of the ore to an insoluble oxide, thus reducing the amount of acid to leach the ore. Eliminating most of the iron with the insoluble residue greatly simplifies subsequent recovery of uranium and vanadium, reducing costs and increasing recoveries.

(4) Roasting changes the physical and chemical condition of the ore so that subsequent filtrations are speeded up. This action is very important, especially in the case of dust or slime concentrates, which are very difficult to treat unless roasted.

(5) In general, a carefully controlled roast makes possible the extraction of a large part of the vanadium by a sodium carbonate leach previous to the acid treatment. This soda leach also removes soluble sulphates which would otherwise cause re-precipitation of radium during the acid leach. After the ore has been conditioned by these two operations, the nitric acid exerts its full strength as a solvent for radium and the residue of vanadium; there is slight possibility of loss through re-precipitation.

In many cases roasting appears to reduce the solubility of the radium, both as to rate of solution and the total extraction. Experiments demonstrate that this effect is due to inclusion of radium in agglomerated particles, consisting of, or coated with, insoluble iron oxide, and that the dissolution of radium is rapid and nearly complete if the agglomerates are thoroughly disintegrated by light grinding or attrition.

Reduction of the gangue material, which consists principally of silica, may be accomplished by fusing

the ore with an excess of caustic soda (or soda ash) and leaching the soluble silicate from the melt with hot water. The practically complete recovery of radium by this method has made possible its commercial application to relatively high-grade slime concentrates produced by sliming a sulphated ore, but the cost of chemicals is prohibitive for direct treatment of an ore or even a dust concentrate from a low-grade ore. The use of hydrofluoric acid to remove silica from a slime concentrate was patented by McCoy. More recently Fleck and Haldane have patented the use of a soluble fluoride (NH_4HF_2) and sulphuric acid, with subsequent regeneration of the fluoride. The following is an abstract of their process :

A slime concentrate, ammonium hydrofluoride, and sulphuric acid are mixed in the proper proportions and slowly heated to volatilize the silicon fluoride, which is collected in a tower. The residue is digested in very dilute sulphuric acid and filtered ; the filter cake contains the radium as a high-grade sulphate. Slaked lime is added to the filtrate, from which ammonia is then distilled and used to regenerate fluoride from the tower liquor. The lime precipitate from the ammonia retort contains the vanadium and uranium.

The chief merits of the above method are the substantially complete recovery of all the valuable constituents of the ore and the regeneration of the fluoride reagent. The design and operation of a plant using this process may involve considerable expense. The reactions require about twice as much 65° Bé. acid as the weight of material treated and also its chemical equivalent in quicklime for regenerating the ammonia. From these considerations it appears that, though the process may be the best treatment for a rich slime concentrate, its application to a dust concentrate from low-grade ore is more doubtful.

It is not difficult to obtain a good recovery of uranium and vanadium as by-products from the treatment of carnotite by any of the usual methods of extracting radium. The market for uranium products is limited, but there is ample demand for vanadium. According to Hess, "In 1922 with high-grade ferro-vanadium selling at $4·50 to $5·00, iron vanadate carrying 32% V_2O_5 was sold at 36 to 75 cents per pound and fused vanadium oxide carrying 75% V_2O_5 was sold for $1·40 per pound of material." At the present price of ferro (about $3·50) a good grade of V_2O_5 should bring about $1 per pound. This figure leaves a wide margin of profit when vanadium is a by-product in the recovery of radium from carnotite. At the present time, however, with the decreasing amount of South American vanadium available, metallurgical industries are again turning toward the carnotite deposits. Vanadium is again the chief product sought and radium is not even recovered as a by-product on account of the Belgian competition. This situation is deplorable when the limited resources of this most valuable of all elements are considered.

The usual, and probably the best, method of recovering vanadium from the vanadiferous sandstones (roscoelite and carnotite) is to roast the ore with about 10% of common salt and 2·5% of soda ash. The calcine is first leached with water and then with dilute sulphuric acid and vanadic acid or ferrous vanadate is precipitated from the extracted solutions. Any radium present in the ore will be left as a fine precipitate in the tailings. If these tailings are discarded, the water used to flush them out and subsequent weathering will disperse the radium beyond all possibility of recovery. If, however, the tailings are deslimed, and the slimes are dewatered and stored, the radium will be saved in a concentrated form at a cost which is an insignificant fraction of its potential value, provided the original ore contains as much as 1% U_3O_8.

If such low-grade ores can be produced in sufficient quantity to permit efficient counter-current leaching operations on a large scale, it is probable that treatment costs could be considerably lowered. However, until it is certain that such operations would not break the present price of radium, the large investment required for such an enterprise would not be justified.

THE GEOLOGY OF NORTHERN RHODESIA

(*Concluded from the February issue, p.* 117.)

The N'Kana Concession. By Anton Gray and D. Sharpstone. — The N'Kana Concession comprises an area of approximately 2,000 square miles, bounded on the north and east by the Rhodesian-Congo border and on the west by a line running due south from Tshinsenda to the Lesser Kafue. The southern boundary is irregular, and the concession extends only a few miles south of Bwana M'Kubwa. The concession is an area of low relief, almost entirely covered by a thick growth of trees and bush. The topography is that of a peneplain upon which, comparatively recently, erosion has again become active. Drainage is east and west into the Kafue River, which runs through the concession in a southerly direction. This latter is now actively degrading, and most of the small streams are doing the same over the greater part of their courses, and in part they meander in wide swampy dambos. Rock outcrops are almost confined to stream beds and occasional kopjes.

General Geology.—The rocks exposed in the area, and their correlation so far as is known by Rhodesian Selection Trust geologists, are shown in the following table :—

Sedimentary and Metamorphic Rocks.
System of the Katanga : Probably Palæozoic.
Purple quartzite series.
Mutondo series. Predominantly shales.
Kundelungu of the Katanga.
Ecca of South Africa (?)
Fluvio-glacial series. Tillite of the Katanga.
Dwyka of South Africa (?)
Christmas series. M'Washia of the Katanga (?)
Roan series, Serie de Mines, in part, of the Katanga
(?) Great Unconformity.
Muva System : Probably Pre-Cambrian.
Lufubu Schists : Pre-Cambrian.
Igneous Rocks.
Younger than Roan series :
N'Changa red granite.
Younger grey granite.
Chambishi gabbro.
Older than Roan series :
Older grey granite.
Muliashi granite (gneiss).

The *Purple Quartzites* are the youngest sediments known in the area, and are over 5,000 ft. thick. Few rocks other than quartzites have been found in the series. These are variable in texture, but characteristically blue-grey colour. The coarser members are felspathic, and many are coarsely cross-bedded. They rest conformably upon the *Mutondo Series*, and are separated from the upper sandy shales of the latter by a gradational zone several hundred feet thick. The Mutondo series is from 7,000 to 8,000 ft. thick. The lowest member is a limestone, 500 to 1,000 ft. thick. This passes gradually upward into the calcareous, usually green, shales which make up most of the series, and these in turn into the upper sandy shales. Exposures of this series are very few and in the outcrops the limestone in particular is usually greatly altered. It is often completely brecciated and silicified. This silicified limestone breccia, so characteristic of the horizon, probably marks the position of bedding plane faults formed during the period when these rocks were severely folded. This is, at least in part, the Kundelungu series of the Katanga, and is thought by Belgian geologists of the Katanga to correspond to the Ecca shales of South Africa.

The contact between the Mutondo limestone and the *Fluvio-Glacial Beds* has not been observed although outcrops of the two rocks have been found not 200 ft. apart, and the two series appear throughout the Concession to be conformable.

The beds which underlie the Mutondo series, about 500 ft. in thickness, have been definitely correlated with the tillite of the Katanga. The rock here is probably not a tillite, but rather a fluvio-glacial deposit, for in most of the good exposures it is distinctly bedded. Layers of very fine, even textured, sandy or shaly material alternate with conglomeratic beds which correspond closely to descriptions of parts of the dwyka conglomerate. The matrix is a fine sandstone or massive shale. The pebbles, and occasional boulders, are irregularly scattered through this matrix, and form less than 25% of the rock. They are usually sub-angular in shape, rarely striated, and from 1 to 10 cm. in diameter, with a few much larger. In composition they vary greatly at any one place, quartz, quartzite, granite, limestone and even large felspathic crystals being represented. In a few exposures thin beds of arkose are found in the series. At the base of this glacial series is a conglomerate, similar to those above, but with a greater amount of larger boulders.

The *Christmas Series*, about 2,000 ft. in thickness, is characterized by two persistent quartzite beds east of the Kafue. These are apparently missing in the western part of the Concession. These are each somewhat over 100 ft. thick and from 200 to 600 ft. apart. They form by far the greatest number of outcrops in the eastern area, and are the key to nearly all the structure which can be determined from the surface. Rather coarse, with rounded grains, often a considerable amount of felspar, and characteristically pyritic, these beds are easily distinguished from the quartzites of the other series. The rocks of this series above and below these beds rarely outcrop, but where found they are black or very dark, more or less banded, shales. In several places a conglomerate has been found at the base of the Christmas series. It is not over 50 ft. thick, and composed of small pebbles of the upper Roan series beds in a coarse gritty matrix.

The *Roan Series*, 3,000 to 4,000 ft. thick, forms the base of the system of the Katanga, and contains all the important copper deposits of the area. It is separated from the older schists, quartzites, and gneisses by a great angular unconformity. At some places the basal bed is a boulder conglomerate over 1,000 ft. thick. At other places there is no conglomerate, the basal bed being a coarse arkose. Where present, the conglomerate is composed of boulders and pebbles of older granite and schists and quartzites of the Muva system, in a coarse arkosic matrix. This passes gradually upward into arkoses and felspathic quartzites which form the lower part of the Roan series. About 750 ft. above the conglomerate, dolomites, dolomitic shales, felspathic sandstones and shales appear, and the upper part of the Roan series appears to be composed of shaly rocks with considerable dolomite.

Very little is known of the *Lufubu* and *Muva Systems*. They are very old rocks, highly metamorphosed and intricately folded. The Lufubu schists show the greatest metamorphism and distortion, and their original nature is not known. The Muva system is composed of quartzites and schists of certainly sedimentary origin. These rocks are intruded by two granites older than the Roan series.

Structure of the Area.—In a belt 20 miles wide or more, running through the concession in a general N.W.–S.E. direction, only the older schists and intrusive rocks are exposed. This belt roughly follows the Kafue River as far south as N'Kana and then swings east of the river. On either side of this belt are found the sediments of the system of the Katanga. On the east, these sediments form a continuous belt, entering the concession just south of Tshinsenda and extending to the south as far as Bwana M'Kubwa. On the west the structure is less regular, being broken by much intrusive granite and gabbro, and containing several isolated blocks of the younger sediments. In these deeply eroded synclinal remnants of the highly folded sediments are found the Roan Antelope, N'Kana, and Chambishi mines.

On the east the sediments form a fairly regular syncline of N.W.–S.E. trend. This is broken by a great deal of minor folding and considerable faulting. Mufulira mine is situated on the S.W. limb of this broken syncline and Bwana M'Kubwa is on the southern extension of the same structure. The Roan series on the N.E. limb outcrop along the Rhodesia-Congo border from Mokambo to a point about 12 miles to the south.

