The Mining Magazine

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EDITORIAL

REMARKS here last month on the benefit that would accrue to the Burma Corporation arising out of the India Budget proposals were a little premature. It seems that the anticipated effect of the duty on silver imports is to be offset by the imposition of an excise duty of exactly the same amount on the metal indigenously produced.

WITH the passing of Lord Balfour the country lost not only a great statesman but one who did more for the promotion of science and kept in closer touch with its progress than any of his colleagues. The initial steps which resulted in the foundation of the National Physical Laboratory were taken during his period of office as First Lord of the Treasury and he was also instrumental in founding the Department of Scientific and Industrial Research.

THE proposed Sinoia-Kafue short cut has again been side-tracked—in railway parlance—and the Commission, referred to here in January last, which makes this report also finds against the construction of a connexion between Beit Bridge and West Nicholson. As for the Walvis Bay line, Mr. Potter disagrees with Mr. Wallace's contention that this is justified. In the meantime the Bechuanaland and Southern Rhodesian Governments are likely to have a survey made of the last-named project.

MEETINGS of the Malayan Tin, Southern Malayan, and Southern Perak companies were called for April 14 at which it was proposed to alter the articles of association to ensure the maintenance of British control, the reason put forward being that there had been heavy buying of shares on foreign account, followed by pressure to secure representation. The changes proposed also included the retention of the services of the present board for a period of at least five years. It was subsequently announced that the meetings had been cancelled.

ONCE again the Channel Tunnel Scheme is before the public with the issue of the report of the Government Committee appointed in April last to consider the economic aspects of the proposal. The MAGAZINE for October and November, 1913, and July and December, 1916, throws light both on the geological and on the engineering aspects of the project. Its construction may be possible from these standpoints, but whether it is economically sound is another matter. Many engineers will be disposed to agree with Lord Ebbisham in his dissent from the views of the remainder of the committee. One further fact may be noted—the military objection seems to be less insistent.

The Empire Mining Congress

The third Empire Mining and Metallurgical Congress may in a sense be regarded as having commenced when the delegates left London on March 7, the leave-taking at Waterloo station and subsequently at Southampton being in every way worthy of the occasion. The Congress was, however, formally opened on March 24 at Cape Town by the Earl of Athlone, the Governor-General of the Union, who, in welcoming the delegation on behalf of the Government and people of South Africa, remarked on the vital part played by the mining and metallurgical industries in the development of the Empire as well as in the whole of modern civilization, and complimented the Council and constituent institutes on the invaluable work they were doing. As no doubt his hearers were aware, this was no perfunctory utterance, for Lord Athlone, like other members of the Royal family, speaks from a profound knowledge of many of the problems underlying these matters. The welcome formalities concluded, Sir Ernest Oppenheimer delivered his presidential address and dealt with the need for the consistent encouragement of European settlement in such parts of South Africa as were suitable for white occupation and instanced unalienated areas in the highlands where mining could continue its work of creating a lasting European civilization. Just as mining has developed the Union, so it bids fair to do in Northern Rhodesia, and in his opinion a vigorous development policy for the whole subcontinent was the best method of civilizing the native. Finally, he drew an interesting parallel between the present wealth and superlative productivity of the Rand goldfield and the probable future prosperity of the Rhodesian copper-field and made a plea for similar group control of the latter. A second session of the Congress opened in Johannesburg on March 31, under the presidency of Dr. H. Pirow, the Government Mining Engineer, at which Honorary Membership of the Institution of Mining and Metallurgy was conferred on Mr. P. M. Anderson, the president of the Transvaal Chamber of Mines, and it was decided to

accept the invitation to hold the fourth Congress in Australia in 1933.

With regard to the papers presented at the various sessions, it is unnecessary to attempt here more than a summary survey of the field covered. The papers may conveniently be divided into sections, of which some notes are appended concerning the more important from the viewpoint of readers of the MAGAZINE. Under the heading of reviews and occurrences are a number of reports, covering the period 1927–9, by Canadians, on the mineral industry of the Dominion and its provinces, to which may be added a paper on the mining industry in Southern Rhodesia and one on the Lydenburg platinum areas. Papers on mining deal almost exclusively with Rand practice, if we include as sub-sections papers dealing with shaft sinking, breaking ground, hoisting and hauling, ventilation, and power. While few of these cover new ground, yet some disclose details and present data not previously obtainable. For example, on the subject of tunnelling at West Rand Consolidated, Mr. C. S. McLean reveals that as many as 10,000 drills are dealt with by a central station in one 8-hour shift, while Mr. W. G. C. Nixon, dealing with high-lift pumping, describes the practice of pumping settled sludge in single lifts of 1,200 feet instead of baling. Mr. W. Eldson Dew's paper on winding at great depths is a valuable supplement to two recent textbooks on this subject and a paper by Mr. C. L. Butlin on shovelling and tramming indicates new economies possible in underground practice. In the ventilation sub-section a paper by Mr. James Boyd on the estimation of dust in mine air deals with a subject of which the literature is sparse. Ore-dressing and metallurgy are covered by eight separate contributions. Included here is a useful historical review of flotation practice by Mr. H. L. Sulman, proposals for water concentration tests by Professor B. W. Holman, and a particularly valuable paper by Messrs. W. J. Gau and J. I. Jameson on the metallurgical practice at Leeuwpoort Tin Mines. A paper on platinum metallurgy by Messrs. F. Wartenweiler and A. King contains interesting flow-sheets. In the field of prospecting and sampling Professor Truscott presents a thesis on the computation of ore reserves which will be abstracted in our next issue, as will certain other papers in this series, and Mr. J. Allan Howe deals with the conservation of drilling records.

As to the mines, works, and other places of interest visited in the course of the tour, these have already been referred to in the MAGAZINE for September last. The elaborate arrangements made for the reception and hospitable treatment of the delegates have worked as admirably as was to be expected. In this connexion mention may be made of two names in particular, Captain J. H. Jefferies, the general secretary, and Mr. George Reid, the manager. In conclusion it is only necessary to repeat what has been stated here concerning previous conferences and tours, that by far the most important result of these meetings of Empire members of the profession, and others interested who join therein, is the opportunity of studying at first hand the various phases of the work in progress, while at the same time enjoying all the benefits of friendly intercourse and informal discussion, nothing being better calculated to advance the well-being and future prosperity both of the enterprise and of the individual.

Metals in History

The past month has witnessed the appearance of three papers dealing either directly or remotely with history. Two of these were presented at the March meeting of the Institution, when Sir Harold Carpenter and Dr. M. S. Fisher introduced " A Study of the Crystal Structures of Native Copper," which deals with the metal in geological time, while Dr. T. A. Rickard, in outlining the story of " Copper Mining in Cyprus," confined himself to historical time. The last-named author also presented the third paper at the annual meeting of the Institute of Metals on March 12, under the title of " The Early Use of the Metals." History is ever a matter of interest as much to the scientist as to the layman, as was evidenced by the discussion which these respective studies promoted, and the final paper referred to deserves special consideration as being one of the few occasions on which metallurgists and anthropologists have got together.

It will be remembered that two years ago Professor Carpenter, in collaboration with Dr. S. Tamura, presented to the Institution an account of a preliminary investigation of the inner crystal structure of some native metals, a brief account of which was given in the MAGAZINE for April, 1928. The main purpose of that work was the application of metallographic technique to the interpretation

of structures of native metals whereby it was hoped that some light might be thrown on the origin and geological history of native metal deposits. As the authors pointed out in their reply to the discussion arising from that paper, the study was simply an introductory survey of a very wide field. In their investigation of native copper the authors of the present paper have proceeded a step further and limited the field of inquiry to one particular metal. One important application of the results obtained was noted immediately by several speakers and that was the light which would be thrown by such work on the temperature of formation of minerals paragenetically associated with the native metal. Dr. W. R. Jones, for example, in referring to the work of Wright and Larsen (which was discussed, in the light of investigations by Brammall and Harwood, in the MAGAZINE for March, 1927), pointed out that the results obtained by these workers in the use of quartz as a geological thermometer were difficult to duplicate and it was evident that for certain limited conditions a study of the crystal structure of native copper would be of immense importance. What is more significant is the fact that copper is but one of several metals and metalloids which occur in the native state and separate studies of these elemental minerals will be capable of application to a series of differing geological conditions. This led Dr. H. C. Boydell to ask the authors seriously to consider a study of native silver, as it seemed to him that this would be of incalculable benefit to Canadian geologists in the investigation of such important mineral deposits as those of the Cobalt district of Ontario. Briefly, it may be stated that the authors have reached the conclusion that the whole of the twenty specimens included in their examination had been formed at low temperature, either by rhythmic precipitation from a gel, by the replacement of pre-existing minerals, or by deposition from aqueous solution, all of which conclusions are additional support to theories of origin which have been suggested by geological workers. The question of electrical deposition was raised in the discussion by Dr. Jones, who referred to the work of Fox on mineralized fissures in Cornwall. It was further evident that reconstruction of the metal after deposition had left unmistakable signs, certain specimens, for instance, being in a state of strain, recrystallizing when heated at temperatures between 500° C. and 600° C. and becoming homogeneous at a temperature below 800° C., thus showing that none of the specimens had ever been at a temperature near the melting point. In yet other cases it has been possible, by a careful study of the behaviour of mineral inclusions during progressive heat-treatment, to show that certain specimens had undergone thermal metamorphism subsequent to deposition. Altogether the paper is an excellent example of the illuminating assistance to other workers which is so often afforded by a specialized study of a particular problem.

Of the two papers by Dr. Rickard the more interesting discussion was raised by that before the Institute of Metals, in which, as already remarked, some eminent anthropologists took part. It is evident from the wealth of bibliographic references cited that the author has taken a great deal of pains to assemble his data and, while all will not agree with his every conclusion, he has undoubtedly knit together an interesting story from the time when primitive man first discovered the native metals—copper, gold, silver and meteoric iron—and beat and fashioned them into shape for ornamental or implemental use to the time when, in a later stage of development, he discovered by chance the effect of his camp fire in producing metal from the earth and so hit upon the idea of smelting as distinct from melting, which Dr. Rickard rightly emphasizes as the most momentous factor in the whole story of man's conflict with nature. The discovery of bronze by the chance smelting of a copper ore containing cassiterite and in a similar manner brass were successive steps and in due time the idea of the effects of heat, draught, charcoal, and fluxes having been grasped the smelting of iron from its ores followed. Evidence is adduced to show that the use of iron preceded that of bronze in some civilization and this encourages the author to dispose of the successive stone, bronze, and iron ages of history. There is nowadays a general agreement with the subdivision of time into two ages—the Stone Age and the Metal Age. The Stone Age is held to cover that period of time when man was as yet unaware of metals and to be succeeded by a transition period when the native metals became known and appreciated and this led to the age when the use of metals and fortuitous alloys became extended consequent upon the discoveries of the effects of fire upon the earth. The author pays well-deserved tribute to the writings of the late Professor W. Gowland on this

fascinating subject, while in the discussion reference was made by one of the speakers to the work of Professor V. Gordon Childe as one of the archeologists who had dealt with metallurgy in his recent book on the bronze age.

The Education of the Engineer

Consideration of the extensive scale on which the development of the copper deposits of Northern Rhodesia has been planned, economically to exploit the vast tonnages of ore available, and the fact that the supervision of these operations has been mainly entrusted to engineers trained in the United States must carry with it the realization that the management of many mines under British control and situated within the British Empire is in the hands of engineers of other than our own nationality. The development and exploitation of the low-grade porphyry copper deposits of America, the scale of operations and the exact technique demanded to ensure profitable extraction of values, and above all the resultant aptitude of men trained in such large-scale environments have not unnaturally led those responsible for the opening up of comparatively low-grade copper properties to turn at once to the United States for technical direction. Indeed, it is difficult to see what other choice could have been made. Copper deposits of this character, however, are not the only ones in the Empire which have been developed and are being managed for us. More than one important gold mine, apart from those of the Rand, are entrusted to the management—and, it must be admitted, capable management—of American-trained engineers and the same is true of a number of base-metal enterprises. That the directorate of a British company would choose a foreigner as superintendent of its property in preference to a Briton—if a competent Briton were available—it is impossible to believe ; it is, in fact, common knowledge that in several cases posts have been filled by other nationals only after many British applicants have been interviewed. If the foregoing may be regarded as a fair statement of the present position it is surely worthy of examination.

The possibilities for practical training in metalliferous mining in Great Britain are, it will be generally admitted, extremely limited. Apart from the Cornish mines, the only properties which are, or have been, worked on large-scale lines are the hematite bodies of the north-western counties. The Jurassic iron-ores are bedded deposits of regular character, the working of which can generally be run in accordance with normal colliery practice. For experience on such a scale as will create self-confidence in tackling operations of any magnitude it will be admitted that a British student must go outside these islands. As this is only possible in a limited number of cases during the period of studentship it is evident that foreigners—and particularly Americans—trained in close proximity to and spending their vacations on important metalliferous mines have a decided advantage over their average fellows in this country. On the other hand, their course of instruction at a mining school completed, most British graduates go abroad for their first appointment and doubtless some of them proceed to mines where there are opportunities for supplementing their technical education. It would seem, however, that some additional explanation is required to account for the failure of engineers of British training to reach positions controlling operations of magnitude.

This train of thought raises a question whether the primary education system of this country is in any way responsible. While we do not feel we are justified in analysing a system which is the envy of the world, it may be excusable for us to endeavour to throw some light on the effect of school tradition on training for the profession of engineering and more particularly the highly specialized profession of mining engineering. Recently Professor Truscott mentioned one of our less worthy national characteristics, that of a tendency to praise "artistic indolence," referring, among other things, to the prevalent youthful attitude of regarding hard work as something to be avoided, a dangerous conception if carried to a late period in life. The product of the universities and technical institutes in this country is a complex blend of these and other worthier types. In this connexion there is the possibility that a particular college may obtain a bad reputation because of those "work shy" young men—however much they be in a minority—which it sends out into the world. At a time when so much important development work is in progress within the Empire it seems desirable to focus attention on this subject and if a more disappointing view has been taken than is justified no one will be more pleased than ourselves.

REVIEW OF MINING

Introduction.—The date of issue of the MAGAZINE almost synchronizes with Budget Day and the general tone of business, which has lately shown improvement, will doubtless be ruled by the new conditions. In the metal market the price of tin has again been disappointing, the relief anticipated from restriction not yet having materialized.

Transvaal.—The output of gold on the Rand during March was 852,089 oz. and in outside districts 37,281 oz., making a total of 889,370 oz., as compared with 818,188 oz. in February. At the end of March the number of natives working in the gold mines was 200,134, as compared with 196,752 at the end of February.