Ore Deposits.—All the ore deposits known in the N'Kana concession occur in the lower part of the Roan series. The upper part of this series is believed to correspond to the Serie de Mines of the Katanga. The ore in this concession, therefore, is found in rocks stratigraphically lower than the ore-bearing rocks of the Katanga.

The Roan Antelope and Mufulira mines are the two best known deposits of the area. They are similar to the others in all but minor details, and a description of these two properties will suffice for an understanding of all.

Mufulira Mine.—This property is situated on Mufulira stream, about 50 miles N.W. of N'Dola. The beds of the Roan series here strike N.W. and dip from 40° to 45° N.E. Three ore-bearing

horizons are recognized, the lowest being about 750 ft. above the base of the series.

A generalized section through the lower Roan series here is as follows :—

	Feet.
Silicified dolomitic shale. .	?
Felspathic quartzite . .	25–30
Argillaceous sandstone . .	60 ±
Sandstone and grit . .	15—20
Argillaceous sandstone . .	50 ±
Felspathic quartzite . .	
Dolomite	0—20
Felspathic quartzite . .	300 ±
Arkose and conglomerate .	500—600

Great unconformity.

Schists of the Muva system.

The lowest of the three ore bodies occurs in the lower felspathic quartzite. The middle ore-body occurs in part in the same formation, and in part in the dolomite. The upper ore-body occurs in the felspathic quartzite just above the dolomite.

The deposits are impregnations of copper minerals in the sedimentary rock. The mineralization follows the three ore-bearing horizons with remarkable consistency, resulting at Mufulira in ore bodies from 10 to 30 ft. wide and over 6,000 ft. in length. These deposits have not yet been explored at depth, but shallow drilling indicates a secondary chalcocite zone reaching in places a depth of over 500 ft. Below this the ore minerals are bornite and chalcopyrite. Oxidized copper minerals extend to a depth of 700 ft., but are probably not economically important below 300 ft.

The source of the mineralizing solutions is probably the granite which intrudes the Roan series near Mufulira Stream. In the copper-bearing beds pegmatite and quartz veins are frequently encountered, and there has been much silicification. Why the ore-bearing solutions followed definite horizons so persistently is a problem not yet solved, but two reasons suggest themselves. In one case the ore horizon is extremely dolomitic. In the other the ore follows a greywacke phase of the quartzite. It is significant that when the limit of one lens of this greywacke quartzite is reached copper values drop so low as to be of no value.

Roan Antelope Mine.—The Roan Antelope Mine is situated about 20 miles S.W. of N'Dola. The Roan series here forms a syncline, trending N.W., closed at the S.E. end and pitching to the N.W. It is about 2,500 ft. in width at its widest part, probably over 2,000 ft. deep, and has been traced unbroken for a distance of over three miles from the nose.

The structure is in large part surrounded by granite which intrudes the beds about three miles N.W. of the closure. The contact between the Roan series and older rocks has not yet been located at this place, and it is not possible to say just how far above the base of the series the ore-bearing horizon lies. It probably is very close to, or slightly above, the middle Mufulira ore horizon. Directly underlying the ore-bearing beds are about 60 ft. of interbedded felspathic sandstones and sandy shales. At the top of this formation there is a conglomerate of variable width, called at the mine the "footwall" conglomerate. Above this is a biotite schist, 3 to 10 ft. thick, and this is overlain by about 80 ft. of banded metamorphosed sandy shale. The lower part of this shale carries the ore.

The ore consists of metamorphosed shale with disseminated chalcocite, bornite and chalcopyrite. Oxidation usually extends to slightly below 100 ft., and no well-defined chalcocite zone has been recognized, this mineral reaching to the bottom of the structure near the nose where a drill hole has penetrated the ore horizon at a depth of 1,000 ft. Mineralization also commonly extends into the biotite schists, but is usually sharply defined by the footwall conglomerate.

Here, as at Mufulira, the adjacent granite is given credit for being the source of the copper, and for much the same reasons. However, the sediments are certainly intruded by granite, and contain pegmatites and quartz veins, as well as considerable general silification. Also, the copper minerals are distinctly not syngenetic. From the information available, then, an igneous origin seems the most reasonable explanation. Why the ore-bearing solutions chose a particular part of this particular bed is again a problem unsolved. It is to be noted, however, that at N'Kana Mine this particular horizon more nearly resembles a shaly dolomite, and it is possible that the shale at the Roan may have been originally much more dolomitic than at present. There is also evidence that the shales contained carbonaceous matter.

RECENT DEVELOPMENTS IN THE RECOVERY OF MERCURY

In Technical Publication 264 of the American Institute of Mining and Metallurgical Engineers, L. H. Duschak describes recent improvements in the metallurgy of quicksilver. Full extracts from his paper are given here.

During the war there were a number of departures from what may be termed the classical quicksilver metallurgy. Attempts were made to beneficiate low-grade ores by gravity concentration and flotation; mechanical furnaces began to replace the Scott furnace and the vertical coarse-ore furnaces, and condensers of sewer tile and redwood tanks were used in place of the older brick and stone condensing chambers. Other developments that have occurred during the current period of quicksilver activity are mainly in the nature of improvement and further refinement of those started during the war period.

Each period of quicksilver activity has been accompanied by the proposal of various new processes, including wet methods for the treatment of quicksilver ores and innovations in furnaces, retorts and condenser equipment, but there is in fact no real need for any essentially new process for the treatment of quicksilver ores; the direct furnace treatment is simple and inexpensive. Moreover, with rare exceptions, the quicksilver industry has no complex or refractory ore problems corresponding to those which are receiving more and more attention from metallurgists in other branches of the non-ferrous field. Under these conditions improvements in quicksilver metallurgy

must be looked for through the adaptation of current developments in engineering and metallurgy generally to the particular needs of quicksilver practice rather than through the invention of new processes.

Preliminary Treatment.—At Sulphur Bank, in the treatment of old dump material left by the early operators, wet screening is being used as a preliminary step in concentration ahead of flotation. Power shovels and trucks are used to deliver some 400 tons of ore per day to the lower terminal of a hoist, which in turn discharges the material at the top of the screening plant. Wet screening is carried on in two stages. Depending on the character of the material, 1 in. or 2 in. punched screens are used on the first trommel. The oversize from this passes to a picking belt. The undersize is conveyed to twin trommels where two products are usually made. The −3 mm. material, in the form of pulp, passes directly to a storage tank ahead of the flotation plant. The +3 mm. material up to −½ in. or −1 in., depending upon the distribution of values, passes to a storage bin ahead of the ball mill. With heads to the screening plant running approximately 0·1% it has been found possible to recover 75% of the values with a 4 to 1 concentration. This practice is particularly applicable to a condition like that in the old dumps at Sulphur Bank, where the values occur chiefly in the fines and where the cost of delivering the material to the screening plant is low.

At another mine in California hand sorting is employed on a large scale to obtain a furnace grade of ore.

Flotation.—The application of the flotation process to quicksilver ores and to old mercury-bearing dumps has received considerable attention within the past few years. During the early development of the flotation process a number of attempts were made to utilize flotation in quicksilver metallurgy but without notable success. One difficulty appears to have been the low grade of the concentrate produced. A low-grade cinnabar concentrate carrying a large proportion of gangue slime is not only difficult to filter and dry but also presents difficulties in its subsequent treatment for the recovery of the metal. Better results can be obtained nowadays and it may be safely stated that flotation has a definite place in quicksilver metallurgy. In the treatment of ores, cinnabar is the principal mineral to be recovered. In treating old dumps from amalgamation or quicksilver condenser products, finely flowered metallic mercury and synthetic mercuric sulphide are found. All of these substances are readily amenable to flotation.

Generally speaking, cinnabar floats with great readiness and good recoveries can be made from low-grade material. Laboratory tests on several different ores have yielded tailing running from 0·01 to 0·05%. The high-grade of the concentrate is important, as a concentrate of this grade can be retorted easily for the recovery of the metal. Experience with actual mill practice indicates that these laboratory results can be duplicated on a large scale. Aerofloat has been found particularly selective for cinnabar and a small amount of copper sulphate is sometimes helpful. Flotation equipment in which the froth is under close control is essential for the production of a high-grade concentrate. The Kraut cell exemplifies this type of equipment.

The Sulphur Bank operation presented a rather unique flotation problem. The old dump material was not only highly acid but contained considerable elemental sulphur, and there was a large amount of extremely fine slime resulting from the action of the acid on the gangue. The flotation plant equipment includes a Hardinge mill, a Dorr classifier, Minerals Separation Sub A cells, Dorr thickeners and an Oliver filter; also a two-cell Kraut unit for cleaning concentrate. Originally the −3 mm. pulp coming from the screening plant was delivered to a storage tank equipped with a Devereux agitator and thence directly to the classifier. The coarser material from the screening plant was delivered to a bin and thence to the Hardinge mill together with the oversize from the classifier. Later, it was found that better results could be obtained by passing the −3 mm. pulp through the ball mill. Apparently the passage of this pulp through the mill served to polish the cinnabar particles and release adhering gangue slime. The flotation tailing averaged about 0·05%, and with the Kraut cleaning unit a 35 to 50% Hg concentrate was made. With this grade of concentrate, thickening was unnecessary. The cleaner froth was delivered directly to plate filters, which were constructed from old 50-gal. oil drums with filter bottoms.

Part of the sulphur contained in the old dump material showed a marked tendency to float. It was found that this portion of the sulphur could be floated readily with a small amount of kerosene before the cinnabar was conditioned and floated. Some of the remaining sulphur entered the cinnabar concentrate but the greater portion was discharged with the tailing. When elemental sulphur is present its elimination is essential, as a cinnabar concentrate carrying a large proportion of elemental sulphur presents serious difficulties in subsequent treatment. The alternative to milling and retorting is the direct furnace treatment of the ore, which is both simple and inexpensive. The great majority of quicksilver operations are on a moderate scale, say 50 to 100 tons per day. Within this range the first cost of a flotation plant including retorts for treating the concentrate will not differ greatly from that of a furnace plant. Milling has the advantage that the units are relatively mobile and can be moved to a new site when the first operation is at an end. Moreover, milling plant equipment in general has a fair salvage value. On the other hand, even with a mechanical furnace, the loss in moving a furnace plant will be considerable.

For furnace treatment, crushing to 1 to 2 in. is usually sufficient. Thus the power required for crushing is small and the other power requirements for a furnace plant are also low. The over-all cost of furnace operation need not exceed one to two dollars per ton. With milling the power for fine grinding may be a considerable item. Naturally no general rule can be laid down as to the relative merits of the two procedures. With ore running 0·25% Hg direct furnace treatment will give a more favourable economic outcome. The best opportunities for flotation seem to lie in the treatment of relatively large tonnages of lower grade material where fine grinding is not an expensive item and where the costs of mining and transport are low.

Furnace Treatment.—During the last few years, mechanical furnaces, particularly the rotary,

have been widely used. For many years the Scott furnace was the accepted type of fine-ore furnace and in the recent trend toward mechanical furnaces the merits of the Scott furnace have been more or less overlooked. As far as metallurgical results are concerned, the Scott furnace leaves little to be desired. Its fuel requirements are no greater than the rotary and it has the advantages of requiring no power and having no moving parts that require mechanical attention and replacement. Even with dusty ores the Scott furnace produces little dust, whereas the mechanical furnaces, particularly the rotary, are dust makers. It is commonly believed that the construction cost of the Scott furnace is higher than that of the rotary. The cost of a rotary is not so definitely fixed as that of the Scott furnace; the cost can be decreased by using a light-weight shell, omitting an insulating lining between the refractory lining and the shell, and in other ways. This may be an advantage for a short-lived operation but in the long run the economy of such practice is doubtful. With most ores the rotary kiln produces so much dust that special equipment is necessary for cleaning the gases before they enter the condenser system. The cost of the dust-collecting device is properly a part of the rotary kiln cost. The substitution of oil fuel for wood in the Scott furnace makes possible an increase in capacity of at least 25% over the old rating. When all of these factors are considered, there is little difference between the first cost of a Scott furnace and that of a rotary furnace plant. The choice of furnace necessarily depends on many local factors and any general statement on this point is impossible.

Rotary Kiln.—The external dimensions of rotary kilns now in use range from 40 to 70 ft. long and 3 to 5 ft. diameter. The lining is from 4½ to 6½ in. thick, depending on whether or not an insulating layer is placed between the refractory lining and the shell. Monolithic linings have been used with success in a number of cases. The best combination for such a lining is crushed firebrick, 100 mesh firebrick dust, and a quick-hardening Portland cement. In some cases roasted ore from the furnace has been used as the coarse aggregate. This lining is tamped into place behind movable forms. At Sulphur Bank, where the ore is soft, a lining of this type has been in service for two years with only minor repairs. With hard or abrasive ore the life may not exceed 4 to 6 months, but under such conditions a firebrick lining has shown no better life.

The feeding of ore into a rotary kiln of small diameter has been a difficult problem. The so-called "grasshopper" or reciprocating tube feeder has been extensively used. In order to avoid back feeding, it is necessary for this feeder to extend from 6 to 9 ft. within the kiln. At Sulphur Bank, back feeding has been avoided by placing a set of six helical blades just within the feed end of the kiln. This construction is similar to that commonly used in rotary dryer practice.

The inclination of the rotary kiln ranges from 0·5 to 0·75 in. per foot and the speed of rotation is usually from 1 to 2 r.p.m. The time the ore stays in the kiln is about one hour. The capacity of the rotary kiln ranges from 40 to 100 tons per day, depending on its size and the character of the ore. The moisture content of the ore is one of the important factors. At the Opalite plant of the Mercury Mining Syndicate a kiln 4 by 70 ft. is handling 90 to 100 tons of ore per day with a fuel consumption of slightly less than 7 gal. of oil per ton. This ore carries only a small amount of moisture but is particularly refractory because the cinnabar is disseminated through a siliceous sinter. The burning temperature for this ore is considerably higher than for the usual quicksilver ore. The feed for a rotary kiln is usually crushed to 2 in. An excess of fines tends to reduce furnace capacity. The calcine is discharged into a pit, through which the air for combustion passes on its way to the kiln.

At Sulphur Bank an exceptional metallurgical problem was caused by the presence of elemental sulphur in the ore. In the early operations with the Scott furnace at Sulphur Bank, sulphur vapour distilled with the mercury. These two elements united in the condenser, and gave rise to large quantities of mercurial soot. The same difficulty was encountered when a rotary kiln was used with the customary counter-current firing. Sulphur evaporates noticeably at a temperature below its ignition point and with counter-current firing it is inevitable that some sulphur vapour should be released in the upper part of the kiln where the oxygen content of the furnace atmosphere is low and the temperature insufficient for complete combustion. In the current operation at Sulphur Bank this difficulty has been overcome by reversing the method of firing; that is, by feeding the ore and firing at the same end of the kiln. With this practice the temperature throughout the lower half of the kiln is substantially uniform, thus providing a considerable zone in which the combustion of the sulphur vapour may be completed. With approximately 4% oxygen in the furnace atmosphere and a temperature of 650° to 700° C. at the discharge end, no unburned sulphur escapes from the furnace. The SO_2 formed shows no tendency to react with the mercury vapour and with the conditions just described no recombined mercury is found in the condenser product. With this practice the fuel consumption is necessarily increased because of the high temperature at which the furnace gases escape from the kiln; therefore, provision must be made for extra cooling in the condenser system.

The Herreshoff Furnace.—In recent years several Herreshoff furnaces of the familiar McDougall type have been installed for the roasting of quicksilver ores. The multiple-hearth furnace was developed for the roasting of sulphide ores, which ordinarily have a fuel value sufficient to make them nearly, if not entirely, self-roasting. The usual quicksilver ore has practically no fuel value; hence in applying this furnace to the quicksilver field it was necessary to devise a method for supplying heat from an external source. This problem has been successfully worked out, and an account of recent practice in Nevada was summarized in the MAGAZINE for December last.

New Designs of Mechanical Furnaces.—Several innovations in mechanical furnaces as applied to quicksilver metallurgy have been proposed in the last few years and some of them have been tried out in practice. Several of these designs have embodied the idea of a continuous muffle furnace; that is, a furnace in which the ore would be calcined in a closed chamber. The separation of the mercury-bearing gases from the fuel gases greatly simplifies the condenser problem. On the other hand, the indirect transfer of heat to

ore through a separating wall is much less efficient than the direct transfer from a luminous flame and from the incandescent interior of the furnace. Furthermore, the rate of heat transfer is necessarily low. It follows that any apparatus working on the muffle principle will show a relatively high fuel consumption and a small capacity. The designs include externally heated rotary shells and mechanically rabbled furnaces of iron and steel construction resembling the general design of the Hegeler furnace, or consisting of a series of short sections of screw conveyor mounted in a brick chamber.

The Dust Problem.—The dust problem was practically unknown in the quicksilver industry until the advent of the rotary kiln. The rotary, whether in quicksilver or other industrial uses, is generally recognized as a dust maker. Dust production varies widely with the character of the ore, ranging from 0·5% to as much as 5% of the furnace feed in extreme cases, the average being probably between 1 and 2%. The condition of the lining of the rotary has a great part in dust production, cracks and crevices in the lining serving as lifters, which shower the fine ore into the gas stream. Even a small amount of dust in the gas stream entering the condenser system is highly undesirable, as it tends to clog the condenser system and diminish its cooling efficiency. The troublesome job of cleaning the condenser system must be performed more frequently and the mixture of dust or mud with finely flowered mercury is a difficult product to treat for the recovery of the mercury.

In any method of dust collection the object is to remove as much dust as possible at high temperature. Dust so collected is a mixture of roasted and unroasted ore particles. The minimum temperature for collecting a low-grade dust is from 200° to 250° C. This is well above the mercury dew point for most furnace operations but a good margin of safety is necessary on account of local cooling along the walls of the dust-collecting device or through the inward leakage of cold air. If a panning test reveals metallic mercury in the dust it indicates that the temperature in the dust chamber is too low or that some local cooling is taking place.

The first attempts at dust control in connexion with rotary kiln operations were through the use of dust chambers patterned after the familiar masonry chambers used in conjunction with the Scott furnace. These were relatively tall structures of small cross-section and were obviously not well designed from the standpoint of dust collection. A dust chamber is nothing more or less than a settling device. To be at all effective its horizontal dimension should be large in proportion to its height. A dust chamber of this latter type was originally installed at the Opalite plant of the Mercury Mining Syndicate. It consisted of two horizontal chambers each 16 ft. long, 5½ ft. wide and 6 ft. high. The walls were of concrete, 1 ft. thick, to provide good thermal insulation. Several vertical chain curtains were used to break up eddy currents and produce a uniform flow of gas. These two chambers operated in parallel, each handling approximately 1,500 cu. ft. of gas per minute at a temperature of 200° C. to 250° C. The horizontal velocity of the gas stream through these chambers was less than 1 ft. per second, thus allowing over 16 sec. for the settling of dust particles. Theoretically, particles well below 200 mesh size should have come to rest in the dust chamber. Samples of dust actually collected showed that this was the case; nevertheless there remained in the dust stream a sufficient quantity of extremely fine material to give trouble in the condenser system.

The problem was solved by installing a Cottrell electrical precipitator. The kiln handles from 90 to 100 tons of ore per day and the Cottrell collects on the average some 1,250 lb. of dust per day—a recovery of about 93%. Approximately 1 lb. of dust per ton of furnace charge enters the condenser system, and this quantity has not been troublesome.

Water sprays have also been used for knocking down the dust. Mercury vapour is condensed at the same time and the product flowing from the condenser system will be a mercury-bearing mud. In exceptional cases the mercury particles settle rather freely through this mud and a fair separation can be obtained by the use of riffled launders and settling boxes. Tanks with low-speed agitators have also been used. The separation just referred to seems to take place most readily when the dust partakes of the characteristics of clay and forms a colloidal suspension in the water. When the dust has the characteristics of an extremely fine sand rather than of a true slime it tends to settle with the mercury particles and no satisfactory separation can be made by mechanical means. The handling and retreatment of mercurial mud is disagreeable. Loss of mercury is bound to occur and a serious health hazard is involved. Frequently the mud is too low grade to justify retorting, and returning the mud or dust to the kiln tends to build up a heavy circulating load. Treatment of this material by flotation will be described later. Electrical precipitation by the Cottrell process is undoubtedly the most satisfactory solution of this problem.

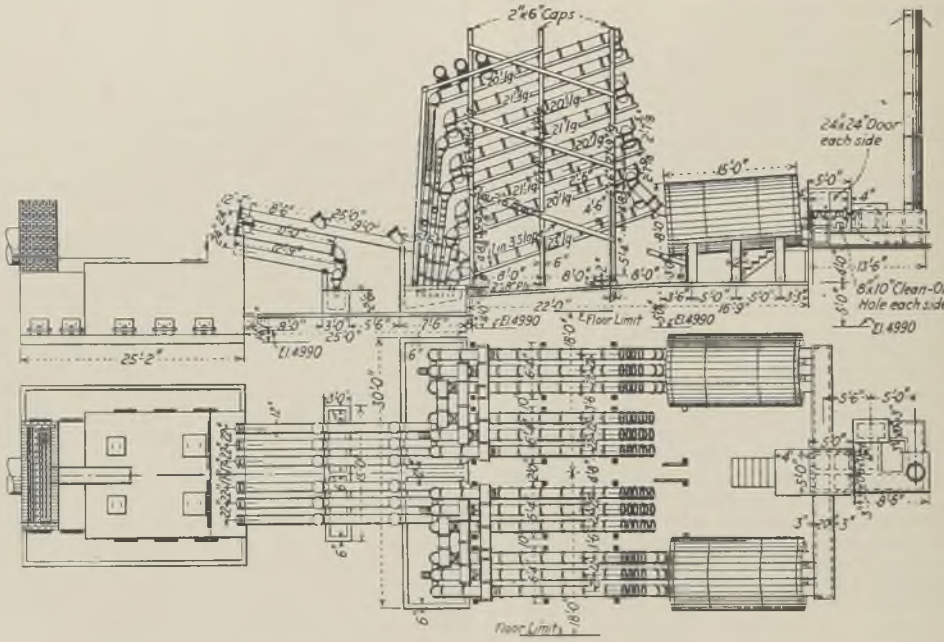
Cyclone Dust Collectors.—Important pioneer work in the development of a suitable design of cyclone for this purpose was carried out at Sulphur Bank. The original design of the Sulphur Bank plant included a Cottrell precipitator or so-called hot treater. When the plant was put in operation it was found that the dust burden was much heavier than had been anticipated. The hot treater stopped a large amount of dust but the clearance was not as good as desired. The alternatives were to increase the hot treater capacity or to use some other auxiliary device, and it was decided to investigate cyclones. The cyclone is essentially a centrifugal device and it seemed clear that a design which provided for a high angular velocity coupled with a relatively short path for the travel of the dust particles should give the best results. This was confirmed by tests with several models. The work led to the design of tall, narrow cyclones with special provision for trapping the collected dust at the bottom of the cone. It was also found that by suitable design the draft loss through the cyclones could be reduced materially.