The report of Rand Mines, Ltd., for 1929 showed a profit for the year of £545,470 and £511,288 was distributed as dividends, equal to 100%, the same as for the previous four years. The interest in Trinidad Leaseholds is proving a profitable one and developments on the properties of the North Venezuelan Petroleum Company and of the Tocuyo Oilfields of Venezuela company are favourable. The report also states that an interest has been taken in certain mining ventures in Bolivia and it is understood that the company is becoming interested in tin mining.

Good progress continues to be made with the development of the East Geduld property, which is being carried on from the east of the Geduld Proprietary workings. The report for 1929 shows that progress during the year amounted to 17,305 ft. and while as yet little ore has been blocked out completely the work done indicates that partially-developed and probable ore amounted to about 2,400,000 tons at the end of the year. In March, 1929, it was decided to sink a vertical shaft and the work was started the following month, the depth mark at the end of the year being 460 ft. In a circular to shareholders issued later it is stated that developments continue to be so encouraging that a reduction plant is to be installed capable of treating 60,000 tons per month. To meet the expense of installation 500,000 new ordinary shares are to be issued.

A serious accident at the Crown Mines towards the middle of last month resulted in the death of 28 natives and a white miner. The natives were in a cage which broke away and crashed to the bottom of the shaft, a distance of 1,600 ft.

Cape Colony.—A circular to shareholders of the African Asbestos Trust states that owing to the financial position of the company it has been necessary to restrict mining operations to the extraction of long-fibred mineral. This will mean that the developments on the Munnik Hill property, where ore reserves were estimated at 274,000 tons, will be temporarily suspended.

Diamonds.—An announcement in the Legislative Assembly of the Union on March 26 by the Minister of Finance revealed that an agreement has been reached with regard to the allocation of diamond producers' quotas and also the sale of both the Union and South-West Africa diamonds.

Southern Rhodesia.—The output of gold during February was 43,385 oz., as compared with 46,121 oz. in January and 44,551 oz. in February of 1929. Other outputs in February were : Silver, 5,509 oz. ; copper, 108 tons ; coal, 92,437 tons ; chrome ore, 21,049 tons ; asbestos, 4,126 tons ; mica, 10 tons.

The report of the Globe and Phœnix for 1929 shows that the available ore reserves at the end of the year were estimated to be 51,400 tons containing 48,300 oz. gold, together with 49,100 tons containing 67,300 oz. in the pillars. The total of 100,500 tons containing 115,600 oz. compares with 86,700 tons containing 111,700 oz. at the end of the previous year. During the year 72,369 tons of ore was crushed and 60,225 oz. of gold recovered, which is 15,705 oz. less than in 1928. Nearly two-thirds of this reduction is due to the suspension of operation of the sands plant during the year, it having been found better practice to allow sands to accumulate for a period and then to run the plant to capacity. Development on the 15th level has revealed 615 ft. of ore, averaging 18·5 dwt. over 37·3 in., and on the 29th level ore was exposed for a distance of 130 ft., averaging 49·1 dwt. over 44·4 in. The limits of this ore have not yet been determined.

A circular to shareholders of Southern Rhodesia Base Metals Corporation states that in the quarter ended March 31 last 535 tons of copper concentrates, averaging 67% copper, was produced, the plant operating satisfactorily. It is also stated that arrangements have been made with Minerals Separation, Ltd., for the construction of a copper segregation plant capable of treating up to 50 tons of oxide and mixed

oxide-sulphide ore per day, a large tonnage of such ore having already been developed. Developments in the Alaska mine continue to be favourable and it is stated that from the north-east side of the shaft 20 ft. has been driven in ore, full width unknown, averaging 7·2% copper as sulphide. In addition to the sulphide there is present 1·2% copper in the form of oxide.

Northern Rhodesia.—The sixth progress report of the Rhodesia-Katanga Company states that up to the end of January at the Kansanshi mine some 2,000 ft. of driving has been done along the west, north, and east sides of the hill on the 100 ft. and 150 ft. levels. This work has shown that there is a zone of replacement ore, of varying width, extending around the hill on the dolomite-schist contact. On the 100 ft. level this ore has been proved over a length of 300 ft. and assays 15·8% copper, and similar values were obtained on the 150 ft. level. A new reef has been discovered to the east of A reef and development work is in progress, having so far revealed 105 ft. of ore averaging approximately 4% copper over 4 ft. of lode. It is said that values are increasing to the north. Work on the sulphide reefs continues to show favourable results.

Shareholders of Rhodesian Congo Border Concession have been informed of the results of two bore-holes situated west of the N'Changa boundary. The first of these, N.E. 33, situated on the southern fold-limb in the Chingola area, entered ore at 215 ft. and from 215 ft. to 250 ft. the assays averaged 10·35% copper. At 260 ft. the hole entered a second ore-zone and from 260 ft. to 275 ft. the core recovered assayed 18·33% copper, while the sludge assayed 7·73%. The second hole, N.E. 17, lies nearer the N'Changa property and is said to have entered ore at 988 ft. and to 1,061 ft. the ground assayed 6·38% copper. This hole is, at 1,071 ft., still in ore.

The Bwana M'Kubwa Company announce that a cross-cut at the 450 ft. level from No. 1 vertical shaft on the N'Kana mine has penetrated the ore-body, which over a true width of 22·8 ft. averaged 5·40% copper.

Australia.—The decision of the Commonwealth Government to pay a premium on gold equivalent to the selling exchange rate less 25% has, in effect, introduced a bounty on gold. This will vary with the exchange, but amounts approximately to 4s. an ounce.

The interim report of the Broken Hill South for the half-year ended December 31 last shows that the estimated surplus for the period is £154,000, as compared with £140,000 in the corresponding period of 1928. Approximately one-third of the surplus was derived from the production and sale of zinc concentrates. During the period mentioned 165,660 tons of ore, averaging 14·3% lead, 11·0% zinc, and 5·2 oz. silver, was treated, and 33,922 tons of lead concentrates, averaging 66·1% lead, 6·4% zinc, and 23 oz. silver, and 30,227 tons of zinc concentrates, averaging 49·2% zinc, 2·1% lead, and 1·6 oz. silver, were produced.

The first section of the tailings retreatment plant on the Golden Horseshoe came into operation at the beginning of February and ran intermittently during the month. The ground treated amounted to 13,232 short tons and yielded gold worth £2,854.

India.—The report of the Ooregum Gold Mining Company for 1929 shows a slight decrease in the ore reserves, which at the end of the year were estimated to be 270,788 tons. During the year 69,889 oz. of gold were obtained from 165,445 tons of ore milled, 11,887 oz. from 220,555 tons of tailings retreated, 555 oz. from old mill plates, and 152 oz. from 398 tons of ore mined and milled by the Nundydroog Company, making a total of 82,483 oz. The average value of ore milled was 8·68 dwt. per ton. The net profit for the year was £76,556, a reduction of £23,371 as compared with the previous year. During the year 2s. per share was distributed on the Preference and 1s. per share on the Ordinary shares.

Malaya.—The report of the Temengor Tin Mining Company for the year ended September 30 last shows that development of the property is proceeding smoothly. Owing to exceptional drought, hydraulicking operations were somewhat restricted, but it is expected that as soon as weather conditions permit work will be possible on a full scale. The output of tin concentrates during the financial year was approximately 63 tons and the value of the ground per cu. yd. was 2·53 lb. The working of the experimental stamp battery has shown that there is a large quantity of rock available for treatment by this plant. The capital of the company is to be increased to £300,000.

At a meeting of shareholders of Ampang (Perak) Tin Dredging, held on March 31 last, it was resolved that the company should go into voluntary liquidation.

It is proposed to reduce the capital of the Straits Trading Company from $6,750,000

to $900,000, by writing down the value of each share of $7·50 to $1, and refunding in cash the balance of $6·50 per share.

Panama.—The fourteenth progress report of the Panama Corporation confirms the favourable developments at the Mina Blanca mine, Hatillos. The mineralized fissure is of much greater width than had previously been supposed. Crosscuts are being actively driven and it is stated that gold values are not limited to the gold-lead vein. The extension of this has been located for 3,000 ft. northwards, prospect assays showing 66s. gold per ton, the total value of the ore being £8 per ton. A pilot plant is to be erected and the results obtained will largely determine the course of future work. At the Remance mine it is estimated that ore reserves averaging 33s. in gold per ton are immediately available in sufficient quantity to supply the mill for two years. Work on the El Mineral and Cana concessions is also well advanced, the design of the necessary plant for the former being under consideration, while hydraulic plant is being installed on the latter.

Bolivia.—The report of Patino Mines and Enterprises for 1929 shows that the ore reserves, excluding dump material, at the end of the year were estimated to contain 82,606 tons of fine tin, as compared with 71,462 tons at the end of 1928. During the year 795,052 tons of ore, averaging 3·71% tin, were developed, and 703,592 tons containing 3·94% tin mined. The cost of production of concentrates has been reduced by 7s. 3d. to 53s. 6d. per ton. The acquisition of the tin-smelting plant of Williams Harvey and Co. is stated to have cost £1,332,000. Later, all rights under the Williams Harvey agreement were transferred to General Tin Industries, an American Company, on the condition that the latter company assumed the obligations of the contract and sold to the Patino Company fully-paid General Tin Industries shares equal in value to the ordinary and extraordinary reserves of the Patino Mines, which is £634,995.

Venezuela.—An agreement has been concluded between Bolivar Venezuela Gold Mines, Ltd., and New Goldfields of Venezuela, Ltd., whereby the two companies are to be amalgamated. The basis of the merger is such that each shareholder in the former company will receive one share of the New Goldfields company for every share held in Bolivar Venezuela Gold Mines. At the same time the capital of New Goldfields of Venezuela, Ltd., will be reduced, the issued £1 share being written down to 5s. and the unissued shares being split into four shares of 5s. each. It is proposed in due course to create 700,000 additional shares of 5s. each, which will make the total authorized capital £1,675,000. The amalgamation will enable the reserves on the Bolivar Venezuela property, which in the neighbourhood of the Union Shaft alone are estimated at 250,000 tons, to be conveniently exploited by the transport system and mill installed by the New Goldfields company.

Spain.—The report of the Tharsis Sulphur and Copper Company for the year 1929 shows the net profit earned to be £182,739 and £82,139 was brought forward from 1928. Dividends at the rate of 12½% will absorb £125,000 and £115,000 is to be transferred to general reserve, leaving £24,878 to be carried forward. Work at the mines was carried out uninterruptedly during the year, all the production being from the Calañas mine and from the Sierra Bullones opencast at Tharsis.

The dividends paid by the Rio Tinto Company during 1929 equalled 55% on the capital increased to £2,125,000 in June last. This compares with 40% on £1,875,000 in 1928. The trading profit for the year was £1,669,782 and the total income £1,930,110. The mines worked smoothly during the year, the total quantity of ore delivered by the company being in excess of that for 1928, and all the copper produced found a ready market.

Portugal.—The total quantity of ore broken and raised from the San Domingos mine during 1929 by Mason and Barry, Ltd., was 222,685 tons, as compared with 184,868 tons in 1928. Ore shipments during the same period amounted to 203,778 tons, as against 200,701 tons the year before. The profit realized on the year's working was £20,238. It is proposed to pay a dividend of 12½%, which will absorb £23,146, leaving £19,413 to be carried forward, as against £22,321 the previous year.

Consolidated Mines Selection.—The report for 1929 shows that the profit for the year was £112,300, as compared with £79,836 in 1928. The dividend is maintained at 20%, which will absorb £100,750. The dividend equalization account has been reduced from £18,000 to £10,000 by the transfer of the difference to profit and loss account.

A FIELD TEST WITH A NEW SEISMOGRAPH

By CAPT. H. SHAW, M.Sc.

A new electrical seismograph is described and an account given of a survey made over a known area to test the applicability of the method to the location of simple structures.

INTRODUCTION.—In the last issue of the MAGAZINE, Professor A. O. Rankine gave a detailed description of the construction and method of operation of a new portable seismograph made by the Cambridge Instrument Company for geophysical survey. It may be appropriate, therefore, to describe the essential features of another seismograph by the same makers, which has been developed recently from the instrument previously described, and to give an account of field tests which have been carried out with this apparatus. The aim of these tests was to investigate the possibility of locating simple geological structures by means of the seismic method of geophysical surveying, and to report upon the suitability for this purpose of the new seismograph. Through the courtesy of the Hodbarrow Mining Company, who also provided the explosive and the requisite personnel, the survey was conducted over an area near Millom, in Cumberland, where the geological structure is well-known from borings, and over which a survey by the gravitational method had previously been made. For the particular purpose in view it was unnecessary in this area to penetrate to great depths, as reasonably short profiles suffice to reveal the tectonic features which are known to exist, and comparatively small charges of explosive have therefore been employed throughout the tests. For greater penetration and over longer traverses, or in less suitable ground it would have been necessary to employ bigger charges, but for these tests it was not considered desirable to increase the scale of the operations unduly.

FIG. 1.—GENERAL PLAN OF SURVEY.

DESCRIPTION OF THE AREA.—The region over which the test was made was the treeless sandy foreshore off the village of Haverigg near Millom. In this area the overburden is of glacial drift comprising a mixture of sand, clay, and gravel, beneath which is carboniferous limestone, and which in turn is underlain by conglomerate. In this particular locality hæmatite occurs usually as well-defined masses in the limestone, and is frequently found associated with faults. The sandy surface is fairly hard in places, but very soft and muddy in others. In some places large patches of shingle are to be seen while considerable areas exist on which, almost as soon as the tide has receded, the sand becomes very fine and loose.

A well-marked fault crosses near the middle of the area selected for these tests, as may be seen from Fig. 1 in which the position and direction of this fault, as deduced from a gravitational survey, is shown, whilst the section shown in Fig. 2 indicates the throw of the fault as computed from the gravitational results. The position and throw of this fault have subsequently been verified by the bore-holes B.H. 63 and B.H. 129. On the down-throw side of the fault the limestone is overlain by a considerable thickness of sandstone (about 260 ft.) and as the velocity of seismic waves in sandstone is very much less than the corresponding velocity in limestone there is good reason to believe that this method might furnish a practicable means of locating the position of the fault and probably also of indicating its throw.

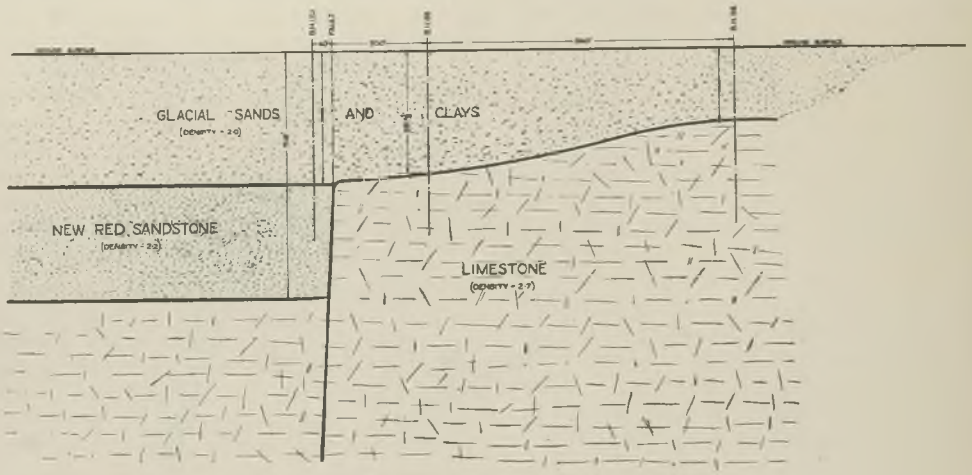


FIG. 2.—SECTION ACROSS AREA ALONG LINE *ABC*, SHOWING POSITION AND THROW OF FAULT AS DETERMINED FROM A PREVIOUS GRAVITY SURVEY AND FROM BORE-HOLE DATA.