The cyclone installation at Sulphur Bank consists of 12 tall, narrow cyclones arranged in two sets of 6 each, so that either series or parallel arrangement can be used. Each set of cyclones is preceded by a so-called "precharger," which consists of a small Cottrell treater of the pipe and wire type. In passing through this precharger the dust particles become electrically charged and passed in the charged condition into the cyclones. Agglomeration

also undoubtedly takes place. The net effect of this precharging is a noticeable increase in cyclone efficiency. The cyclones are more effective when operated in series, owing to the higher velocity through the individual cyclones and the double treatment. These cyclones are also remarkably efficient as coolers. As mentioned, the Sulphur Bank kiln is operated with parallel firing, so that the gases leave the kiln at high temperature. The cyclones operated in series cool the gas stream from an inlet temperature of 500° to 550° C. to an outlet temperature of 200° C.

Condenser Practice.—Masonry chambers of brick or stone were almost universally used in connexion with early quicksilver furnace practice in this country. With the advent of the Scott furnace a condenser design consisting of a series of brick chambers became standardized, although

These may be classified under three general heads, namely, (1) pipes slightly inclined from the horizontal; (2) pipes in the form of an inverted V with concrete connecting chambers at the base; (3) pipes in the form of an inverted U with concrete chambers at the base. The horizontal arrangement has the advantage that a large cooling surface can be constructed over a relatively small area, thus making for compact construction and minimizing the danger of mechanical loss of mercury. Pipes in the horizontal position give better opportunity for the circulation of cooling air or the application of water sprays, and, therefore, give a greater cooling effect per unit area. On the other hand, vertical pipes or pipes slightly inclined from the vertical, are more easily cleaned. The choice of design is largely a matter of preference and should be governed by local conditions.



Condenser system at Opalite plant of Mercury Mining Syndicate.

in a few cases cast-iron chambers connected by large cast-iron U-bends were used. In 1917, the U.S. Bureau of Mines in co-operation with certain quicksilver producers conducted an investigation of quicksilver metallurgy and in this connexion an experimental condenser unit constructed of glazed sewer tile was tested. In Europe, condensers of chemical stoneware had been in use for some time. These tests were followed by the construction of a tile condenser at the Oat Hill mine, Napa County, California. Concurrently, condensers of glazed sewer tile and wooden tanks or chambers were constructed at several other plants. Since 1918, condenser practice has developed along the lines of what may be termed a pipe and tank construction. Steel or cast-iron pipe have been employed for the section of the condenser closer to the furnace in the temperature range where little condensation of water occurs; glazed sewer tile and wooden tanks are commonly used for more remote parts of the condenser system.

A variety of arrangements have been used.

There is evidence that there is a certain lag in the condensation of mercury vapour; that is, that an atmosphere supersaturated with mercury vapour may persist for an appreciable time in the condenser system. This is not surprising, in fact, is to be expected, when one considers the extremely small concentration of mercury vapour in the condenser gases. For example, the gas stream leaving a furnace treating ore assaying 0·5% Hg will contain approximately 0·1% mercury vapour by volume. As the mercury vapour condenses, the concentration falls to an extremely small value and it seems inevitable that a certain time factor should be involved in the establishment of equilibrium. From a practical standpoint the existence of this lag points to the need for the inclusion of several large chambers in the condenser design. These chambers, which in practice take the form of wooden tanks, allow time for the supersaturation of mercury vapour to be relieved.

With a well-designed condenser system the loss of mercury from the stack is extremely small,

and is very little more than that corresponding to the normal saturation of the stack gases with mercury vapour. A furnace plant handling 100 tons of ore per day will discharge from 3,000 to 5,000 cu. ft. of stack gas per minute. This corresponds to 6 to 10 tons of gas per hour. The mercury contained in this weight of gas may range from 0·5 to 1 lb. Viewed in this way, the performance of quicksilver condensers is remarkable.

Water Sprays Seldom Desirable.—In a number of plants water sprays have been used for the direct cooling of the mercury-laden gases. It should be noted that the spraying of a stream of hot gases with water actually removes very little heat from the gas stream but merely converts sensible heat into the latent heat of water vapour. The only heat actually removed from the gas stream by the water is that carried away by the portion of the water that does not evaporate. A calculation will show that the actual removal of any large quantity of heat in this way calls for the use of a volume of water which is entirely impractical. There is a fundamental objection to the use of water sprays, namely, the production of finely flowered mercury. As a general principle, the introduction of water to the condenser system should be avoided. When the dust problem is particularly serious, and when in spite of dust-collecting devices a considerable amount of dust passes through to the condenser system, water sprays may be advantageous in knocking down this dust and preventing it from fouling the cooling surfaces. When this practice is following suitable provision must be made for recovering the mercury from the muddy water leaving the condenser system.

Treatment of Condenser Products.—Reference has been made to the use of settling boxes and slow-speed agitators for separating finely divided mercury from condenser mud. Both horizontal tanks fitted with a horizontal shaft and paddles in some ways resembling a log washer, and circular tanks with slow-speed paddle agitators, have been used. Devices of this sort will recover a certain proportion of the mercury in fairly concentrated form but the overflowing mud is usually too high-grade to be discarded. When there is any quantity of mud to be treated, flotation is undoubtedly the best method. At Sulphur Bank a two-cell Kraut unit is used for treating the mud. A mud carrying 5% mercury will yield a 50 to 70% Hg concentrate and a tailing carrying only a few pounds per ton dry weight. Tests have demonstrated that mercury sulphide formed by the recombination of mercury and sulphur in the condenser is as readily floatable as finely divided metallic mercury.

For the final recovery of the mercury from high-grade condenser products or from a flotation concentrate, D retorts still remain standard.

Hydrometallurgical Processes.—It is well known that mercury sulphide is soluble in a dilute solution of sodium sulphide. In 1916, Thornhill described a method for the recovery of mercury from the amalgamation tailing at the Buffalo mines, Cobalt. This was based on the use of sodium sulphide solution as a solvent and metallic aluminium as the precipitant. From time to time attempts have been made to apply this procedure to the treatment of ores, electrolytic precipitation being proposed in some cases in lieu of precipitation by metallic aluminium. To date no practical application of this process has been forthcoming. Tests that were made under the supervision of the author showed that one of the fundamental difficulties is the excessive destruction of the solvent. Sodium sulphide in dilute solution is extremely sensitive to oxidation by atmospheric air and this oxidation is catalyzed in an extraordinary way by the presence of iron oxide. Sodium sulphide in solution reacts readily with limonite or hematite to form ferrous sulphide and the films of ferrous sulphide so formed are rapidly oxidized by dissolved oxygen. Moreover, the reaction between ferric oxide and sodium sulphide results in the destruction of a certain amount of the sodium sulphide, since the iron is reduced to the ferrous condition. As practically all quicksilver ores contain more or less oxidized iron, the difficulty is fundamental.

Several processes based on the use of chlorine or hypochlorite in aqueous solution have been proposed recently. These reagents will act as solvents for mercuric sulphide, but no practical means have been developed for the recovery of mercury from the resulting solution. There are also other drawbacks. In this connexion, it is well to point out again that the direct furnace treatment of quicksilver ores is not only simple and inexpensive but metallurgically efficient. The quicksilver industry presents no general complex ore problem.

Summary.—The direct furnace treatment of quicksilver ores remains the standard practice and when suitable attention is given to the design of the plant leaves little to be desired. The problem of treating a large tonnage of ore below the necessary furnace grade may be solved under favourable conditions by wet screening followed by flotation and the retorting of the concentrate. There is a very apparent need for economical methods for use during the development of a property or where operations are necessarily on a small scale. Hand sorting and retorting have been the chief reliance in this connexion. However, this practice is successful only where a relatively high-grade product, say 5 to 10% Hg, can be economically produced by sorting. When this is not possible a small furnace plant or a small flotation plant and battery of retorts offer the best solution.

Chromium.—In Part I of the "Mineral Resources of the United States, 1928," Department of Commerce, Lewis A. Smith shows that rapid expansion in the consumption of chromium, begun in 1922, has continued in recent years, and present indications point to a further increase in consumption. The most noteworthy recent developments include the extensive adoption of chromium plating, especially for automobile parts; the increased utilization of rustless iron and steel and nickel-chromium steel; and the further substitution of chromite refractories for magnesite refractories, owing to a favourable price. The tanning industry appears to be turning more and more toward chromium reagents, and the demand for chromium pigments seems to have been maintained.

The estimated world production of chromite in 1928 was about 449,000 metric tons, an increase of 41,000 tons over 1927. The production in Rhodesia increased slightly to 199,060 metric tons in 1928 and was about 44% of the estimated world output. The exports from New Caledonia in 1928, were 56,698 metric tons, compared with 42,885

tons in 1927. Practically all Cuban production is shipped to the United States; imports from Cuba into the United States amounted to 34,248 metric tons in 1928, compared with 17,256 tons in 1927. Production in Greece in 1928 is reported as 20,953 metric tons, but imports into the United States from Greece, which usually account for a large part of the actual Grecian output, decreased 24% in 1928. The Union of South Africa produced 31,756 metric tons in 1928. Brazil, India (British), Japan, Russia, Turkey, the United States, and Yugoslavia also contributed to the world total; the figures for three of these countries are not yet available.

From a world-wide view of the chromite situation, considering past production, consumption, prices, potential production, and producing capacity, the deposits of Rhodesia, India, Union of South Africa, Turkey, Greece, and New Caledonia appear capable of supplying the world demand with ease for many years.

Copper, Lead and Zinc Mining Production in the United States.—Figures showing the smelter and refinery output of copper, lead and zinc in the United States in 1929 have been issued recently by the United States Bureau of Mines. The smelter production of copper from domestic ores in 1929 was 1,015,000 short tons and the refinery production of new copper from domestic and foreign sources was 1,386,000 tons. The output of primary refined lead from domestic sources in 1929 was 689,000 short tons and from domestic and foreign sources 792,000 tons. The smelter output of primary zinc from domestic ores in 1929 was 610,700 short tons and from domestic and foreign ores, 624,000 tons. All figures shown in the following résumé and table are of estimated recoverable metal output of the mines and should not be confused with figures of smelter and refinery production.