The mean velocities of elastic waves as given by Sieberg are as follows :—

Limestone 16,400 ft. per sec.
Sandstone 5,850 ,, ,, ,,

while the mean value available for glacial drift appears from other sources to be of the order of 5,000 ft. per sec., so that there is little difference between the velocities in sandstone and in the overburden, although there is a marked difference between the limestone velocity and the other two. The high-velocity of elastic waves in limestone compared with their velocity in the overburden should also enable a determination of the depth of the limestone surface to be determined by the refraction method along a suitably chosen traverse. The velocity in the glacial drift is determined in practice without difficulty, but in the case of limestone it was necessary to conduct an auxiliary test on outcropping limestone in order to determine the velocity of the waves in that medium. This test was made on another portion of the Company's property (near Hodbarrow Point) and will be described later.

APPARATUS.—The particular apparatus employed in these tests was a single-component Cambridge seismograph of the vertical type, kindly lent by the makers for the present survey. The vibrometer portion of this instrument resembles very closely the apparatus described by Professor A. O. Rankine in the March issue of the MAGAZINE, and used in the tests on Chobham Ridges during the summer of 1929. That instrument was, however, a purely mechanical one, in which the relative motion of a heavy mass is magnified by a light aluminium helm and transmitted by a fine inclined link to a vertical axis carrying a mirror which is thereby caused to rotate. In the electrical type of instrument which has been used in the tests here recorded, this mirror is replaced as shown in Fig. 3 by a light coil of fine wire supported vertically in a strong magnetic field in which it is free to rotate about a vertical axis. The coil is thus caused to rotate by every small movement of the vibrometer mass relative to the base of the instrument. This principle has previously been employed in seismographs by Galitzin, Ambronn, Reutlinger, and more recently by Karcher and others in America, and possesses a number of distinct advantages over the purely mechanical form of instrument.

In the particular instrument supplied, the small electric current generated in this light coil was measured by a Cambridge Portable

Electro-cardiograph, a form of Einthoven string galvanometer enabling the motion of the vibrometer mass to be studied in considerable detail. In 1903, Einthoven introduced his string galvanometer, in which, as its name implies, the vital part is a string or fibre. This fibre is made extremely fine, and when suitably mounted in a magnetic field, responds with a high degree of accuracy to minute electric currents. The actual movements of the fibre are small and it is necessary to use a microscope in order to observe and record them. At the speeds and magnification used for cardiograph work the fibre must be strongly illuminated by a suitable lamp. Fig. 4 shows diagrammatically the arrangement employed in the present instrument. The fibre *C* is illuminated by the filament of a 12-volt gas-filled silvered lamp *M*. The beam is projected on to a combined cylindrical lens and mirror *G* which reflects the beam back on to the mirror *X*, and this in turn directs the beam on to the camera, the light passing through the slit *J* from the cylindrical prism *L* in the camera to the photographic film. The fibre appears in front of the prism as a long vertical shadow about two millimetres wide, the part crossing the cylindrical prism becoming a dark spot in the band of light which falls on to the film. Thus if the film is given a motion at right angles to the cylindrical prism, the whole width will be exposed except that portion which is hidden by the shadow of the fibre. The movements of the fibre, however, are in a direction parallel to the length of the cylindrical prism, and as the instantaneous position of the fibre is indicated by an unexposed spot, a continuous record of these vibrations is formed on the moving film, which is carried on a revolving drum (see Fig. 5). The period of revolution of this drum is approximately 5½ seconds, and its speed is governed by an automatic electric damping device. As the drum is brought to rest after one revolution, the record in each case is restricted to a period of 5½ seconds. The magnification of the combined vibrometer-cardiograph system is extremely high, and throughout the tests it was never possible to employ more than one-third of the maximum sensitivity for which the instrument is calibrated. Greater sensitivity even than this is available if required. This wide range of sensitivity that is immediately available and readily controlled by the electro-cardiograph is an important feature of great practical utility, as the instrument can be adjusted to the greatest sensitivity practicable at any particular time. Furthermore, the electro-cardiograph, being calibrated immediately before each observation, furnishes a permanent record of the sensitivity (in millimetres per millivolt) for each record.

The record (see Fig. 6) is crossed at right angles to its direction of motion by a series of parallel lines, which are produced by interrupting the focussed beam of light at regular intervals by means of a revolving wheel, *F* in Fig. 4, carrying one or more projections so that momentarily no light falls on the film as these travel past the slit,

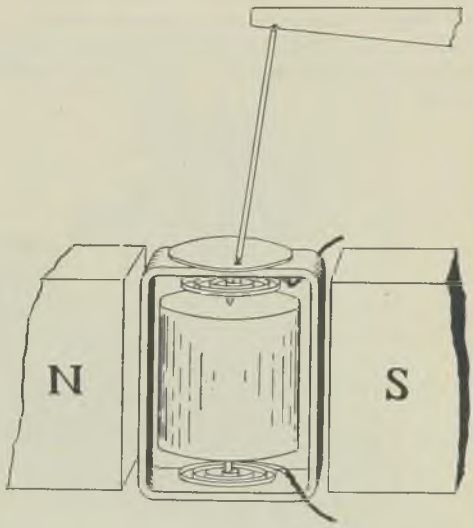


FIG. 3.—DIAGRAMMATIC SKETCH SHOWING ARRANGEMENT OF COIL IN THE MAGNETIC FIELD, AND THE METHOD OF OPERATION BY AN INCLINED LINK.

and in consequence a sharp line appears on the record. These lines indicate fifths of a second and form the time scale.

A light vertical pointer situated immediately in front of the cylindrical lens of the electro-cardiograph causes a shadow to be thrown on the film which is recorded as a line, at right angles to the timing lines. This pointer may be moved a short distance horizontally by means of a small electro-magnet, thus causing a discontinuity in the line which is produced on the record. If therefore this electro-magnet is included in an electric circuit which is broken at the moment of the explosion, that instant will be recorded on the film by a discontinuity in the otherwise continuous horizontal line.

Hand Generator.—The charges were detonated by means of a hand generator, specially modified for these tests by Messrs.

Evershed and Vignoles of Chiswick, who kindly lent the instrument for the survey. This instrument is capable of generating sufficient current at 50 volts to detonate readily the ordinary high tension electric detonators that were employed throughout the test. This hand generator proved a very convenient and efficient means of exploding the charges.

Explosives and Detonators.—Nobel's "Arctic Gelignite," which is generally regarded as the standard explosive, was employed throughout the tests, the cartridges used weighing on the average 0·1 lb. each. The detonators as already described were of the high tension electric type, in which the ignition is effected by the passage of the electric current through the flashing mixture itself.

Locating the traverse lines, shot points, and general surveying duties.

Assistants: Laying the land lines, from charge to seismograph, and from charge to hand generator, digging holes for charges and refilling them, and operating the hand generator.

PROCEDURE.—Owing to the particular characteristics of the area, certain unusual difficulties were encountered which would not ordinarily be present, and these necessitated a modification of the usual procedure. It is the general practice when conducting a seismic survey, to arrange the seismographs (usually from 3 to 6 in number) at different distances from the shot point, and after recording one shot, to move the instruments to different locations, still shooting from the same position. Theoretically, in shooting a traverse across an area, it is immaterial whether the seismograph is moved along and the shot point kept fixed, or whether the seismograph remains stationary and the shots fired at various points along the profile, as is done by Rieber. In this particular case it was found to be more convenient to adopt the latter procedure. In this way the routine work for each shot was reduced to a minimum, it being necessary only to dig a hole to receive the charge, prepare and lay the charge, make the necessary electrical connexions and fill in the hole. As the whole of this routine work would have been necessary in any case and as only one seismograph was available it was found more convenient to keep the seismograph stationary throughout each traverse.

The seismograph was set up at one end of the traverse line which was then laid out and the proposed shot points located by pegs. The two portions of the seismograph—the

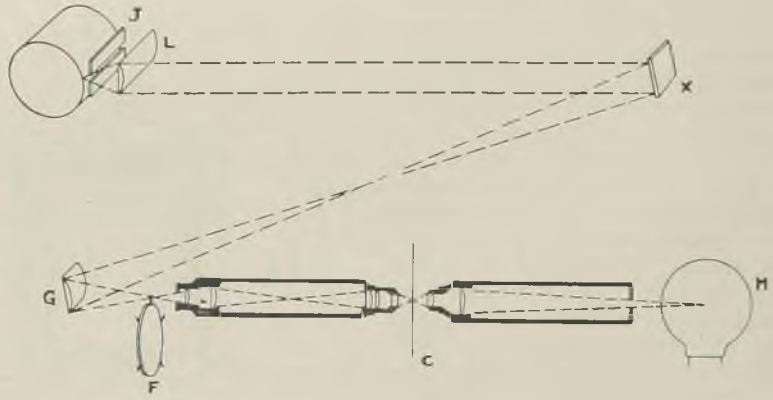


FIG. 4.—OPTICAL ARRANGEMENT OF PORTABLE CARDIOGRAPH.

Leads.—Various lengths, ranging from 150 ft. to 500 ft. of well insulated wire were employed. The longer lengths were of well insulated 3 (0·029) stranded steel cable, but the shorter lengths were of well insulated 0·029 twin copper wire.

Stop-Watches.—Two similar stop-watches were kindly supplied by the Director of the Meteorological Office, and these greatly assisted the timing arrangement.

PERSONNEL.—The personnel consisted of the author, Mr. D. S. Metcalfe (the Company's Geophysical Surveyor) and two assistants. The various duties connected with the survey were allocated as follows:—

The Author: In charge of the seismograph, explosive and detonators, and also the preparation of the charges.

Mr. Metcalfe: Assisting in the preparation of the charges. Responsible for laying the charges, making the necessary electrical connexions, and also the firing of the charges.

vibrometer, and the electro-cardiograph—were placed in separate huts about 60 ft. apart, and connected electrically. The vibrometer was set up and adjusted, after which the tent was closed and left, and so was protected as much as possible from local disturbances. The electro-cardiograph and the shot point were then connected electrically, and a sufficiently strong current passed through this circuit to energize the electro-magnet of the explosion marker on the electro-cardiograph. In the longer shots a voltage of 16 to 18 volts was necessary for this purpose. At the shot point this circuit was completed through a fuse wire either

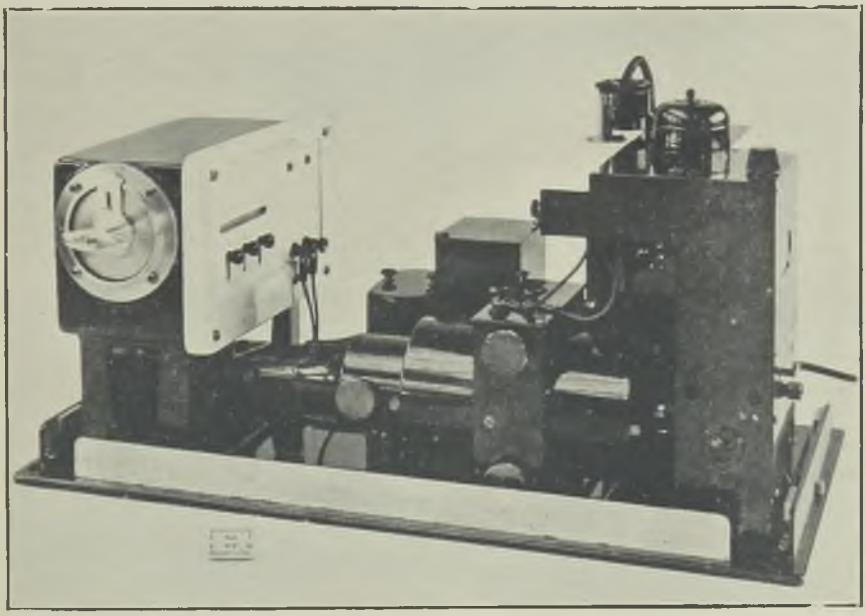


Fig. 5.—Cambridge Portable Electro-Cardiograph.

threaded through, or wound round the explosive charge (see Fig. 7) thus ensuring that the circuit was broken at the instant of explosion.

Charges Employed.—The maximum charge employed during the survey was 12 sticks of Arctic Gelignite, but only in exceptional cases did the number exceed eight. With this charge it was found that over short distances, even in the presence of considerable ground unrest, the first arrival was readily determined. As the distance increased, however, and approached 2,000 ft., the first arrival did not show up so readily, and it became more difficult to recognize the arrival of the first wave. There is little doubt therefore that larger charges should have been employed over distances greater than, say, $\frac{1}{4}$ mile. The amount of charge necessary, however, in any particular case varies considerably with the type of ground, with the distance, and also with the amount of ground unrest present at the time, the latter controlling the sensitivity at which the receiving and recording equipment may be satisfactorily operated. With the charges indicated above, the effect of the explosion was to produce a crater in the sand or shingle about 5 ft. in diameter and approximately 4 ft. deep. Pebbles of varying sizes were thrown laterally to a distance of about 250 ft. and vertically upwards to a height of approximately 400 ft. A photograph of one of the explosions resulting from the firing of 0·8 lb. of gelignite is shown in Fig. 8.

Preparing the Charge.—The charge was prepared by taking one of the cartridges, opening up the paper wrapping at one end, and thrusting a pointed wooden rod into the end of the explosive, thus making a cavity into which the detonator was pushed and completely buried. The paper cover was then replaced and bound firmly with twine, after which this end was well covered with tallow. The requisite number of gelignite sticks were arranged around the primer cartridge as centre, and the whole securely bound together with cord. A length of fuse wire was then threaded through or wound around the charge and connected to the two wires leading from the small electro-magnet

attached to the explosion marker on the electro-cardiograph, after which the charge was placed in the hole that had been dug to receive it, and the earth or sand carefully replaced.

In order to obtain the maximum effect from any explosion it is desirable that the charge should be buried well below the surface of the ground. Hubert has shown

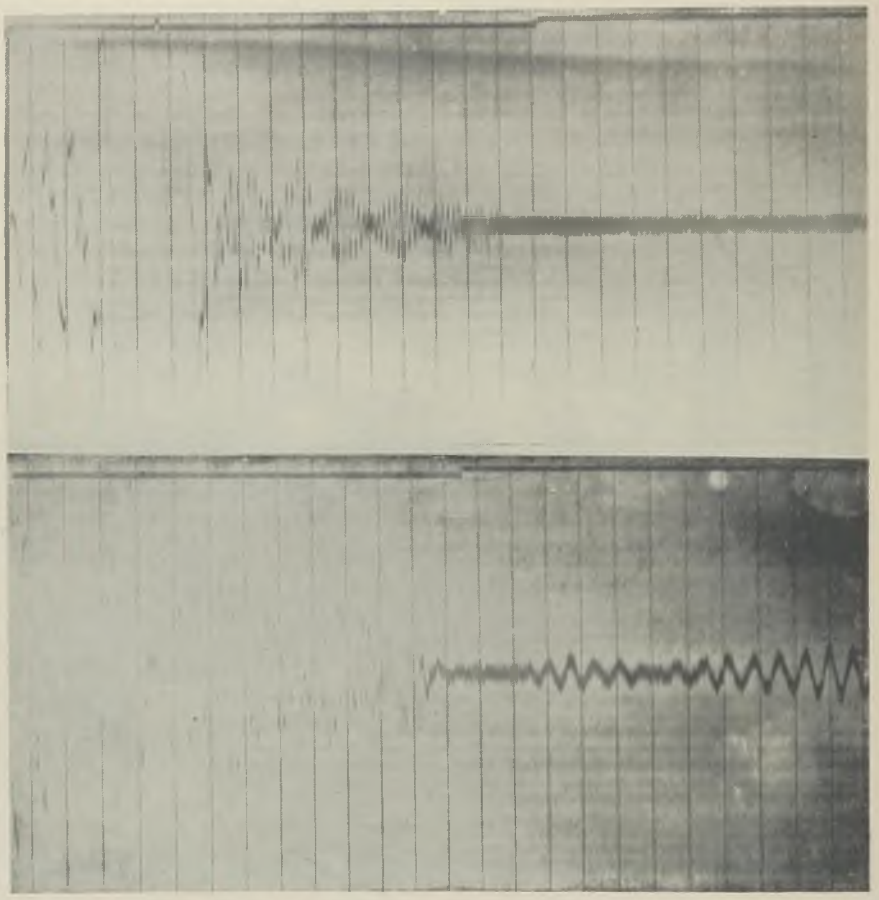


FIG. 6.—SEISMOGRAMS TAKEN WITH CAMBRIDGE ELECTRICAL SEISMOGRAPH.

that in this way it is possible to increase the effectiveness of a charge between 50 and 100 times. Owing to the water-logged state of the sand and gravel in this area it was in general impracticable to bury the charge at a depth greater than about 2 feet, so that, except for one or two shot points along the D traverse where the sand was dry, all shots were placed at this depth. Finally the detonator wires were connected up to the hand generator, which was located at a safe distance from the shot point, usually at about 250 ft. to 300 ft.

FIRING THE CHARGE.—The procedure of firing a shot was briefly as follows:—The two stop-watches were synchronized, one being held by the observer operating the seismograph and the other by the firing party. On receiving the signal that the laying of the charge and the necessary electrical connexions had been completed, the observer tested the explosion marking circuit, adjusted the sensitivity of the electro-cardiograph to the required value, inserted a film carrier drum and prepared to take a record. He then signalled to the firing party, and the charge was fired by closing a switch on the hand generator circuit at a predetermined time. A short time before the instant of detonation, the observer started the rotation of the film drum of the electro-cardiograph, so as to ensure that the time signal was properly recorded, followed by the arrival of the elastic waves.

One of the greatest difficulties encountered during the survey was the laying of land lines, and the maintenance of adequate

insulation of the many-jointed circuit over the water-logged tidal area in conditions of high-wind and rain and there is no doubt that with wireless recording of the instant of detonation instead of the land line the speed of operation would readily have been doubled. A further increased efficiency in the operation of the survey would result from the use of a group of three or four seismographs placed at different distances along the profile and all recording the same explosion. In this way the speed of operation can be greatly increased, and the cost of explosive reduced very materially, both of which are of considerable importance in commercial work.

Sensitivity of the Apparatus.—In order to obtain the most satisfactory results it is desirable to operate the seismograph at the maximum sensitivity consistent with ground unrest, but in order that the first arrival of the incoming waves should be most easily recognized it is preferable that this sensitivity should be adjusted so that the ground unrest is just smoothed out, and that the charge employed should be sufficiently powerful to produce a first arrival large enough to be noticeably recorded at this sensitivity. The readily variable sensitivity provided in the Cambridge instrument is, therefore, of great advantage, and is particularly convenient in the field. It enables work to be done under widely varying conditions and facilitates operations in high wind. In strong winds the sensitivity may be decreased so as to reduce the wind effects, thus necessitating higher charges, whereas in calm weather the sensitivity can be increased as much as is practicable. It is well known that a treeless area such as the one in which the survey was conducted is particularly favourable to seismic operations, and that work in the same atmospheric conditions may not have been possible in a wooded area, but on the other hand it is equally well known that surf on the coast is one of the most important factors in generating ground unrest, and this was present in close proximity to the seismograph, during practically the whole of the survey. The sensitivity of the seismograph equipment was such that on no occasion throughout the survey was it possible to operate the instrument at more than a very small percentage of its maximum sensitivity. Only in a few exceptional cases could the apparatus be worked with a sensitivity even up to 15 mm. per millivolt, while the scale of the instrument permits of a measurable sensitivity adjustment up to 40 mm. per millivolt, and much greater sensitivity can be employed if desired, although no provision is at present made for calibration under these conditions. At the present time, even when adjusted to the minimum sensitivity, a slight tap on the ground with the foot at a distance of 100 ft. gives a large deflection, while sledge hammer blows were readily recorded at distances of 200, 300, and 400 ft.

Fig. 7.—Diagram of electrical connexions used for exploding the charge and communicating the explosion time to the time-marker on the cardiograph.

Portability.—In comparison with instruments of the mechanical type due to Mintrop and Schweydar, this apparatus is somewhat larger and heavier, but this fact is more than counterbalanced by the great increase of sensitivity, and above all by the variable sensitivity. On the other hand the equipment is smaller, more portable, and more convenient than many other seismographs of the electrical type, which are usually mounted in a special car, carrying a large amount of electrical apparatus.

Velocity in Limestone.—In order to determine the velocity of the elastic waves in the Carboniferous limestone of this locality, shots were fired across the longest continuous outcrop of limestone available in the neighbourhood, a distance of 1,748 ft. At one end of the line two holes were drilled in the rock in close proximity to each other, but spaced sufficiently far apart to ensure

that the explosion of a charge inserted in one hole would not damage the other hole. The vibrometer was located at the other end of the outcrop, in a pit 3 feet deep and about 10 feet square, where it rested directly on the limestone. No protecting tent was placed around the vibrometer, but the electro-cardiograph was housed in a light tent situated on the surface about 20 ft. from the emplacement. Similar charges (4 sticks of gelignite) were fired in the two shot holes, one being exploded in the usual way by a high tension electric detonator, while the other was fired through 4 feet of the new instantaneous type of fuse known as "Cordeau-detonant," by means of an electric high tension detonator. This limestone velocity test, which was conducted in the immediate vicinity of the mine, was undertaken on a Saturday after the mine had closed down for the week end in order to ensure the least possible disturbance from the usual working activities; considerable vibration was, however, still obtained from a Cornish pump at a distance from the seismograph of only about 250 ft. The two values for the velocity in limestone obtained from these two shots were 16,300 and 16,450 ft. per sec. respectively so that 16,400 ft. per sec. has been taken as a close approximation to the mean value. This agrees exactly with the figure given by Sieberg.

Examination of the Records.—The photographic record obtained from the electro-cardiograph, see Fig. 6, is in the form of a film negative $6\frac{3}{4}$ in. by $3\frac{1}{4}$ in. clamped round a carrier drum. The revolution of this drum causes the film to pass continuously past a fine slit through which the exposure is made. The complete rotation occupies a period of about $5\frac{1}{2}$ seconds, so that a continuous record is obtained over this interval. By means of the time-marker previously described, the record is traversed vertically by a series of parallel lines at intervals of $\frac{1}{5}$ second. In this way it is possible to determine quickly and with reasonable accuracy the moment of arrival of any individual wave with relation to the previously recorded explosion time. In cases

Fig. 8.—Explosion of eight sticks of Arctic Gelignite buried at a depth of 2 ft.

where the explosive charge is adequate, the first arrival shows up particularly well. The earlier waves to reach the instrument are in general damped out fairly quickly, so that the time of arrival of succeeding waves can be readily determined, some records showing up the arrival of several separate incoming waves. In other cases, however, where the charge is somewhat inadequate, the first arrival does not show up so readily, and the measurement of the record becomes a matter of greater difficulty.

Measurement of the Records.—It proved both practicable and convenient to measure the records by means of a Coradi-Co-ordinatograph which was available at the Science Museum. With this instrument it was found possible to measure the time intervals with an accuracy of approximately 0·001 of a second, but for various reasons it is doubtful if an accuracy even of 0·003 sec. can be claimed for the final results.

Results of the Survey.—As may be seen from Fig. 1 three seismic profiles were shot across and perpendicular to the fault, with the seismograph situated respectively at the points marked *A*, *B*, and *C*. As a result of the information obtained from these three traverses, it was hoped that it might be possible to indicate both the position and throw of the fault. A further test was made in order to estimate the depth of the limestone below the surface, at a place where it had already been determined by boring, and along a line where the depth was considered to be fairly constant. This line was chosen

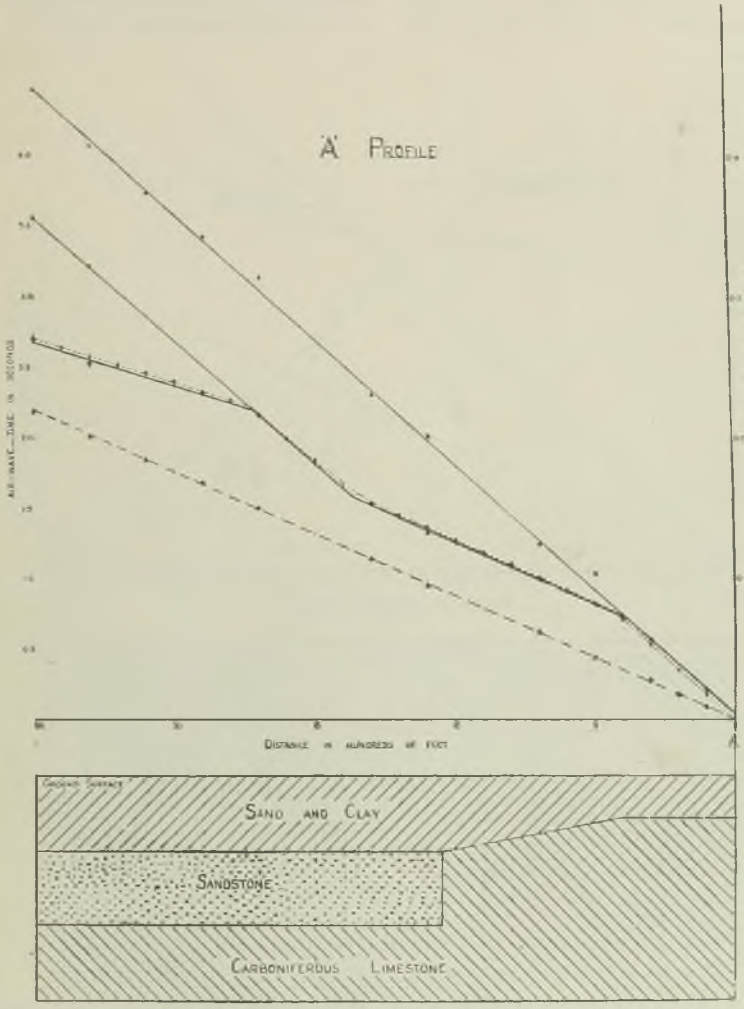


Fig. 9.—Time-distance curves obtained along "A" profile.

on the upthrow side of the fault, through the borehole B.H. 63, and parallel to the fault. In shooting this traverse the seismograph was located at the point *D*.

"A" PROFILE.—The results obtained from the "A" profile are given in Fig. 9 in which the fault is shown in the position indicated by a gravity survey carried out in 1928. The time-distance curve obtained from a measurement of the records to the time scale given on the right is shown by a continuous thick line, while second and sometimes third arrivals are indicated where distinguished. The curves showing these later arrivals are represented by thinner continuous lines. The heavy line represents the time of first arrival, and shows two distinct discontinuities. The first occurs at a distance of approximately 400 ft. from the explosion point, and for distances greater than this, the first wave to arrive travels for some part of its path through limestone. After passing the fault the first arrival curve is deflected somewhat, but does not suffer another definite discontinuity until at a distance of 1,720 ft. from the explosion. The upper line shows the times of arrival of the wave travelling along the earth's surface, while the thinner branch after the second discontinuity corresponds to the time of arrival of waves radiating from the upper edge of the limestone-sandstone fault. The theoretical curve resulting from calculations of the structure assumed from the gravity survey is shown by a dotted line, and is seen to agree very closely with that obtained by measurement of the seismic records. The lowest broken line (which is drawn to a different time scale, shown on the left) gives the time of arrival of the air-wave as measured on the records.

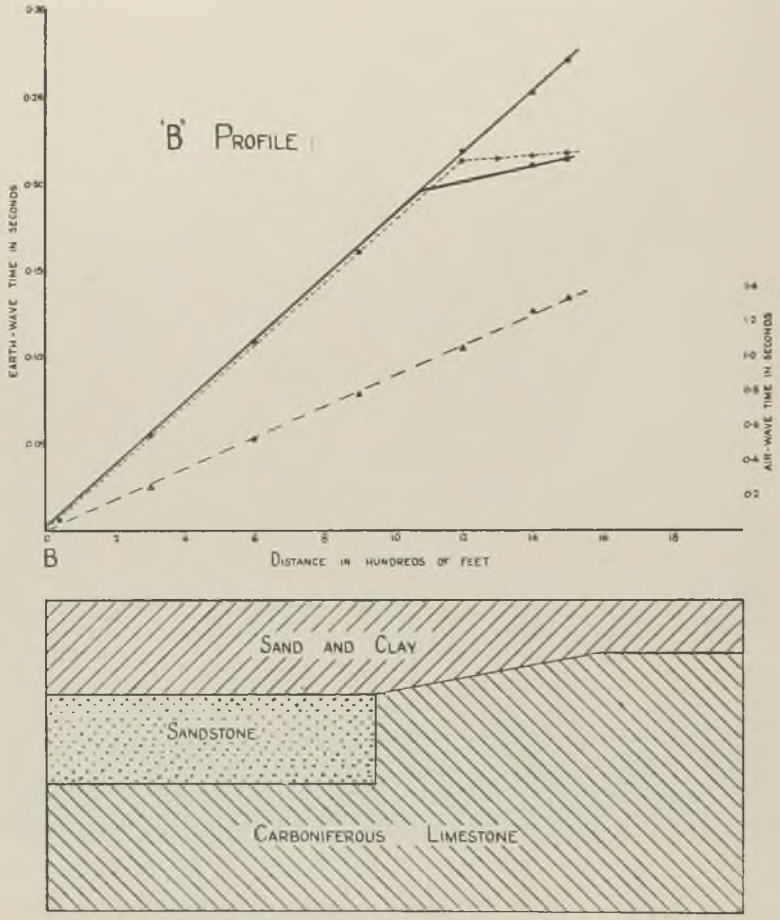


FIG. 10.—TIME-DISTANCE CURVES OBTAINED ALONG "B" PROFILE.