The output of recoverable copper by the mines in the United States in 1929 was about 995,900 short tons as compared with an output of 904,898 tons in 1928, an increase of about 10%. The mine production in 1929 was only 7,000 tons below the record production of 1916 and is second only to the output of that year. There were increases in all of the important copper-producing States with the exception of Nevada where production decreased from 79,438 tons to 66,000 tons, and Alaska where a small decrease was noted. Arizona, the most important State, had an estimated production of 416,800 short tons, compared with 366,138 tons in 1928. Utah's production was 160,100 tons compared with 146,618 tons in 1928 and Montana's 149,300 tons, compared with 124,131 tons in 1928.

The recoverable lead contained in ore mined in the United States in 1929, exclusive of Virginia, was about 647,500 short tons, as compared with an output of 627,153 tons in 1928, an increase of 3%. The largest output came from the South-eastern Missouri district and amounted to 201,700 tons, compared with 194,270 tons in 1928. The race between Idaho and Utah for second place has been very close for the past two years but Idaho definitely lead Utah in 1929 with 152,100 tons compared with 143,400 tons. In 1928 these States produced 145,323 tons and 145,915 tons with Utah slightly in the lead. The output of the Joplin district increased from 70,086 tons to 73,500 tons in 1929 and the production of all other important lead-producing States, with the exception of Colorado, increased. Colorado's production dropped from 26,751 tons to 24,900 tons. The price at Joplin of lead concentrates was $85 a ton at the beginning of the year, rose to $105 a ton for the weeks of March 23 and March 30, from which it declined to $85 a ton for the weeks of July 13 to August 31, inclusive, rose again to $87·50 a ton for the weeks of September 7 to October 26, inclusive, and then declined to $75 a ton, the lowest figure for the year, which held during the last eight weeks of the year.

The recoverable zinc contained in ore mined in the United States in 1929 was about 731,300 tons, as compared with 695,170 tons in 1928, an increase of 5%. The mine production of zinc in 1929 is the largest on record with the exception of the production of 774,563 tons in 1916. The output of the Eastern States was about 153,100 tons, an increase of 6% over production in 1928, of the Central States about 321,000 tons, and of the Western States about 257,200 tons. These figures compare with 144,045 tons for the Eastern States in 1928, 319,089 tons for the Central States and 232,036 tons for the Western States. Production in the Joplin district increased from 297,020 tons in 1928 to 299,600 tons in 1929, approximately 1%. In all of the Western States except Colorado production was larger in 1929 than in 1928, the increase amounting to 59% in Idaho. Colorado recorded a decrease of 17% in 1929. The price at Joplin of zinc concentrates was $40 a ton from the week ending May 19, 1928 to the week ending February 9, 1929. The price rose to $44 a ton for the weeks of March 30 to October 26, inclusive, then declined to close the year with an average of $36·56 for December.

The accompanying table gives the estimated mine production of copper, lead and zinc in the United States in 1929, in terms of the recovered and recoverable metal content, in short tons:—

District.	*Copper.* 1929.	*Lead.* 1929.	*Zinc.* 1929.
Eastern States	16,600	—	153,100
Central States—			
Tri-State District	—	73,500	299,600
S.-Eastern Missouri	—	201,700	3,700
Upper Mississippi Valley	—	1,600	17,700
Michigan	92,500	—	—
Other	—	800	9
	92,500	277,600	321,000
Western States—			
Arizona	416,800	7,800	1,200
California	16,600	600	25
Colorado	4,200	24,900	29,700
Idaho	2,400	152,100	49,600
Montana	149,300	19,800	84,800
Nevada	66,000	8,200	7,000
New Mexico	50,000	11,000	34,000
Oregon	400	13	—
South Dakota	—	—	—
Texas	200	500	—
Utah	160,100	143,400	50,200
Washington	600	400	700
Wyoming	—	—	—
	866,600	368,700	257,200
Alaska	20,200	1,200	—
Total	995,900	647,500	731,300

Centrifugal Concentration.—An investigation of the centrifugal concentration of certain types of ores, especially the application of the process to the treatment of the slime portion of tailings from mills that use gravity-concentration methods, has been conducted at the Rare and Precious Metals Experiment Station of the United States Bureau of Mines, Department of Commerce, Reno, Nevada, in co-operation with the University of Nevada. A centrifugal bowl designed by H. A. Doerner, of the Bureau of Mines, gave encouraging results in preliminary tests on slime tailings from a mill concentrating a scheelite ore.

In Technical Paper 457, Mr. Doerner states that to construct and operate a centrifugal concentrator which will develop much more powerful centrifugal force than that used in the Bureau of Mines tests is entirely feasible. The present machine concentrates and recovers particles that are too small to be saved by gravity machines, and there is no reason to doubt that a larger and more powerful centrifuge will effectively concentrate particles in a still lower range of sizes. The practical limit still remains to be determined.

The present work does not begin to exhaust the possibilities of centrifugal concentration. Gravity concentration requires a sized or classified feed for maximum results. The same is true for centrifugal concentration; but sizing of slimes is out of the question, and gravity classification is not effective in the lower range of sizes. Centrifugal classification, however, is possible and will be necessary to realize the full potentialities of centrifugal concentration. By the use of more counter-current water or less speed of rotation with the same water the centrifugal jig described in the Technical Paper will operate as a classifier.

Jigs are primarily adapted to handling a coarse, sized feed. "Surface concentrators," such as tables and vanners, are much more effective on fine, classified feed. It is therefore probable that a centrifuge employing surface concentration would concentrate slimes better than the present jig type of centrifuge. The Bureau of Mines has recently constructed a centrifugal bowl that employs surface concentration in a manner exactly like that of an advanced type of slime table. Preliminary tests have given encouraging results.

There seems to be nothing to prevent the development of many types of centrifugal concentrators corresponding to the various gravity machines, such as jigs, tables, and classifiers. Although concentration of slime is the most promising field, the centrifuge will also concentrate fine sands. Any competition with gravity machines in the latter field must be based upon capacity rather than recoveries or grade of product.

Testing a centrifugal concentrator involves unusual difficulties because it is not possible adequately to observe the concentrating action. The reason for any result must be deduced from theoretical considerations. Large machines are expensive, and their construction must be justified by results obtained in small experimental units. It is difficult, if not impossible, to obtain as good results in a small machine as in a large one, and it is hard to devise satisfactory details of design and operation for a small unit; therefore progress has been slow and failures frequent.

The Bureau of Mines believes that centrifugal concentration should be tested in the following fields:—

(1) Concentration of heavy minerals from the slime tailings or re-ground middlings of mills using gravity concentration.

(2) Elimination of colloids from a crushed ore as a preliminary to flotation or leaching operations. The presence of excessive colloids in a milled ore may cause difficulties in, and greatly reduce the capacity of, plants using flotation or leaching operations. By passing the slime portion of such an ore through a centrifugal concentrator it may be possible to eliminate the colloids with only a small loss of valuable mineral and to obtain a colloid-free concentrate much richer and of smaller bulk than the original slime. In a problem of this type the centrifuge should be adjusted to give a low ratio of concentration, thereby obtaining the maximum recovery. The increase in plant capacity obtainable by such elimination of slime is worthy of considerable study.

(3) Treatment of ores that slime badly. There are many known deposits of ore that are not amenable to flotation and that slime so badly when milled that gravity concentration will not obtain recoveries large enough for profitable operation. In many instances centrifugal concentration of the slimes may add enough to the recoveries to allow a profit.

(4) Centrifugal concentration of slimes from the tailing dumps of gravity concentration mills.

(5) Cleaning and dewatering of flotation concentrates and possibly the separation of lead and zinc from flotation concentrates.

(6) Recovery of flour gold, tellurides, and amalgam from the tailings of amalgamation mills.

Statistics of Lead Production.—In Economic Paper 5 of the United States Bureau of Mines, Department of Commerce, Lewis A. Smith and the Staff of the Common Metals Division of the Bureau deal with the production of lead since 1800. In commenting on the data contained in this review, Scott Turner, Director of the Bureau, says that world production of lead during the 127 years since the beginning of the nineteenth century has amounted to more than 58,000,000 short tons. It has been estimated that from the beginning of man's utilization of lead probably no more than 5,000,000 tons had been mined prior to 1800. Compared with the first decade of the nineteenth century, world production of lead for the first decade of the twentieth century increased forty-fivefold. During the 90 years from 1821 to 1910 there was an average increase in the rate of production of more than 51% per decade. Only during the period 1912–1921 was the acceleration of world production interrupted; subsequently the rate of production recovered to what might have been expected from the pre-war trend. Since 1800 the United States has produced nearly 17,400,000 short tons of lead, or nearly 30% of the world's output. By far the larger part of American production has been obtained in the last 50 years, the rate of increase of the United States output during this period having been much faster than that of the world.

The past 127 years have witnessed a geographical shift in the production of this metal. During the first half of the nineteenth century Europe contributed 88⅓% of the world's output and North America 11⅓%. During the next 50 years Europe produced 70⅔% of the world total, North America more than 25⅓%, Australia 3⅓%, and Asia less than ⅓%. During the first 25 years of the present

century North America produced 47½% of the world's output of lead, Europe about 39⅕%, Australasia 9⅗%, Asia 2½%, Africa nearly 1%, and South America the remaining ⅓%. During 1926 and 1927 North America produced 58⅜% of the world's total, Europe 25⅓%, Australasia 9⅔%, Asia 4½%, and South America and Africa each about 1%. The diminishing importance of Europe and the increasing importance of the other continents as lead producers constitute the most striking change in lead production during the last 35 or 40 years.

During the first decade of the nineteenth century the average annual world production of lead was estimated at 24,100 tons. Great Britain produced 41%, Germany and Spain 21% each, Austria 8%, the United States 4%, and Russia, France, and Belgium smaller amounts. At the close of the century the production had increased thirty-sevenfold and approximated 900,000 tons. Important changes in sources of production had taken place. The rapid increase in the United States placed it in the first place by 1881. The production of Great Britain, which had dominated the world during the first seven decades of the century, declined rapidly and at the close of the century was less than 6% of the world total. The production of Spain and Germany had kept pace with the expanding world production, and Mexico and Australia had become important producers.

In the first quarter of the twentieth century nearly 30,000,000 tons of lead was produced, double the output of the preceding quarter century and 20% greater than the entire output of the nineteenth century. As a result of large increases in production, the United States acquired a more commanding position.

In 1926 and 1927 world production exceeded all previous records, averaging 1,847,745 tons per year. A more widespread distribution of production outside of the United States was attained during the period.

The increase in the production of lead from 1801 to 1925 averaged 140% per quarter century. Such a rate if maintained would indicate a production of 71,000,000 tons for the period 1926 to 1950 and a total of 649,000,000 tons for the twentieth century, contrasted with 25,000,000 for the nineteenth century.