"B" PROFILE.—This profile was shot across the fault in the reverse direction to the "A" profile, the distance between the

two points A and B being 2,000 ft. As in the former case the curves obtained from measurement of the records are given together with a theoretical curve calculated from the assumed structure, see Fig. 10. In this case the earth-wave scale is shown on the left and the air-wave one on the right.

"C" PROFILE.—This profile was shot along the same line and in the same direction as the "B" profile, the distance from B to C being 300 ft. Both practical and theoretical results are given in Fig. 11, as in the case of the previous profiles, the earth-wave and air-wave scale being arranged as in Fig. 10. Unfortunately it was not possible to continue the B and C profiles further towards the east owing to the presence of the Outer Barrier which effectively prevented the shooting of charges beyond the points recorded.

"D" PROFILE.—The time-distance curve of this traverse is shown in Fig. 12 from which it may be seen that the discontinuity occurs at a distance from the seismograph of 700 ft. Taking the velocity of elastic waves in the glacial drift and in Carboniferous limestone as 5,650 ft. per sec. and 16,400 ft. per sec. respectively, we have from the formula

$$\text{Depth} = \frac{\text{distance to discontinuity}}{2}\sqrt{\frac{V_2 - V_1}{V_2 + V_1}}$$

$$= \frac{700}{2}\sqrt{\frac{10750}{22050}} = 244{\cdot}5 \text{ ft.}$$

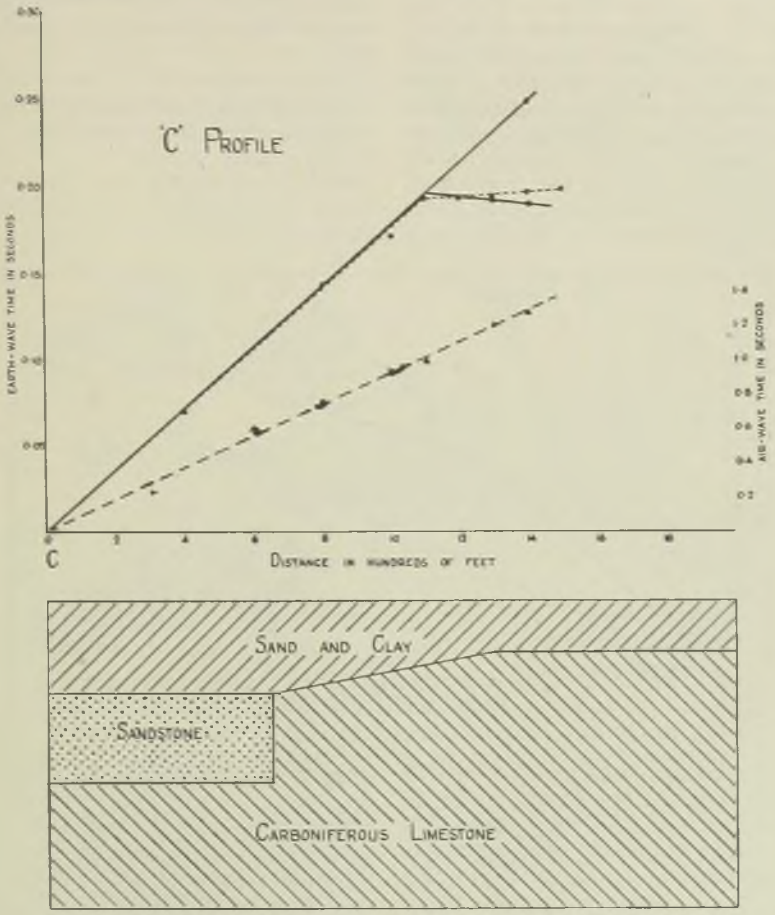


FIG. 11.—TIME-DISTANCE CURVES OBTAINED ALONG "C" PROFILE.

which gives the depth of the limestone below the surface as 244·5 ft. The actual depth of the limestone below the surface at B.H. 63 is 257·3 ft., so that assuming the depth of the limestone-drift interface to be horizontal along the "D" profile, the error of the determination by the seismic method is 12·8 ft., or slightly under 5% of the actual value.

EXAMINATION OF THE RESULTS.—From an inspection of the time-distance curves of Figs. 9, 10, and 11, it is apparent that the

results of this survey with the elastic-wave method agree very closely with the curves to be expected from the assumed structure, as given by a previous gravity survey. Both the position and throw of the fault are confirmed in a manner which is eminently satisfactory, while in view of the known irregularities of the limestone-drift interface, the depth of this interface on the up-throw side of the fault as determined by the seismograph agrees very closely with the borehole figure. It is of interest to note that generally the second, and sometimes subsequent arrivals were readily recognized, while in addition the air-wave was usually picked up well. In certain cases where the explosion "C," and "D" profiles. The interval between the arrival of these explosion reports was found to increase with the distance of the explosion, and the length of this interval (estimated roughly by the observer) would appear to suggest that the first arrival may under favourable conditions actually be "heard" by the observer, this being followed later by the usual air-wave. On the longer shots of the "A" traverse three reports were distinctly heard, so that one of the later earth-waves may in these cases have been heard also.

Conclusions.—The results of the above tests may be summarized briefly as follows:—(1) Under favourable conditions, the seismic

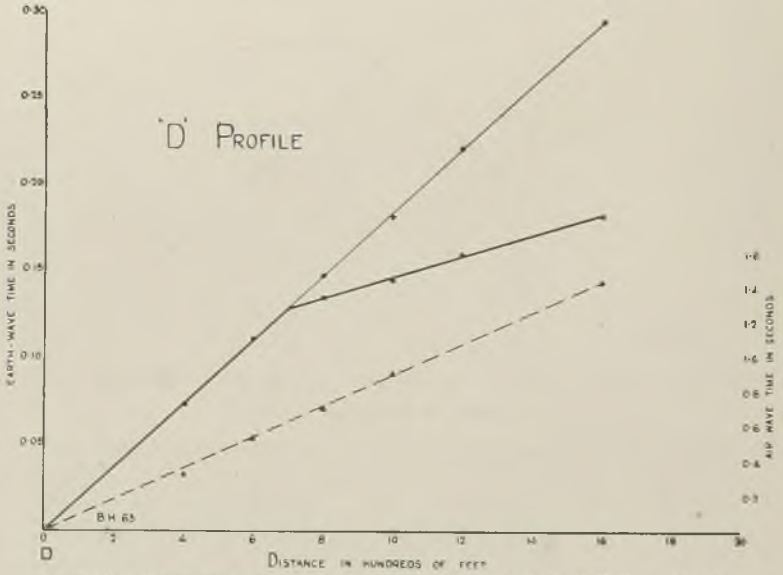


Fig. 12.—Time-distance curves obtained along "D" profile.

signal was not recorded, the time of explosion has been computed in the manner employed in the earlier seismic surveys, but this practice is open to numerous objections and is not recommended. Land-lines also are very inconvenient, except in the most suitable localities, and the use of wireless for communication, signalling, and even firing, is likely to produce the most satisfactory and efficient results, and to increase the speed of operations very considerably.

Sound Waves.—An interesting feature of the tests was the arrival of what appeared to be two or occasionally three distinct sound waves. These waves were first noticed during the shooting of the "A" profile, when the explosion and the seismograph were located on opposite sides of the Outer Barrier (a high and massive sea wall of concrete) and were also heard later when shooting the "B," method of geophysical surveying is capable of locating certain geological structures satisfactorily, and in the case of a fault where dissimilar rocks or strata abut upon each other, on either side of the plane of fracture, it is possible to estimate very closely both the position and the throw. (2) In suitable cases it is also possible to ascertain with fair accuracy the depth below the surface of a horizontal or slightly inclined interface. (3) The Cambridge electric seismograph employed in these tests has proved suitable for the purpose and is simple and convenient to operate in the field. (4) The readily variable sensitivity in this apparatus is a particularly useful feature, and enables the instrument to be employed at the maximum sensitivity that the ground unrest will permit and under widely varying atmospheric conditions.

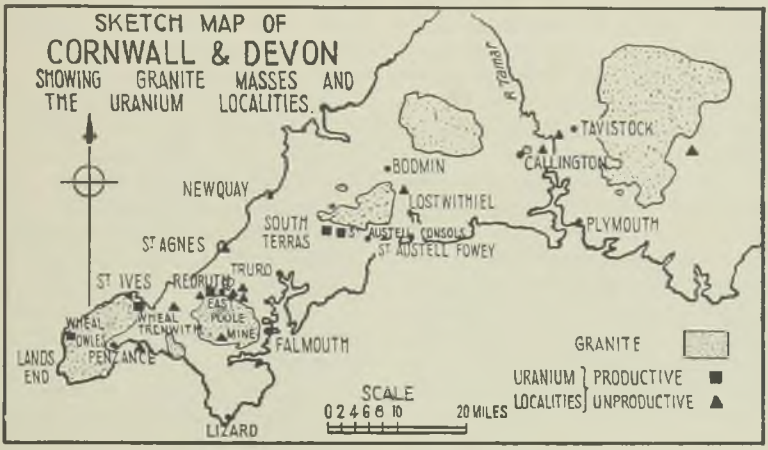
URANIUM IN CORNWALL

By H. G. DINES, A.R.S.M., A.I.M.M.

The author describes briefly the habits of uranium minerals and summarizes the occurrences in the West of England.

INTRODUCTION.—In the issue of the MAGAZINE for April, 1929, the Cornish correspondent, in an endeavour to stimulate interest in the possibilities of Cornwall as a radium producer, suggested systematic prospecting of the old mine dumps. Uranium-bearing minerals have been recorded as occurring in many Cornish mines, and J. H. Collins goes so far as to state that they have "been found in the form of groups of fragile crystals in the shallow parts of almost every copper mine in the county."[1] The most important of the known occurrences are those of Wheal Trenwith, St. Ives, and South Terras Mine, St. Stephen. Collins was well acquainted with both of these, and he expressed his belief that they are not the only workable ore-bodies thus: "Contrary to the general opinion, . . . Trenwith is by no means the only mine in Cornwall which is capable of producing considerable quantities of uranium. Such ores have been found in scores of mines, and at the uranium mines near Grampound Road [South Terras] have been sold by hundreds of tons. . . ."[2] Up to the present, however, the hopes expressed by Collins have not materialized, no further large ore-bodies having been found.

Since the discovery of the radio-active properties of radium, those engaged in mining operations in Cornwall have been watchful for further occurrences of these minerals and even small indications have been made known. In some cases, however, there is no doubt that certain green minerals have been erroneously referred to as "uranites." Moreover, some of the published records appear to be of little more than academic interest. At Wheal Buller, Redruth, for instance, uranite is stated to have been phosphorescent and easily discernible in the mine workings when lights were extinguished. This interesting fact has been frequently referred to by writers on Cornish mining, but there is no record of uranium-minerals having been exploited at this mine. On the other hand, it is conceivable that though the brightly coloured crystals of the uranites have attracted attention, the less obvious pitchblende may have escaped notice, especially since it was at one time regarded as an undesirable gangue mineral. A note on the pitchblende at Wheal Trenwith by Henwood is interesting in this respect. He states: "Pitch-blende occurs in great abundance among the copper ores of Wheal Trenwith, and was long carefully collected, and thought to be black copper ore. The low prices obtained for the ores with which it was mixed, and the inferiority of the metal they yielded, equally disappointed the miner and the copper-smelter; until a specimen of the copper was examined by Mr. Mitchell of Calenick and found mixed



[1] "Observations on the West of England Mining Region," *Trans. Roy. Geol. Soc. Corn.*, vol. xiv, 1912, p. 343.

[2] Ibid., p. 158.

with titanium in a metallic state. The ores were then inspected, and pitch-blende being discovered among them, its nature and prejudice to the copper ores were explained to the workmen, by whom it has been, of course, since rejected. Was there ever an instance in which an acquaintance with mineralogy and chemistry would have been more useful?"[1] This is sufficient to show that had the pitchblende not occurred in sufficient quantities as to affect the quality of the copper-ore it may never have been recorded here.

The writer has endeavoured to set out below a brief account of the habits of uranium minerals, and a summary of the records of occurrences in the West of England. The records have been obtained from published works on Cornish mining, chiefly those of Henwood and Collins, and from the mining notes by D. A. MacAlister, which appear in various district memoirs of the Geological Survey. Other sources of information, no doubt, exist, such as the old mine records mentioned in the letter of the Cornish correspondent above referred to. In making an examination of any particular district information obtained from such sources may be of considerable value.

Mode of Occurrence.—The chief uranium minerals occurring in Cornwall are pitchblende, autunite, and torbernite. Pitchblende, as its name implies, is a black, massive substance, with no individual characteristics. It may easily be mistaken for other minerals, such as certain ores of zinc and iron. The "uranites", autunite (calcium-uranite) and torbernite (copper-uranite) are alteration products of pitch-blende, and are confined to the zones of secondary alteration of the lodes. The former is usually greenish-yellow and the latter vivid green. They occur as bunches of crystals incrusting vughs or fissures. Zippeite (hydrated uranium sulphate), another alteration product, sometimes referred to as uranochre, occurs as a canary-yellow fibrous or scaly incrustation, but this mineral is less widely distributed.

Pitchblende, like the other Cornish lode-minerals, was deposited by the magmatic vapours or solutions emanating from the magma of the granite intrusions. As well as occurring in lodes it is also known to be associated with the kaolinization of felspar, specimens of uranite having been found in altered granite near Redruth,[1] at Tolcarne mine, Gwennap, and at Stenna Gwynn, St. Austell. It belongs to a group of minerals which was precipitated at comparatively low temperatures, and in nearly all recorded instances is associated with such "low temperature" minerals as those of iron, cobalt, nickel, bismuth, and sometimes lead or zinc. It may, therefore, be expected to occur under any of the following conditions:—

(*a*) As a lode mineral filling a fissure-vein at some distance from the granite intrusions. Under such circumstances it might be said to come in its proper position in the zonal sequence of ore deposition.[2] The writer is not aware, however, of any case in which pitchblende is known to occur in this position. In the district around Perranporth, south of Newquay, there are many lodes carrying silver, lead and zinc, but neither pitchblende nor the minerals usually associated with it are known to occur here.