The United States may be expected to maintain present production for some years to come, although its proportion to the total world output may decrease as a result of increased production elsewhere. Mexico undoubtedly has large undeveloped resources that will sustain an enlarged future production. The productive areas of Australia apparently have a limited life, and unless new deposits are found decreases may be expected. Spain has not as yet attained the pre-war rate of production, and future increases are not to be expected. Canada will no doubt produce increasing amounts of lead in the future, as will Germany upon further development of the upper Silesian fields. South America is also believed to have possibilities as a future source of lead, but Belgium is not expected to increase production to any great extent.

Flow of Gases Through Beds of Broken Solids.—Although a number of the most important industrial processes depend upon efficient contact between a bed of broken solids and a stream of moving gas or vapour, up to the present time very little work has been done on the laws that govern the flow of fluids through such beds.

The North Central Experiment Station of the United States Bureau of Mines, Minneapolis, has undertaken a laboratory study of blast-furnace phenomena with the intention of eventually formulating a more or less complete quantitative theory of the physical and chemical reactions within the furnace. The first phase of this work has been the laboratory study of the flow of gases through beds of broken solids. In so far as possible the results of the work have been formulated into general laws, but special attention has been paid to the particular materials entering into the blast-furnace processes. The data so far obtained from this study have been published in Bulletin 307 by C. C. Furnas.

The data are to be correlated in a later publication with data obtained for gas flow in commercial furnaces, thus affording a means of intelligently criticizing present blast-furnace practice and of suggesting and criticizing innovations.

SHORT NOTICES

Mining Low-grade Copper Ore.—In Technical Publication No. 314 of the American Institute of Mining and Metallurgical Engineers, F. W. Maclennan describes the method of mining a low-grade ore-body adopted by the Miami Copper Company.

Mining in Steep Stopes.—The *South African Mining and Engineering Journal* for January 25 contains an article on modified mining methods, which offers suggestions for a method of modified shrinkage stoping adaptable to steeply inclined workings.

The Hawkesworth Detachable Bit.—L. Berrien describes the development and installation of this bit in Technical Publication No. 274 of the American Institute of Mining and Metallurgical Engineers.

Subsidences at Rio Tinto.—Technical Publication No. 271 of the American Institute of Mining and Metallurgical Engineers contains a paper by R. E. Palmer on " Observation on Ground Movement and Subsidences at Rio Tinto Mines, Spain."

Compressed Air.—The use and cost of compressed air are discussed by R. S. Lewis in Technical Publication No. 287 of the American Institute of Mining and Metallurgical Engineers.

The Noranda Concentrator.—The *Bulletin* of the Canadian Institute of Mining and Metallurgy for February contains an article by C. G. McLachlan on twelve months' milling at Noranda.

Lead Refining.—Lead-refining practice at the Bunker Hill smelter is described by Alfred F. Beasley in Technical Publication No. 303 of the American Institute of Mining and Metallurgical Engineers.

Tantalum.—G. W. Sears treats of the progress in the production and use of tantalum in Technical Publication No. 279 of the American Institute of Mining and Metallurgical Engineers.

Flotation.—Chemical reactions in flotation processes are dealt with by A. F. Taggart, T. C. Taylor, and A. F. Knoll in Technical Publication No. 312 of the American Institute of Mining and Metallurgical Engineers.

Photo-Electro Metallurgy.—R. W. Drier describes a new method of separating minerals, metals, and metallurgical products in *Industrial and Engineering Chemistry* for February.

Classifier Efficiency.—Technical Publication No. 275 of the American Institute of Mining and Metallurgical Engineers contains the results of an experimental study of classifier efficiency by A. W. Fahrenwald.

Conductivity of Asbestos.—Relative heat conductivities of asbestos have been studied by H. W. Gartrell and the results of this research are contained in the Mining Review of the South Australian Department of Mines for the half-year ended June 30 last.

Lead Assay.—A rapid volumetric method for the determination of lead in alloys containing lead, tin, and antimony, and the use of a new end point indicator, are described by R. C. Wiley in *Industrial and Engineering Chemistry* for January 15.

Laterite.—J. B. Scrivenor discusses the definition and use of the term "laterite" in the *Malayan Agricultural Journal* for December last.

Magnesite in Canada.—The Canadian Magnesite Industry is reviewed by F. E. Lathe in an article appearing in *Industrial Canada.*

East African Geology.—The geology of the Lower Shire-Zambesi area forms the subject of an article by F. Dixey, which appears in the *Geological Magazine* for February.

Engels Copper Deposits, California.—A. Knopf and C. A. Anderson discuss the problem of the genesis of the Engels copper deposits of Plumas County, California, in *Economic Geology* for January.

Chihuahua, Mexico.—Technical Publication No. 304 of the American Institute of Mining and Metallurgical Engineers contains an account of the geology of the Parral Area of the Parral District by H. Schmitt.

Iron-ore in Venezuela.—The Pao deposits of iron-ore in the State of Bolivar, Venezuela, are described by E. F. Burchard in Technical Publication No. 295 of the American Institute of Mining and Metallurgical Engineers.

Sand Specifications.—The classification and specifications of siliceous sands are dealt with by Ralph Tuck in *Economic Geology* for January.

Gas Bubbles in Capillary Spaces.—I. I. Gardescu examines the behaviour of gas bubbles in capillary spaces in Technical Publication No. 306 of the American Institute of Mining and Metallurgical Engineers.

Steam-Nozzles.—The Institution of Mechanical Engineers has issued the sixth report of the Steam-Nozzles Research Committee.

RECENT PATENTS PUBLISHED

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

18,129 of 1928 (292,611). Société Anonyme des Manufactures des Glaces et Produits Chimiques de St.-Gobain, Chauny et Cirey, Paris. Artificial crystalline abrasives having a base of alumina are manufactured by heating a mixture of ground bauxite, with a small proportion of fluorides or fluo-silicates of alkalies or alkaline earths, to a temperature of about 1,300–1,350° C. without, fusing.

19,431 of 1928 (323,765). B. Leech and F. Hammond, Macclesfield. Binary alloys are produced by electrolytic deposition from solutions containing two depositable components. It is found that through certain small ranges of variation of the solution components, which may be called critical ranges, alloys of certain definite proportions are deposited. The method particularly applies to alloys of iron and nickel.

22,616 of 1928 (323,718). N. V. Philips' Gloeilampenfabrieken, Holland. Metals of the zirconium group of the periodic classification table are used for the reduction of alkali and alkaline-earth metal compounds. An excess of one of the reducing metals is heated in a vacuum or in an inert gas together with one or more of the particular compounds, when reduction takes place.

23,249 of 1928 (303,347). Société Alsacienne de Produits Chimiques, Paris. Partially dehydrated copper hydroxides, whose composition can be controlled and stabilized, are found to be an improvement on the usual copper-hydroxide catalyst employed for de-hydrogenation processes.

23,832 of 1928 (323,021) and **35,329 of 1928 (323,332).** I. G. Farbenindustrie A.-G., Frankfort-on-Main. Material from which a carbonyl is to be obtained is mixed before treatment with a substance which prevents sintering, whereby the activity of the metal towards carbon monoxide is increased and lower temperatures can be used with increased efficiency. It is also found that the process can be carried out effectively by suspending the reaction material in a paste or melt, using, for example, paraffin oil or molten paraffin wax as suspension media.

24,848 of 1928 (323,466). G. Bürg. Charlottenburg. A process for the preparatory treatment of ores containing precious metals in a very finely divided form, whereby the metal is coagulated and remains in the raw material in such a form as to be amenable to further treatment for recovery.

29,358 of 1928 (309,476). Balz-Erzrostung G. m. b. H., Gleiwitz, Germany. A modification of a process for the roasting of zinc-blende (Pat. No. 303,055) in which roasting air is withdrawn by means of a fan from one part of the kiln and reintroduced into other parts of the kiln.

579 of 1929 (323,919). I. G. Farbenindustrie A.-G., Frankfort-on-Main. The production of pure-sulphur from solutions of ammonium polysulphides.

17,290 of 1929 (321,919). H. D. Elkington, London. Sulphur is removed from gases containing sulphur vapour by causing the vapours to come in contact with solid condensing elements which are maintained at temperatures which allow the condensed sulphur to flow off in a liquid condition.

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.

An Outline of Metallurgical Practice.—By Carle R. Hayward. Cloth, octavo, 612 pages, illustrated. Price 30s. London: The Library Press.

Theorie der Erdbebenwellen; Beobachtungen; Bodenunruhe. Handbuch der Geophysik, Band IV, Lieferung 1. By B. Gutenberg. Paper covers, 298 pages, illustrated. Price to subscribers 22 M.; copy 30 M. Berlin: Gebrüder Borntraeger.

Gmelins Handbuch der anorganischen Chemie: Eisen. Teil B, Lieferung 2, pp. 313–512. Paper covers, illustrated. Price 32 marks; to subscribers 25 marks. Berlin: Verlag Chemie.

Miners Welfare Fund. Committee Reports 1929. Paper covers, 73 pages, illustrated. Price 1s. 6d. London: H.M. Stationery Office.

Reports and Papers relating to Research with Coal Dust, Firedamp and other sources of Danger in Coal Mines. Publications of the Safety in Mines Research Board, Vol. IV, 1928. Price 2d. London: H.M. Stationery Office.

Mine Rescue Apparatus: The S.M.R.B. Gas Mask. By S. H. KATZ and C. S. W. GRICE. Paper covers, 37 pages, illustrated. Price 9d. Safety in Mines Research Board Paper No. 57. London: H.M. Stationery Office.

British Columbia: Report on the Taku River Area, Atlin Mining Division, North-Western Mineral Survey District. By J. T. MANDY. Paper covers, 22 pages, illustrated. British Columbia Department of Mines Bulletin No. 1, 1930, Victoria, B.C.

South Australia: Mining Review for the half-year ended June 30, 1929. No. 50. Paper covers, 105 pages, illustrated. Adelaide: Department of Mines.

Kalgoorlie. Geology and Ore Deposits of the Boulder Belt, Kalgoorlie. By Dr. F. L. STILLWELL. Paper covers, 110 pages, illustrated. Bulletin No. 94 of the Geological Survey of Western Australia.

Summarized Data of Lead Production. By LEWIS A. SMITH and others. Paper covers, 44 pages, illustrated. Price 15 cents. Economic Paper 5, United States Bureau of Mines, Washington.

Manganese and Manganiferous Ores in 1928. By LEWIS A. SMITH. Mineral Resources of the United States, 1928—Part I (pp. 205–259). Price 10 cents. Washington: Bureau of Mines.

Silver, Copper, Lead and Zinc in Central States in 1928. Mine Report. By J. P. DUNLOP and H. M. MEYER. Mineral Resources of the United States 1928—Part I (pp. 169–203). Price 10 cents. Washington: Bureau of Mines.

Gypsum in 1928. By R. M. SANTMYERS and J. MIDDLETON. Mineral Resources of the United States, 1928. Part II (pp. 155–174). Price 5 cents. Washington: Bureau of Mines.

Quin's Metal Handbook and Statistics, 1930. Compiled by L. H. QUIN. Cloth, pocket size, 284 pages. Price 5s. London: The Metal Information Bureau.

COMPANY REPORTS

Penawat (Malaya) Tin Dredging.—This company was formed in 1927 to work alluvial tin property in the Kinta District, State of Perak, F.M.S. The report for the year ended August 31 last shows that No. 1 dredge was completed on May 17 and No. 2 on July 15. During the period under review No. 1 dredge treated 208,303 cu. yd. of ground and recovered 33 tons of tin concentrates, while No. 2 dredge treated 83,000 cu. yd. to recover 17·6 tons. The concentrates realized $65,500 which has been credited to development account.

Lower Bisichi (Nigeria) Tin Mines.—This company was formed in 1912 to acquire alluvial tin property in Northern Nigeria and further areas were acquired in 1919. The report for the year ended September 30 last shows that 76 tons of tin concentrates was recovered during the year as compared with 67¼ tons the year before. Of the 76 tons, 51¼ tons came from the Lower Bisichi areas and 24¾ tons from the Rudos areas. The year's working resulted in a profit of £1,373, which was carried forward. Negotiations are in progress for the acquisition, in conjunction with another company, of a mining lease of 58·54 acres and of an exclusive prospecting licence over 4,523 sq. miles in the Mada District.

DIVIDENDS DECLARED

Amalgamated Zinc.—4%, payable April 10.

Anglo-American Corporation.—2s. 3d., less tax, payable February 27.

Balaghat Gold Mines.—Pref. and Ord., 6d., less tax, payable March 27.

Champion Reef.—1s. 3d. less tax, payable March 15.

Consolidated Mines Selection.—2s., less tax.

Kinta Kellas Tin Dredging.—3d., less tax, payable March 5.

Kramat Pulai.—1s., less tax, payable March 13.

Malayan Tin Dredging.—6d., less tax, payable March 14.

Mysore Gold.—1s., less tax, payable March 29.

North Broken Hill.—2s. 6d., payable March 31.

Nundydroog.—1s. 9d., less tax, payable April 3.

Rawang Concessions.—1s., payable March 28.

Renong Tin Dredging.—1s. 6d., payable February 24.

St. John del Rey.—1s. 6d., less tax, payable May 2.

South African Gold Trust.—2s., less tax, payable March 27.

Southern Malayan Tin Dredging.—4½d., less tax, payable March 14.

Southern Perak Dredging.—6d., less tax, payable March 13.

Temoh Tin Dredging.—1s., less tax, payable March 25.

Wankie Colliery.—1s., less tax, payable March 11.

Witbank Colliery.—6d., payable April 3.

NEW COMPANIES REGISTERED

Barima Barama Goldfields.—Registered as a private company February 21. Nominal Capital: £60,000 in 100,000 "A" shares of 5s. each and 140,000 "B" shares of 5s. each. Objects: To search for, mine, and deal with minerals or other natural products in British Guiana or elsewhere.

British American Mines.—Registered as a private company February 11. Nominal Capital: £100,000 in £1 shares. Objects: To investigate and explore and finance the investigation and exploration by others of mining properties and propositions of all descriptions, including properties or territories containing mineral or other oils; to investigate and compile statistics and finance the investigation and compilation of statistics by others with regard to the stocks, shares and securities of mining and oil companies whether quoted on the London, New York, or any other Stock Exchange or not, and to join or co-operate with others in New York or elsewhere in so doing; to carry on all kinds of exploration business, etc. Directors: W. Broadbridge and P. K. Horner. Office: 62 London Wall, E.C. 2.

South Tigon Mining.—Registered February 26. Nominal Capital: £200,000 in 5s. shares. Objects: To acquire and turn to account mineral or other product-bearing properties in any part of the world. Directors: P. R. Hughes and F. T. Cottell.

COMPANY MEETINGS AND REPORTS SECTION

SOUTH AFRICAN GOLD TRUST, LTD.

Directors: E. Birkenruth (*Chairman*), O. V. G. Hoare, Sir Godfrey Lagden, H. C. Porter, James Prinsep. *Secretary:* W. R. Francklin. *Office:* 49, Moorgate, London, E.C. 2. *Formed* 1894. *Capital:* £1,000,000.

Business: Finance of and investment in mining and other companies in various parts of the world.

The ordinary general meeting of the South African Gold Trust, Ltd., was held on March 13, 1930, at River Plate House, London, E.C., Mr. E. Birkenruth (Chairman of the company) presiding.

The Secretary (Mr. W. R. Francklin) having read the notice convening the meeting and the report of the auditors,

The Chairman said: Gentlemen, before proceeding to the business before us to-day I feel sure you will wish to associate yourselves with the expression of regret with which the Directors received the resignation from the Board of the late Chairman, Lord Harris, at the end of last year. My colleagues have elected me as their Chairman and I need hardly assure you that my best services will be given to this Company of which I have been a director for many years during which I have been in daily touch with its affairs. I think we may consider ourselves fortunate that in spite of troublous times our revenue from the operating Company places us in a position to-day to recommend the same final dividend as last year. This satisfactory result is mainly due to certain profitable realizations to which I shall presently refer and if I may assume that it is your pleasure to take the Directors' report and accounts as read I will proceed to the accounts and compare them with those of the previous year.

Taking the accounts of the New Gold Trust, which as you are aware is the operating Company, first, the profit and loss account shows that the gross profit amounted to £186,290 8s. 3d. as against £192,556 0s. 9d. last year. Deducting therefrom the Directors' fees and commission on profits which remain the same as last year, and Office Management £7,902 19s. 4d. (against £7,761 3s. last year) this leaves a balance of £173,369 11s. 11d. against £179,777 0s. 9d. last year. Depreciation amounted to £33,156 8s. 6d. and the interim dividend of 2½% absorbed £25,000. Income Tax amounted to £22,486 1s. 2d. against £5,476 17s. 5d. last year the increase being due to the incidence of taxation in that the profits of 1928 largely exceeded the profits of 1927 and became payable in the year under review. Adding to the balance of £173,369 11s. 11d. the balance brought forward from last year, namely, £3,555 7s. 4d. there remains an available balance of £96,282 9s. 7d. compared with £103,555 7s. 4d. last year. After allocating £25,000 to reserve a final dividend of 5½% has been declared which leaves £16,282 9s. 7d. to carry forward to next year and places the old Company in a position to recommend the final dividend to which I shall presently refer. Profits from dividends were £78,102 as against £93,146 in the previous year whilst profits from sales were £113,066 as against £108,196. The reduced amount derived from dividends is largely due to the lower dividend received from the Sub Nigel Company—but the recent favourable mine developments give hope for improved results from that source in the near future. As regards the amount written off for depreciation of investments we have considered it prudent in these times to make a somewhat drastic revision of our assets with the result that we have written off the amount referred to and I am pleased to say that after this weeding-out our total assets show a satisfactory appreciation at to-day's prices. Turning to the Balance Sheet Capital authorized and issued is unchanged. The larger debit to sundry creditors £94,875 9s. 4d. against £69,330 3s. 6d. last year is accounted for by the increased amount of income tax due. Contingent Liabilities are £97,439 4s. against £85,168 14s. last year the difference representing the balance between new commitments and the maturing of liabilities. Per contra the figure at which our investments stand is £970,416 1s. 5d. against £1,035,873 8s. 8d. showing a decrease whilst on the other hand Loans at Short Call and on Fixed Deposit are up from £17,325 14s. 10d. to £165,475 7s. 7d. of which £162,000 on Fixed Deposit represents the proceeds of sales to which I shall presently refer, which have been placed on deposit for the time being. Advances and Loans £48,810 0s. 2d. against £53,087 16s. 3d., Sundry Debtors £31,845 19s. 4d. against £37,977 11s. last year and Cash at Bankers call for no special comment. Turning to the accounts of the old Company whose meeting we are holding to-day and taking the balance sheet first the issued capital remains the same and the reserve of £50,000 is intact. The preference dividend is practically the same as last year. The credit side shows our holding in New Gold Trust, the dividend and the loans at short call to that Company and Cash at Bankers. The profit and loss account shows that after taking credit for the balance at December 31, 1928, of £22,292 13s. 11d. and adding thereto £2,470 4s. 4d. being interest on loans plus the dividends from New Gold Trust £80,000 and deducting therefrom the Preference dividend amounting to £25,785 and the interim dividend of £21,487 10s. paid in August there is a balance of £57,490 8s. 3d. carried to the Balance Sheet and available for a final dividend on the Ordinary

shares. As you know we recommend you to take a final dividend of 10% or 2s. per share less tax at 3s. 1.67d. in the £ making together with the interim dividend paid 15% for the year absorbing £42,152 1s. 8d. and leaving to be carried forward £15,338 6s. 7d. as against £22,292 13s. 11d. last year. May I make it quite clear at this stage that although there are reasons often explained for carrying on our two companies as separate entities the fact that this Company owns all the shares in the New Gold Trust obviously denotes common ownership of assets and that therefore the fluctuation in the carry forward is unimportant so long as the combined carry forward of both companies is satisfactory. It will thus be seen that the combined carry forward in December, 1928, was £25,848 1s. 3d. whilst in the year under review it was £31,620 16s. 2d. and that the decrease in this Company's carry forward just referred to is thus of no consequence. The same remark I may say applies to the reserve. The combined reserve of the two companies at December, 1928, was £100,000 whilst it now stands at £125,000. A list of the Company's principal investments has as you are aware been included in the report and as you will see on comparing the same with the list given by the Chairman at last year's meeting of shareholders there has been no material change in the bulk of our assets. It will however be obvious to you that until such time as our stable revenue may enable us to pay you a dividend that will be satisfactory to you it must be our endeavour to supplement our present income by profitable dealings and we were fortunate in being able to make certain profitable realizations including our holding in the American Potash and Chemical Corporation in the earlier part of the year which not only obviated the necessity of making further realizations during the recent market depression but places us in the position to make re-investments under more favourable conditions. We have availed ourselves of that position to some extent notably by acquiring a substantial interest in the Consolidated Main Reef Gold Mining Company and also by increasing our holding in the Lake View and Star Company and Amalgamated Mining Trust Ltd. but as you will have noted we still have a considerable amount of liquid capital at our disposal which we hope to employ usefully during the current year.

Turning now to the list of our principal investments, I will deal in detail with the more important items but shall be glad to answer any questions to the best of my ability.

The Amalgamated Mining Trust, in which we retain a substantial holding paid an interim dividend of 1s. per share in October last and as that Company's financial year has not yet ended I am unable to-day to forecast the final result of its operations.

Apex (Trinidad) Oilfields paid dividends during its financial year which ended in September, 1929, of 52½%. At the last meeting of shareholders the Chairman stated that there was every prospect of the output for the current year being not less than for the previous year and he confirmed his views expressed three years ago regarding the probability of a long life for the Company.

Our investment in the British Celanese 2nd Mortgage Bonds and First Preference shares calls for no special comment, and as regards our holding of Common shares in the Celanese Corporation of America you may have noted from that Company's recently published report that its profits for the year ended December, 1929, exceeded the previous year's profits by more than $1,000,000. It is anticipated that in spite of price reductions the current year's profit should show a further increase as a result of the enlarged productive capacity of the factories, so that a dividend on the Common shares may reasonably be expected at the close of the current financial year.