(*b*) As a lode mineral filling fissure-veins, in or near the granite, which are later than the main tin and copper lodes of the neighbourhood. As an example of this mode of occurrence attention may be drawn to the area south of the St. Austell granite mass where the tin and copper lodes course roughly east and west, while a later series of lodes or cross-courses striking roughly north and south carry cobalt-, nickel-, and uranium-ores (e.g. South Terras Mine and St. Austell Consols).

(*c*) As a late accessory mineral in the tin and copper lodes, filling fissures caused by widening of the original lode, in small veins crossing the lode or at points of intersection of tin or copper lodes and cross-courses. By far the majority of the recorded occurrences come under this class, Wheal Trenwith probably being the best known example.

In nearly all the mines at which autunite, torbernite, and zippeite are noted they occur in the zone of secondary alteration and are recorded as from the upper levels of the mines. In many cases where these minerals occur, the primary pitchblende is recorded as coming on in depth, below the alteration zone as, for example, at South Terras Mine.

[1] *Trans. Roy. Geol. Soc. Corn.*, vol. v, 1843, p. 19.

[1] Rudler, F. W., "Minerals of the British Islands," *Mem. Geol. Surv.*, 1905, p. 82.

[2] See E. H. Davison, "Recent Evidence Concerning the Zonal Arrangement of Minerals in the Cornish Lodes," *Economic Geology*, vol. xxii, 1927, pp. 475–9.

Mines with Recorded Outputs.— *Wheal Owles*, St. Just, is interesting in that pitchblende, torbernite, and zippeite occurred in tin and copper lodes associated with iron and manganese ores such as hæmatite, gœthite, vivianite, and rhodocrosite, as well as with bismuth, and cobalt and bismuth are recorded in adjoining mines. This mine which was worked together with Boscean Mine was latterly included in the Botallack sett. It was flooded in 1893 due to breaking into flooded workings of an old adjacent mine. Recorded output of uranium-ores with bismuth is 5 cwt. in 1878 and 1879.

Wheal Trenwith, with which may be included *Wheal Providence*, is situated at St. Ives. Pitchblende occurred in such quantities mixed with copper-ore as to affect smelting and ore carrying a high content was cast upon the dumps. In 1907 the dumps were being turned over for the mineral, and in 1908 a company registered as St. Ives Consolidated Mines took over Wheal Trenwith and a number of other mines and tin-, copper-, and uranium-ores were raised. The property was worked by another company from 1917 to 1923, but work was concentrated on a part of the property known as the Giew, and only tin was produced. Pitchblende is recorded as occurring on the 20 and 40 fm. levels in Wheal Providence and has also been noted in workings extending under the sea on the 30 fm. level. At Trenwith it is noted especially on the 35 fm. level, and is apparently associated with torbernite and with cobalt; bismuth, zinc-blende, and galena also occur in the lode. The pitchblende is confined to the same parts of the lode as the shoots of copper-ore, and occurs as stringers along the walls. It is also noted as extending into the country-rock for a distance of 40 ft. from the lode, on the south side; between sea-level and 75 fm. below, the country-rock is fractured and the pitchblende forms lenses and veinlets along the cracks, the surrounding slates also being impregnated with oxides of uranium.[1] The output of uranium-ore from these mines must have been considerable, but there appears to be no record of output except that of three tons of uranium-ore from Wheal Providence before 1846 and several hundredweight since. It was stated, however, that the supply of pitchblende and other uranium-ores in the mine and dumps was worth £80,000 in 1913.[1]

East Pool and Agar, Illogan, near Camborne, works on the important group of tin and copper lodes on the north side of the Carnmenellis granite mass. There appears to be very little information concerning the uranium-ores, but the occurrence of nickel, cobalt, and bismuth are noted, and small outputs of ores of these metals have been recorded, including one of 4½ tons of uranium-ore prior to 1905.

South Terras Mine, St. Stephen near Grampound Road, is situated on the south side of the St. Austell granite mass. The lode courses roughly north and south, and belongs to a later group of fissures. The mine was worked in the early days for tin and for iron which occurred in two distinct lodes coursing roughly north by east, and west-north-west respectively. The uranium lode crosses the others near their intersection and was first encountered in 1873. Development on this lode commenced in 1878 when the 10 and 20 fm. levels (below adit) were driven in that part of the lode which yielded mainly uranites with some pitchblende. The 30 and 40 fm. levels were driven after 1906 and it was found that below 30 fathoms pitchblende only occurred, occupying a shoot pitching north. The ore was originally shipped to Germany for the manufacture of uranium glass. For this purpose the ore was picked to reach a required minimum grade and anything under 3% U_3O_8 was deposited in the dumps. In 1913 the Société Industrielle du Radium, Ltd., took over the property to recover the radium content. It was then estimated that the dumps and stope filling contained 36 gm. radium. In 1927 the mine was taken over by the British and General Radium Corporation, Ltd., which company had, in 1929, unwatered the mine and commenced exploring the lode for further orebodies.

The lode averages 2 ft. wide and quartz generally occupies the full width, with inclusions of slate country rock in places. Apart from the ore shoot, metallic minerals are scanty. They occur usually in small scattered crystals either in the quartz or lining vughs. There is no indication of pitchblende having been confined to any particular portion of the lode, though it is said to have occurred in stringers near the walls. The associated minerals are

[1] Cann, F. C., "The Mines, Lodes, and Minerals of the Stennack Valley, St. Ives," *Trans. Corn. Inst. Engineers*, vol. v, 1917, pp. 16, 17.

[1] The Mining Magazine, Vol. VIII, 1913, p. 42.

iron and copper pyrites, arsenopyrite, galena, and traces of nickel-, cobalt-, and chromium-ores.[1] The recorded output up to 1907 was 545 tons of uranium-ore, but the figure given is probably incomplete. There are no records of later output.

St. Austell Consols, St. Stephen, is situated two miles east-south-east of South Terras and five miles west of St. Austell. The main lode coursing roughly east and west carried occasionally in the middle. This suggests that uranium was one of the last minerals to be deposited, forming in cavities produced by widening of the mineralized fissure. The association of barytes with the minerals in this mine is also significant, though there is no record as to whether it occurred in the main lode or in the cross-courses, though the probability is that it was found in the latter. Records of output up to

Mine.	Locality.	Minerals and Remarks.
Dolcoath	Camborne	Pitchblende with bismuth and arsenical cobalt.
Wheal Edward	St. Just	Pitchblende on 40 fm. level, and uranite on 20 fm. level. Zippeite also occurred and bismuth. The uranium-ores were separated from the walls of the lode by "earthy-brown iron-ore."
South Tresavean	Redruth	Uranium-ore with niccolite, silver- and lead-ores.
Roskrow United Mines	Nr. Ponsanooth	Uranium-ores with nickel- and silver-ores.
Wheal Buller	Redruth	Phosphorescent uranite and zippeite.
South Wheal Basset	Redruth	Torbernite and autunite.
West Wheal Basset	Redruth	Autunite.
Wheal Basset	Redruth	Pitchblende.
Ting Tang Mine	Gwennap	Pitchblende and uranite.
Tolcarne	Gwennap	Pitchblende and uranite, both occurring at 35 fm. from surface.
Wheal Gorland	Gwennap	Pitchblende and uranite.
Wheal Unity	Gwennap	Pitchblende and uranite.
Tincroft	Illogan	Pitchblende and uranite.
Pedn-an-Drea	Redruth	Pitchblende and uranite.
Herland	Gwinear	Uranite with cobalt and arsenical-ores.
East Wheal Lovell	Wendron	Pitchblende.
New Crow Hill Mine	St. Stephen	Situated south of South Terras Mine. Uranium-ore said to occur with silver-, lead-, and zinc-ores.
Egloshellen Mine	St. Stephen	Situated north of South Terras Mine. Torbernite said to have been found at the intersection of a tin lode and a cross-course.
Tolgarrick Mine	St. Stephen	Situated south of South Terras Mine. Exploration levels were driven to search for a southward extension of South Terras uranium lode, without success, but an elvan dyke was driven through from which highly radio-active water entered the workings.
Gunnislake Clitters	Callington	Fine crystals of torbernite were obtained here. Zippeite also occurs, but there is no record of pitchblende.
Bedford United Mines	Nr. Tavistock, Devonshire	Uranite.

tin and copper with some arsenic and cobalt, but no nickel- or uranium-ores. Nickel cobalt and uranium occurred mainly in north-south cross-courses. The richest of these crosses the main lode in the western part of the sett and carries niccolite and smaltite. It is noteworthy that where copper-ore occurred in cross-courses, nickel was absent and that uranium occurred mainly at the sides of the cross-courses but

[1] For further information see T. Robertson and H. G. Dines, "The South Terras Radium Deposit, Cornwall," THE MINING MAGAZINE, Vol. XLI, 1929, p. 147.

1863 show 2½ tons of uranium-ore with 128 tons of nickel- and cobalt-ore. The mine does not appear to have been worked since 1879.

MINES WITH NO RECORDED OUTPUTS.—The accompanying table gives a list of mines in which uranium minerals have been found, but little or no further information than that given here is available. No claim is made that this completes the list of Cornish occurrences, but all the records may be taken as authentic. The following localities may be added to those in the table:—The St. Agnes district, where pitchblende occurs

with cobalt, but the names of the mines at which they were found are unknown; St. Michael's Mount, where uranium minerals occur, and in the vicinity of which cobalt has been worked at the Wherry Mine, though uranium is not recorded; and Buckfastleigh, in Devonshire,[1] where pitchblende has been noted.

The writer is indebted to Mr. E. H. Davison, of Camborne, for the following notes:—Pitchblende is known to occur in an old dump at Nance, about three miles south of St. Ives, and in an old adit-level at Nanpusker, Gwinear. The dump of the Stray Park part of the Dolcoath sett contains uranium-ores and a few hundredweights are said to have been sold from here. Torbernite occurs lining fissures and joints in the pegmatite that is quarried at Ponsanooth, two miles north-east of Redruth, and it is also reputed to occur in an old mine opposite the quarry.

[1] *The Times*, January 18, 1919, and *Nature*, vol. cii, 1919, p. 427.

MAGNESITE DEPOSITS IN SERBIA

By A. IGNATIEFF, A.R.S.M., B.Sc.

The author describes deposits of magnesite in Serbian Macedonia and gives a theory for the genesis of the mineral.

The magnesite of Serbian Macedonia is a compact, cryptocrystalline mineral, and has a low iron and lime content which makes it valuable for the production of caustic magnesia. A picked sample gave the following analysis: $MgCO_3$, 98·25%; $CaCO_3$, 1·16%; Fe_2O_3, 0·28%; SiO_2, 0·12%.

The magnesite is found throughout Central Serbian Macedonia, mostly as small local occurrences of little economic value, with the exception of the deposits described in this paper. These occur about 25 kilometres south of Skoplie, a station on the Salonica-Belgrade Railway, and are situated between Zelenikovo village and the Pchinya River in a belt of country one and a half kilometres broad and ten kilometres long, following the valley of the Vardar River. (See Fig. 1.) Most of the actual mining work has been done on the southern end of the area.

The country is mountainous and barren. Some of the peaks attain altitudes of as much as 2,000 metres. Large plains representing tectonic basins which were probably lakes in late Pliocene times occur to the east and west of this plateau-like country. Ochvie Polie, situated to the east of the district, is an example of such a depression. The Vardar, the most important river, appears to be the axis of a large tectonic break. Its course (N.W.–S.E.) coincides generally with the main strike of the rocks

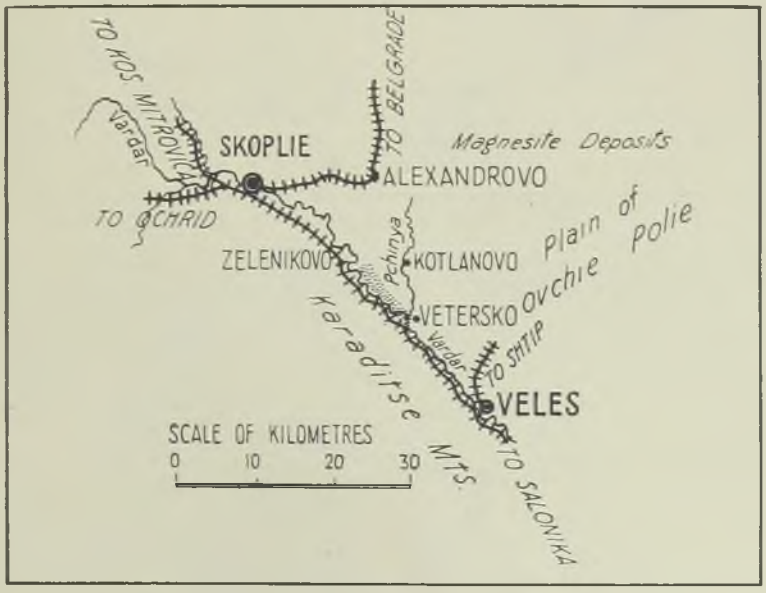


FIG. 1.—SKETCH MAP SHOWING THE LOCATION OF THE AREA

from its delta near Salonica to north of Skoplie, where it changes to a more westerly direction. The Pchinya is a tributary from the east, and both rivers have cut deep and narrow valleys in this region.

The country rock along the Vardar River, south of Skoplie, is a serpentinized peridotite of recent geological date, composed largely of altered olivine, with hypersthene and a little chlorite. In places the peridotite is entirely altered to serpentine rock containing a little talc, and it is then mineralized with

The older rocks are Palæozoic limestones and slates which have been metamorphosed to dolomites and schists. The limestone occurs in belts 200 to 300 metres wide with an approximate N.W.–S.E. strike and steep easterly dip; two of such belts are found in this area (Fig. 2), the eastern being the more prominent.