The Consolidated Main Reef Mines paid an interim dividend of 5% in February last, and our information regarding the prospects of this Company is of a uniformly satisfactory nature.

The Gold Fields American Development Company Limited is principally interested in the American Potash and Chemical Corporation, the South American Gold and Platinum Company and the Celanese Corporation of America. In addition it has recently acquired considerable interests in American Utility concerns together with shares in promising tin ventures. Our holding in this Company which up to the present has not been a source of revenue now bids fair to become contributory thereto during the current year.

I now come to our investments in Western Australia, namely, in the Lake View and Star Company and the Wiluna Gold Corporation which are of particular interest in view of their prosperous future indicated by the present course of development.

In the case of Lake View and Star, recent development has established the correctness of Dr. Maclaren's forecast of the existence of highly important ore bodies in the Horse Shoe Mine hitherto undeveloped. This fact coupled with the discovery of high grade ore in some of the sections of the Horse Shoe property worked by the old Company and the finding of rich telluride ore in the Lake View section have amply confirmed our belief that our holding in this Company will become a highly profitable one. It is anticipated that the first section of the new treatment plant will be in operation within the next two or three months and from that period onwards the monthly profits should be substantial.

Rapid progress is being made with the erection of the Wiluna plant, this being facilitated by the completion of the railway to the property. The development of the mine continues to reveal large and important bodies of ore, a particularly satisfactory feature of this work being the great width and high values exposed in recent development work on the West lode at a depth of about 300 ft.

As the result of recent satisfactory arrangements the lease held by the Mexican Corporation over the Fresnillo Mine has been merged with the interest of the owners thereof in the Fresnillo Mining Company, the Mexican Corporation owning just over a half interest in the latter. The developments on the Fresnillo Mine have been uniformly good during the past year though the recent fall in the price of lead, zinc and silver has correspondingly reduced the excellent profits hitherto earned.

The fall in the value of lead has also militated against the profit earning capacity of Mill Close Mines, whilst development and exploratory work

in the mine have resulted in the opening up of important bodies which at the normal price of lead should prove highly profitable ore. Meanwhile the general outlook at this property is entirely satisfactory.

As regards Moler Products, although the profit earning stage has not yet been reached the Company's affairs are steadily moving in that direction and the attention which has been given to the insulating side of its business is expected to show tangible results in the near future.

We are advised that the plant of the South American Copper Company which was referred to last year as being built has commenced operations but some weeks will elapse before production is fairly under weigh. As regards developments there are indications of the rediscovery of an important section of the main ore body which was cut off by faulting, but the importance of this discovery cannot be gauged until further prospecting has been done.

The Sub Nigel Company to which I have already referred paid dividends amounting to 40% during our financial year. It is likely to remain a consistent dividend payer and recent developments give hope of increased profits in the not distant future. Besides our holding in Sub Nigel we retain interests in Government Gold Mining Areas, New Modderfontein Gold Mining Company and Robinson Deep A shares which holdings require no special comment. I may however add that the recent acquisition of the Village Deep Mine by Robinson Deep affords additional security to the holders of the A shares.

The Waterval (Rustenburg) Platinum Mining Company's plant is now in operation and the Company is earning very satisfactory profits.

In Roumania our main holding is in the Sospiro Company. The Sospiro Field remains among those of our interests the fruition of which the Chairman last year referred to as prospective. A recent most encouraging report of the Manager and Consulting Engineer confirms our confidence in ultimate results.

I am sorry to say, however, that the prospects at one time most promising, but latterly disappointing, of the Amalgamated Oil Lands of Roumania make it appear doubtful whether further expenditure is justifiable on this property for the time being. Our holding is not an important one and we have thus omitted it from our list.

The future of the Oroville Company lies in the carrying on of operations by the acquisition of new dredging areas regarding which negotiations are proceeding. Failing this a distribution of its cash assets and liquidation must follow. In any case our holding stands at a low figure in our books.

The programme of equipping the Mount Elliott property with an up-to-date treatment plant referred to last year has been delayed pending the settlement of outstanding points in connection with the local labour situation. Meanwhile the Company is earning a very good revenue from the leasing of certain portions of its properties to tributers.

The South American Gold and Platinum Company continues to make satisfactory profits and we can only hope that the constant pressure by ourselves and associated shareholders will succeed in the near future in inducing the Board of that Company to distribute a portion of its ample funds by way of dividend.

Our shareholding in the Rhodesia Broken Hill Development Company comes under the category of revenue prospects deferred. Profitable results in this instance also are dependent on a revival of the Base Metal markets. In this category also we must for the present place our holding in the Creole Petroleum Corporation which is making excellent progress, its monthly share of production of late having been approximately 600,000 barrels per month. I am informed it is anticipated that its pipeline will shortly be completed and shipping will then commence and I trust that at our next meeting we may be able to rank it as a revenue producer.

The latest information regarding the progress of the Tocuyo Oilfields is to the effect that 14 wells have been brought in capable of production of oil of exceptional quality. A pipeline connecting the fields with the sea should be completed by May and the Company should be shipping oil within the ensuing three months.

In conclusion I may say that though we are passing through a period of depression in almost every branch of mining and industrial enterprise we are carefully watching the course of events, and as I have already informed you that we are well equipped financially we shall not fail to avail ourselves of opportunities for promising investments during the current year.

I beg to move: "That the Report of the Directors and Statement of Accounts and Balance Sheet to December 31, 1929, and the recommendation of the Directors that a final Dividend of 10% (2s. per share), less tax at the rate of 3s. 1.67d. in the £ (making with the Interim Dividend of 1s. per share, 15% for the year) be paid on the 500,000 Ordinary Shares of the Company, be adopted: and that the dividends paid on the Preference Shares and the Interim Dividend paid on the Ordinary Shares, be confirmed."

Sir Godfrey Lagden, K.C.M.G., K.B.E., seconded the motion.

In the course of a brief discussion a question was asked as to the expenditure on the Sospiro Field, to which the Chairman replied that their holding in that Company was small.

The resolution was unanimously adopted.

NATIONAL MINING CORPORATION, LTD.

Directors : Herbert Guedalla (*Chairman*), Robert Annan (*Managing*), J. A. Agnew, F. W. Baker, E. Birkenruth. *Manager :* A. E. Ford. *Secretary :* R. H. A. Neuschild. *Office :* 428, Salisbury House, London Wall, E.C. 2. *Formed* 1919. *Capital issued :* £1,182,806 in 8s. shares.

Business : Finance of and investment in oil, mining, metallurgical, and other ventures in various parts of the world.

The tenth annual ordinary general meeting of the National Mining Corporation, Ltd., was held on Monday, February 17, 1930, at River Plate House, Finsbury Circus, E.C., Mr. Herbert Guedalla (Chairman of the company) presiding.

The Chairman, in moving the adoption of the report and accounts for the year ended December 31 last said, for reasons which he would explain to them they had not been able to turn to advantage any of their partly-developed enterprises, with the result that the actual loss in working for the year amounted to £12,822. They had also had to write off from investments the amount of £82,196, and their holding in Porcupine Goldfields Development and Finance Company, Ltd., accounted for about £76,000 of this amount. After utilizing their reserve account of £50,000, they had left a credit of £19,933 carried to the balance-sheet. Shares and interests and advances to other companies stood in their books at a total of £1,319,459. This total comprises securities with market quotations at book value of £316,535, and other investments at book value, including advances to subsidiary companies, £1,002,924. At the date of the balance-sheet there was a depreciation of £135,451 in the securities with market quotations, and, although doubtless due to the large fall in prices of base-metals, in his opinion, is exaggerated in certain of their investments, so that he was not without hope that they might see some important recovery in this direction.

They had a holding in the Bolivar Venezuela Gold Mines, Ltd. Development had been centred throughout the year on the Union concession, where there existed a wide mineralized shear zone resembling a stock-work. As exposed to date, this deposit comprised two or three large ore-bodies, and it was estimated that the proved ore reserves up to date amounted to 233,000 tons, averaging almost 10 dwt., and, further, that there were 120,000 tons of probable ore. Having regard to the results obtained, it would be necessary to provide further working capital for this company. In Camp Bird, Ltd., they had a large holding, both in the Preference shares and the new Ordinary shares. The value of the shares had certainly been affected by the fall in metal prices, and particularly in silver, but the mines in which Camp Bird was chiefly concerned are undoubtedly most important properties of great value. They had large reserves, with efficient management and plant, and their earnings even at the present time were quite satisfactory. They had a holding in the Celanese Company of America, and an interest in the Chemical and Metallurgical Corporation, Ltd.

With regard to the Lagares Tin Mine, which was situated in Portugal, developments had been quite satisfactory, and the results obtained from the development campaign carried on throughout the past year at the Mawchi Tin and Wolfram Mine in Burma had also been most gratifying. The reserves above the No. 1 level gave an average value of 4·26% of mixed tin and wolfram. In the lower levels the values showed further improvement. It had been decided to anticipate the original date of milling, and operations were expected to commence towards the end of February on the basis of treating 4,000 tons per month, with an increase to 6,000 tons during the present year.

They still had a holding in the South American Copper Company, Ltd., and the first returns from this company's new plant were expected at an early date. He was glad to state that the results of the active development carried out by the Mill Close Mines, Ltd., had been very satisfactory, and even at the present low price of lead this company was earning satisfactory profits. They had also a considerable holding in Moler Products, Ltd.

He would deal next with their interest in the Amalgamated Oil Lands of Roumania, Ltd., which was represented in their books by the advances to subsidiary companies of £158,481 shown on the balance-sheet. The company had wells on various plots, but he regretted to state that the good production obtained in the early part of the year fell off somewhat towards the end of the year, and the results obtained had been disappointing. Recently, however, two further wells had been brought in on the Runcu field giving a satisfactory initial flow. Their most important investment was their interest in the Roumanian Oil Company known as the Societate " Sospiro." Geological surveys had been made of the greater part of the " Sospiro " lands, although, owing to its extensive area, the survey of the entire property was yet incomplete, mainly so far as it applied to flat lands where few, if any, natural geological indications were available, owing to lack of surface exposures. The surveys which had been completed had resulted in proving the existence of many oil-bearing structures in various parts of the territory, and an intensive drilling programme was also carried out at a number of points in the area. Mr. Fuller, the field manager, had recently embodied his conclusions as to the territory in a most interesting and able report, and had stated that he saw no reason why, with modern equipment that the company now had in its possession, and with modern methods applied, an exceptionally valuable property could not be developed.

The Board informed them in the report that they were not undertaking additional commitments in any way, and that they had to conserve and utilize resources at their disposal for the proper protection of the various interests to which he had referred. To give effect to this policy they had already made important economies in the management of their business. In the circumstances they had thought it best to consult some of their chief shareholders, but the board was not in any way shirking its responsibilities, but felt that, in their present circumstances, they could lay before such a consultative committee any policy which they might propose to adopt with regard to any particular asset, so as to obtain an independent opinion thereon.

Mr. F. W. Baker seconded the motion, and it was duly carried.

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