Certain basic minerals are found in irregular masses along the contacts with the serpentine rock, namely, chromite, magnetite, and manganese oxides. The chromite and

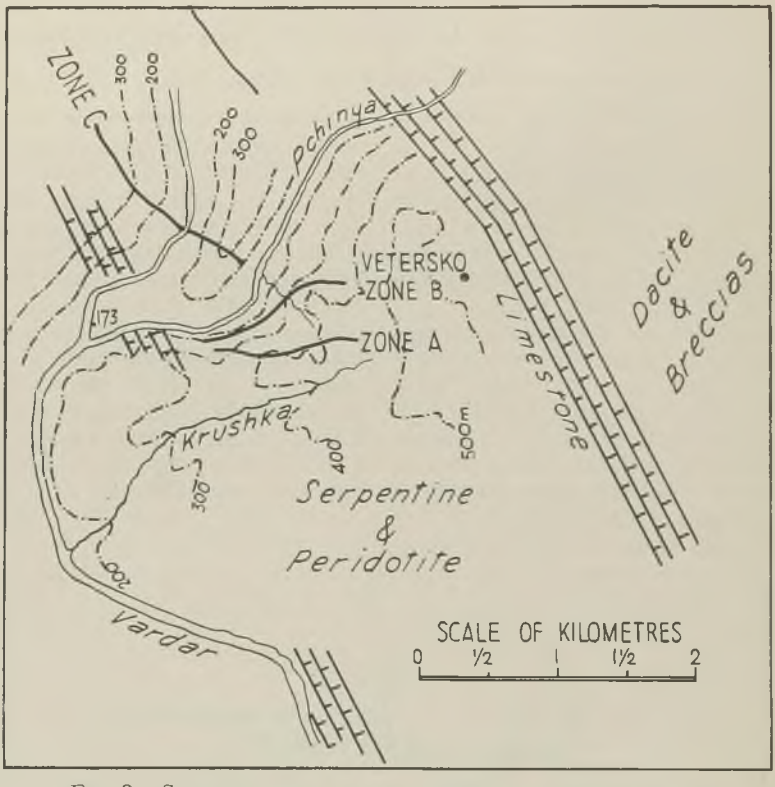


FIG. 2.—SOUTHERN END OF AREA, SHOWING MAGNESITE ZONES.

magnesite, the deposits of this mineral being found only in this rock formation. To the south of the Pchinya, towards Veles, the peridotite shows less alteration and only traces of magnesite are found; the rock is then rich in hypersthene schlieren and contains deposits of basic ores. Still further south, along the Vardar Valley, the peridotite passes into a gabbro, which is well developed at the Greek frontier. The valley is the eastern edge of a great basic batholith which outcrops over a great extent of the country; to the east and west of this intrusion rocks that are more acid occur.

magnetite are probably magmatic segregations as they become more important to the south of the area where the country rock is more basic. The manganese minerals occur in irregularly distributed patches and veinlets along the contacts. Ophicalcite occurs along the contact zone of the limestones with the serpentine.

To the east of the belt of limestone occurs an intrusion of dacite. It is in contact with the eastern belt of limestone (Fig. 2), which it has metamorphosed, and small unimportant deposits of pyrolusite and graphite have resulted. Nodules of pyrolusite are

found on the edge of the plain of Ochvie Polie, south-east of the area, in the dacite, which has been weathered to clays and sands. The dacite is probably older than the peridotite intrusion and is associated with breccias which have resisted weathering and later earth movement.

The magnesite occurs entirely in the peridotite mass which has been altered to serpentine. The deposits become less important towards the contacts, and in most cases peter out altogether before the contact zone is reached. On broad lines, the ore occurs as aggregative masses and networks of veins traversing the serpentine. A careful inspection of the distribution of the magnesite reveals the occurrences to be situated in zones of definite trend, particularly in the case of the larger deposits. In these zones, and, at times, outside them, the joint planes of the serpentine rock are lined with films or plates of a magnesitiferous material and these are particularly prominent near or at the surface, giving the rock a characteristic appearance. It should be noted that traces of the mineral have been found sporadically distributed (not in zones) almost everywhere where the peridotite has been altered to serpentine. The latter form of occurrence is, of course, of no economic value, but gives some indication as to its genesis.

The workable deposits occur generally as lens-shaped veins of no great length or as pockets varying from small nodules to irregular masses of 50 to 100 tons (Fig. 3). As was pointed out above, the occurrence is very sporadic but the survey of outcrops and development of the bodies have revealed that they occur in well-defined zones. Zones A, B, and C (Fig. 2) are taken as representative of this area, though there are several others which have been developed to a lesser extent. Zones A and B are seen striking nearly parallel to the course of the Pchinya River, where the latter flows into the Vardar. Zone A outcrops on high ground and is characteristically a pocket or nest occurrence, though narrow stringers can be traced throughout for short distances. Zone B represents more the vein type of occurrence; there is one distinct vein which may be traced intermittently between the 200 and 300 metre contours for about a kilometre, the length of unbroken outcrop being 200 metres in one place. In the central section of this zone (near and at the Trchi Stream) the vein attains widths of $1\frac{1}{2}$ metres, but towards the western end merges into an intermittent pocket formation. The vein dips steeply into the hillside. Development work revealed that this vein narrows in depth, and in some cases disappears entirely at 8 to 10 metres from the surface. Besides this vein, numerous others with varying strikes and dips are found in this zone, but they are too short, narrow, and impure to be workable. As a general rule it has been found that the pockets and veins of magnesite do not continue in depth and that the best quality of mineral is found very near the surface, generally at the centre of these deposits.

FIG. 3.—POCKET OF MAGNESITE ON ZONE "A."

It is probable that these zones of mineralization lie along lines of weakness —fracture zones or fissures—which have been used by the mineralizing solutions as circulating channels. A more striking example of a fracture zone is zone C, the direction of which is nearly at right-angles

to A and B. A distinct lode of magnesite, apart from numerous unworkable veins and pockets as in the case of the other zones, can be traced intermittently from the northern bank of the Pchinya across to the western bank of the Vardar for about a kilometre (Fig. 4). This vein does not continue south across the Pchinya or in depth below the 200 metre contour. The main vein is three metres wide (Fig. 5) on the northern slope of the Pchinya Valley, where it has been worked, but it narrows in outcrop and depth further north where it has been explored by trenching; its dip is steep and easterly, corresponding to the dip of the contacts described above. In places the vein peters out and a series of pockets

formation of the ore in the latter area was later than in the former.

It is of some interest that springs of mineral water of medicinal value occur in this district (Kotlanovo particularly). These contain magnesium sulphate and chloride, and the former is also found as incrustations in the serpentine.

In considering the question of the genesis of these magnesite deposits it may be well to summarize the evidence under the following five heads :—

(1) Magnesite is not a contact mineral.

(2) The magnesite occurs in fracture zones in the serpentine rock only; these fissures represent circulating channels for mineralizing solutions.

FIG. 4.—EXAMPLE OF VEIN-OCCURRENCE ON ZONE "C."
Pchinya River in foreground: Vardar River in hills in background.

are exposed on the same strike but separated by barren ground.

Other parallel zones occur to the east of zone C but the veins are narrower and shorter. A characteristic feature of these veins is that they are generally more intermixed with country rock than the nests or pockets, the latter type of occurrence being more developed in zones A and B south of the Pchinya, and it is claimed that some of the deposits in the latter zones yield better quality ore than those north of the Pchinya.

The veins and country rock to the south of the Pchinya are greatly contorted by north and south folds, although no appreciable faulting can be observed, whereas to the north of the Pchinya no movement can be detected. This evidence, coupled with the opposite trend of the zones and the purity of the ore, would suggest that the

(3) The magnesite occurs in these zones as pockets or nests and lenticular veins, the purer mineral being found in the former, generally in the centre of the deposit.

(4) The deposits occur near or at the surface and do not continue in depth; the veins are never continuous for long distances.

(5) The country rock is traversed by thin films or plates of magnesite, particularly along the joint planes.

The intrusion of what was then a peridotite was accompanied by great tectonic movement, which was first strongest along an east–west axis, and later along a north–south, resulting in regional metamorphism and fracturing. Strong schistosity of the serpentine suggests that there was also later movement. The alteration of the peridotite into serpentine rock may be accounted for by three agencies: (*a*) Regional metamorphism; (*b*) the hydrothermal solutions;

and (*c*) the ground waters, the two latter being responsible for the formation of the magnesite.

Thus it appears probable that certain of the fracture zones were formed contemporaneously with the cooling of the intrusive, and in its later stages, which was particularly rapid near the surface. The fracture zones became channels for the hot solutions which gave rise to the chemical reactions which formed the more important magnesite deposits. It is well known that the final stage in the intrusion of a magma is accompanied by the evolution of heated

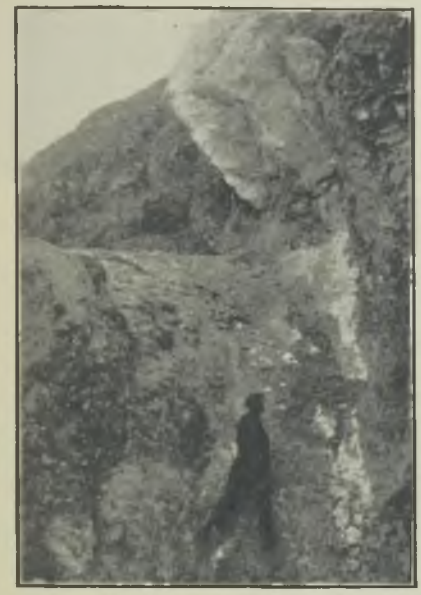


FIG. 5.—NEAR VIEW OF THE MAGNESITE LODE AT THE SOUTHERN END OF ZONE "C," SHOWING MANNER IN WHICH IT NARROWS AT DEPTH.

waters of great chemical activity among which carbonic acid is very prominent. The solutions circulated along the fracture zones and attacked the olivine of the peridotite. The olivine was of the forsterite variety, richer in magnesia than iron, as the alteration of fayalite would result in breunnerite ($FeMgCO_3$). The carbonated waters, if sufficiently saturated with magnesium carbonate and under favourable conditions of cooling, would precipitate the amorphous mineral where suitable cavities were available.

The chemical reactions which, it is suggested, have taken place are:—

(1) $\underset{\text{Forsterite}}{2Mg_2SiO_4} + 2H_2O + CO_2 =$
$\underset{\text{Serpentine}}{2H_2O3MgO2SiO_2} + \underset{\text{Magnesite}}{MgCO_3}$

and to a smaller extent,

(2) $\underset{\substack{\text{Pyroxene}\\(\text{Enstatite})}}{4MgSiO_3} + H_2O + CO_2 =$
$\underset{\text{Talc}}{H_2O3MgO4SiO_2} + \underset{\text{Magnesite}}{MgCO_3}$

It should be noted that fairly pure siliceous nodules are occasionally found in some of the magnesite pockets; the following chemical reaction may be the cause of this deposition:

$$\underset{\text{Forsterite}}{Mg_2SiO_4} + 2CO_2 = \underset{\text{Magnesite}}{2MgCO_3} + \underset{\text{Quartz}}{SiO_2}$$

Where conditions were less favourable for precipitation the zone is entirely devoid of mineralization or only small impure veinlets were formed.

The process of ore formation continued after the country rock cooled down through the agency of acid ground waters, the chemical reaction being similar to the above but, of course, greatly retarded and restricted under the more temperate conditions. The disintegration of the country rock along the joint planes is due to the latter action.

Detached deposits of typical granular magnesian limestone together with a little quartz are found in the country rock; these are apparently of recent date, and again are the product of chemical reaction of the ground waters. The process may be represented as follows:—

$$\underset{\substack{\text{Lime Pyroxene}\\(\text{diopside})}}{2MgCa(SiO_3)_2} + \underset{\text{Olivine}}{Mg_2SiO_4} + CO_2 + 4H_2O =$$
$$\underset{\text{Serpentine}}{2(2H_2O3MgO2SiO_2)} + \underset{\text{Magnesian Limestone}}{2MgCa(CO_3)_2} + 3SiO_2$$

Thus, the origin of the magnesite is probably due to: (1) The circulation of hydrothermal solutions, CO_2, and its reaction with the forsterite and enstatite of the peridotite; (2) the action of ground waters charged with CO_2, the deposition in the latter case being much slower and the consequent deposits are generally not of economic value.

Institution of Mining and Metallurgy.—At the meeting of the Institution of Mining and Metallurgy on April 10, the following papers were submitted for discussion: "Notes on some Unusual Stoping Problems in Mexico," by E. G. Lawford, and "Bottom-Slicing applied to Mining a Large Irregular Replacement Deposit in Limestone," by W. H. Wilson.

THE STANTRG LEAD-ZINC MINE, YUGOSLAVIA

In the MAGAZINE for January an article on the geology of the Stantrg mine by Dr. A. Brammall was given. The illustrations on this page will be of interest as showing the character of the country and the progress of constructive work.

General View.

Looking North.

Looking East.

BOOK REVIEWS

Methods in Geological Surveying. By Dr. EDWARD GREENLY and Dr. HOWEL WILLIAMS. Cloth, octavo, xvi + 420 pages, illustrated. Price 17s. 6d. London: Thomas Murby & Co.

The senior author of this book will be known to many readers of the MAGAZINE for his labours in Anglesey, while Dr. Howel Williams has not only excellent results in Snowdonia to his credit, but has also done considerable geological work abroad. From two such authors one expects a sound book. The preface states that the book was projected and partly completed by Dr. Greenly many years ago and ultimately brought to fruition by the choice of Dr. Williams as a disciple. We may add that at times we are rather sorry for the disciple, for had the senior author contented himself with supplying the ammunition, leaving the firing of it to Dr. Williams, the result would undoubtedly have been better.

That geological surveying can never be acquired by the perusal of textbooks alone no real map-making geologist will deny. Any book, however, which gives the principles of such mapping and brings together the methods employed by various surveyors serves a useful purpose, especially if—as this particular one does—it insists on mapping in the field instead of by "constructive methods" indoors based on too few observations. Rocks seldom behave as some textbook writers would have us believe, and students cannot be too often instructed—as the present authors agree—that three point problems and similar geometrical methods can only be regarded as a last resort when no other means of completing the map are available. To record a dip accurately seems a perfectly straightforward job, but in how many cases is such a dip really reliable? Such direct observations cannot compare with the dip worked out after a careful tracing of the outcrops. It is also essential to develop an eye for country, as much time can be saved and greater accuracy attained by noting and deciphering changes in topography. It is always desirable that the form of the ground should be indicated on the map—preferably by fine lines of the nature of contours. This is a point which has not received the attention it deserves by the authors.

Part I of the book, which occupies 122 pages, is described as introductory and historical. It contains some doubtful philosophy; a chapter on the construction of the ordnance maps of Great Britain, which is somewhat superfluous; chapters on the evolution of general cartography, geological cartography, and cartographic mathematics and terms, all of which are of little use to the average reader.

Part II—Geological Surveying—begins with the topographical framework and passes to the preparation and care of maps, followed by the determination of position and the use of the plane table, etc. Next come the selection of mappable units and the building up of the map, (*a*) by plotting all exposures, (*b*) by tracing contacts, and (*c*) by traverses. These are followed by chapters on observations at outcrops, tracing of concealed contacts, and the geometry of outcrops. These 66 pages are good, are well illustrated, and constitute the most valuable part of the book.

Chapter 21 deals with notes and symbols and, although—as stated on the title page—one of the authors was formerly of the Geological Survey, his views must not be regarded as representing those of that body. He retired from the Survey about thirty years ago and many of the symbols and map details that he quotes belong to that period. Chapter 22 deals with the selection and care of mapping-pens, etc., and seems to be out of place.

With regard to the treatment of maps Dr. Greenly appears to be afraid of colouring field slips, and the remarks on the choice of colours (p. 281) do not seem worth while. The principles of correlation are faithfully dealt with in Chapter 26, and the mapping of large igneous intrusions dealt with in the following chapter follows largely the work of Cloos. The succeeding chapter on crystalline schists might well have been shorter. Superficial deposits, which are dealt with in Chapter 29, are a bugbear to geologists who are interested mainly in the solid rocks. The difficulties lie not so much in the mapping as in the interpretation of these deposits. The authors evidently boggle at glacial drift. They fail to point out that if such deposits are mapped with any degree of accuracy, form lines being inserted for the topographic features and attention paid to anomalous hollows and drainage channels, together with the distribution of boulders and ice markings, a connected story may be

made out. Chapter 30, which is headed "Suggestions," ranges from poetry as mental relaxation in the evenings, to harvest bugs in the field—with a big jump—to rattlesnakes, and goes on to care in railway cuttings and to "returns of work."

The book ends with the tables of constants frequently required and with a very useful set of bibliographies on the various subjects mentioned in the text. Most of the illustrations are excellent text figures, but it is difficult to imagine why the frontispiece—part of the map of Anglesey—was chosen; as a field slip it leaves much to be desired, and should not require an appendix for explanation if the author of it were reasonably true to his own teachings. In conclusion we would say that given a vigorous pruning to reduce bulk and so price, the book would be an asset to geological literature.

T. EASTWOOD.

☞ 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

March 6.

Waaikraal Mine to be Closed.—Another "outside district" gold mine is to be closed down. The boring operations which were being carried out on the property of the Edwards (Waaikraal) Goldfields, Ltd., in the Rustenburg district, Transvaal, in the hope of picking up an extension of the rich gold-bearing lode which is cut off in the mine, have been stopped. The bore-hole had reached a depth of 200 ft., and for 34 ft. up to that point solid diabase was encountered, from which it would appear that the reef does not exist in depth. Steps are now being taken to dispose of the freehold on the farm and also the machinery and plant. The only work which is being done on the company's property at present is the treatment of the slimes, from which a fair recovery is expected. The company was formed in August, 1926, with a capital of £35,000 in shares of 5s. each, for the purpose of acquiring the interest of the Beersheba Options and Prospecting Syndicate in the farms Waaikraal and Beersheba. High gold values were disclosed on Waaikraal in the course of prospecting operations and indications suggested that an important mine had been discovered. There were excited dealings in the company's shares, and the market price at one period rose to over 90s. This boomlet, however, was followed by a slump when it became known that the rich gold carrier had "petered out." Some of the directors were in favour of abandoning the property, but the majority decided to carry on. The capital was increased to £50,000 by an issue of preference shares, a ten-stamp battery and cyanide plant were purchased, and good profits were being earned when a cloudburst swamped the workings and put a stop to mining and milling operations. There was then only a little payable ore left in the mine.

Gold Lost in Tailings.—Although during the past thirty years extraction on the Witwatersrand fields has been raised from about 75% to about 97%, something like £2,000,000 per annum is still being lost in the tailings. On many of the mines the value of gold in the residues is as low as 3%, and, despite a few high percentages of lost gold, the general loss on the Rand does not exceed 6%. During recent years the removal of the amalgamation plates from the batteries to a position in the tube mill circuit was the first result of greater tube mill efficiency and coarser battery screens. Following this came the elimination of plate amalgamation altogether and the substitution of corduroys, with barrel amalgamation for the corduroy concentrate, which, by the way, brought about the recovery of a considerable quantity of osmiridium previously not possible. Only three mines have entirely adopted the all-sliming process so far, the older ones adhering to the sands and slimes process. There is a very considerable difference in reduction costs and in the proportion of gold lost in residues. One of the oldest mines obtains the best recovery, the value of the gold lost in the tailings being well under 1s. per ton of ore treated, whereas the highest loss is about 2s. 3d. per ton. Taking the Far East Rand mines into separate comparison, the Brakpan Mines and New State Areas lose in the tailings gold to the value of 2s. 2d. per ton, whereas the Modder B. only loses 10d., and the Modder Deep 1s. 1d. Each of these mines is treating ore which is peculiar to the Far East Rand basin, and which possesses some chemical characteristic which handicaps extraction. Both costs and value of residues are greater at two all-sliming mines than in most of the other mines in that area.

An Important Merger.—The Committee of Inquiry appointed by the Government has reported favourably on the Robinson Deep-Village Deep amalgamation scheme, and the shareholders of the two companies have confirmed the provisional agreement unanimously. The acquisition of the Village Deep's mining rights almost doubles the ore reserve of the Robinson Deep, and means a considerable extension of the life of the company. It ensures the Robinson Deep being able to develop all of the ground to its southern boundary and to the southern boundary of the Village Deep. This can be taken to mean a life of 15 years for the augmented Robinson Deep, and, further, with a two-shaft system, it offers the possibility of extending that life by the acquisition of ground beyond those boundaries. Such a possibility could not exist if both companies continued to work on their own with a single shaft system. The lower levels of the Village Deep will be advanced westwards, and will within a few months enter the Robinson Deep ground. As the sub-incline shaft which is to be sunk on the Robinson Deep reaches the levels below, drives will be started eastwards towards the Village Deep and westwards to the Crown Mines boundary. This will increase the rate of development and reduce the cost of the work.

An Undeveloped Copper Field.—Further interesting statements have been published recently regarding discoveries of high-grade copper deposits in Southern Rhodesia, about 20 miles north of the Limpopo River, which is the Rhodesia-Transvaal boundary. From time to time, it appears, there has been much pegging in the area indicated, but all the claims have been abandoned. One who has intimate personal knowledge of some of these enterprises has said that he is in a position to show that it has been clearly demonstrated that there are vast deposits of copper and other base minerals in this particular district, but the fields are in an almost inaccessible situation, in dense, forbidding country infested with big game, and offering practically insuperable transport difficulties. A considerable amount of money was spent there some years ago by the Jonah Syndicate and some of the big companies were sufficiently interested to agree to send down experts, but in the end the pursuit of the belt into the blue was abandoned. If the country was opened up by railways the potentialities might be alluring, and maybe this latest discovery will give a spur to the agitation for the linking up of Fort Victoria, or Wedza, or West Nicholson, with the Northern Transvaal railway.

A New Rhodesian Coalfield.—A small company has been formed at Bulwayo for the purpose of acquiring and testing 16 coal areas near Inyantue Halt, on the main railway, some 70 miles distant from Bulawayo and 35 miles south of the Wankie coalfield. The Inyantue property is believed to be a detached portion of the Wankie field, and its entire extent is probably 10 square miles. The whole of this area was investigated in the early days by the Wankie Colliery Company and turned down in favour of the company's present colliery sites. Two shafts were then sunk some distance from where the railway line now is, but they are said to have given negative results so far as a coal mining proposition is concerned. Until about two years ago, all coal within 20 miles of the railway line, apart from the Wankie special grant, was reserved in favour of the British South Africa Company. Upon the restriction being removed at about that time part of the area at Inyantue was pegged by a syndicate, who, however, subsequently abandoned it. This is said to be part of the area now being exploited. The view is expressed in Bulawayo that the new field, even if it fulfils much that is hoped of it in point of its coal contents, cannot compete with Wankie for the northern traffic, owing to the railage from Inyantue being the greater.

A Central Geological Bureau.—The suggestion put forward ten years ago by Dr. Hans Pirow, the present Government Mining Engineer, that a Central Geological Bureau should be established by the mining industry, has been revived by Mr. G. W. Bond in an article in which he deals in a most interesting manner with the study of the determination of "pay streaks" in the Witwatersrand gold mines. It has been suggested that a Central Geological Bureau could undertake petrological and other investigations, and, in addition, would be able to co-ordinate all the detailed work on pay-shoot extension, now carried on by individual mines. This would mean saving to the individual mines and would prove of enormous benefit to the mining industry as a whole. Individual mining companies, and particularly those owning properties of low grade character, might consider that the cost of maintaining a separate department

of this nature was not justified, but if all the mines of the Main Reef series shared jointly in the cost of the institution and assisted in the correlation of results, much highly valuable data would no doubt be obtained at very little cost.

A Concentration Process Dispute.—A Patent Court, consisting of the Attorney-General, assisted by a metallurgical expert, is sitting at Salisbury, Southern Rhodesia, to determine an application by Mr. F. T. Whitworth to patent a process of concentrating mineral ores. The applicant is represented by counsel, as are the Minerals Separation, Ltd., who oppose the granting of Letters Patent on the ground that the applicant's invention cannot be made use of without incorporating in some way a process already patented by the Minerals Separation, Ltd. It was urged on their behalf that, as the registration in Southern Rhodesia would automatically involve recognition in Northern Rhodesia, the company's interests on the Northern copper field would be seriously affected. For the applicant it was contended that the invention was a departure from other known processes, use being made of a particular agent not previously used in this connexion.

South African Kieselguhr.—It is stated in reference to the recently discovered kieselguhr deposits on the municipal commonage of Port Alfred, Cape Province, that assays indicate a yield of 78% pure silica. London interests have supplied the capital required to work the deposits, and the business is to be registered under the name of the Albany (S.A.) Products Company (Prop.), Limited.

Murchison Medal for Dr. A. L. Hall.—The award of the Murchison Medal of the Geological Society of London to Dr. A. L. Hall, assistant director of the South African Geological Survey, is generally considered to be well merited. Since 1903 Dr. Hall has been working in South Africa as a member of the Geological Survey, and during that period he has done extremely valuable work. Of special importance was his investigation of the bushveld region and the structure of the "Vredefort mountain land" in the vicinity of Parys. In addition to the purely scientific investigation, Dr. Hall has done much of economic importance in the study of asbestos, mica, and corundum deposits in the Barberton area.

State Revenue from Mining.—According to the annual report of the Commissioner for Inland Revenue a total of £5,392,923 was collected from 88 mines and 353 individuals in 1929. Of this sum £1,153,961 represents export duty on diamonds, £1,590,953 income tax paid by companies, and £18,467 paid by individuals, and £2,629,547 the contribution from State-owned mines. Gold yielded £3,190,772, as compared with £1,803,124 from diamonds, £310,030 from licences and mynpacht dues, £55,017 from coal, £6,311 from tin, and £5,275 from copper.

IPOH

February 13.

Malayan Statistics for 1929.—The publication of the monthly Bulletin of Statistics relating to the Mining Industry of the F.M.S. to the end of December, 1929, makes it possible to review the progress in the mining industry in the Federated Malay States during that year.

Chief Mineral Products of the F.M.S.—These, as is well-known, are tin ore, coal, gold, and tungsten ores. In the year 1929 all these except the last show very considerable increases in total output as compared with recent years, the tin ore output of over 67,000 tons being the highest ever recorded.

Tin Ore Statistics.—The rapid increase in the proportion of tin ore produced from mines which are financed, managed, or owned by Europeans as compared with production from mines owned and managed by Chinese is very marked. At intervals of five years the proportions are as follows:—

Year.	European Mines. %	Chinese Mines. %
1910	22	78
1915	28	72
1920	36	64
1925	44	56
1929	61	39 (4 years)

The monthly returns for the year 1929 show that the production from European mines (including dredges) amounted to 65% of the total for December. With regard to the horse-power of machinery and number of labourers employed, 1929 shows a net decrease of about 3,500 h.p. and 4,000 coolies during the year. There is a classification of output under eight headings which include gravel-pump mining

and hydraulicking, separately recorded. The methods in use on this field do not make it easy to understand precisely how these two methods can be separated, except on some arbitrary basis, as a large proportion of mines using gravel pumps have water under natural or artificial head. The number of dredges "in use or working" increased from 89 to 195 during the year; and at the end of 1929 there are recorded 10 under construction and 8 on order. The local value of metallic tin in Straits dollars per pikul (of 133⅓ lb.) averaged $114·18 in 1928 and $104·37½ in 1929, with the lowest price recorded in December of that year.

The foregoing extracts from statistics show very clearly how vitally important it is to explore all means or methods of improving the economic position with due regard to the fact that the ore is a wasting asset. Expansion of use industrially is clearly the best remedy for the present market weakness of the metal. Pending definite advances in this way much may be accomplished by economies in operation, and this especially applies to various methods of working opencast. The substitution of electrical power for steam engines, and, in places, for some of the internal combustion engines recently installed has made considerable progress, but the economic advantages of the new power are not always fully realized on account of lack of knowledge and experience in its use. There is room for improvement in efficiency and economy of sand and gravel pumps in common use.

Power Supply.—The Perak River Hydro-Electric Power company have endeavoured to meet the necessities of the moment by introducing a new scale of charges designed to suit cases in which, for restriction of output, or for any other reason, continuous running is not possible during the full 24 hours. To take full advantage of their terms close supervision is required to avoid needless occurrence of peaks in the load chart, and this applies both to the old and to the new terms; but it must be realized that in the nature of the case temporary peaks are sometimes difficult to prevent. Good progress is being made with the Perak River Hydro-Electric Company's dam on the Perak River at Chenderoh. It is hoped soon to begin retaining water to a limited depth behind the dam, which has now reached a stage at which there remains little risk of damage by floods. One unit of the three which constitute the generating plant is almost ready, and the other two are in progress in the power house.

VANCOUVER

March 8.

General Outlook.—February has been a disastrous month for the small metal mine operators and for coal mine operators. Between 1,000 and 2,000 men have been laid off and as many more reduced to three or four days work weekly. The slump in silver and zinc prices and the uncertain stock-market conditions, pending a general clean-up of stock-broking methods of operation throughout the Dominion, are responsible for the metal miners' troubles, and those old enemies, fuel oils and electric energy, for the coal miners'. All the mills of the small silver-lead-zinc operators, with the exception of the Monarch, Ruth-Hope, and Noble Five, have been closed, and at the majority of the mines the force of men has been reduced to caretakers and maintenance men. With the exception of the Reeves-McDonald mine, the Victoria Syndicate, of London, has closed all the properties that it controls. The Premier Gold Mining Company has suspended development operation at the Silverado group, but is continuing work at the Premier mine and at the Prosperity-Porter-Idaho property from which it is shipping some 1,200 tons of $40 silver-lead ore monthly. Duthie Mines closed its mill in the middle of the month but announced its intention of keeping 40 men at development; the latter order was rescinded at the end of the month, and now the mine is completely closed. Noah A. Timmins, the Ontario mine operator, has relinquished his option on a large block of the stock of the Owen Lake Mining and Development Company and has withdrawn from the control of the property, situated 30 miles south of Houston, on the Canadian National Railway. F. H. Taylor, president of the company, has announced that development will be continued, despite Mr. Timmins' withdrawal. The Granby Consolidated Mining, Smelting and Power Company has laid off about 190 men at its Anyox properties, but is vigorously continuing development at Copper Mountain, where the deposit

has grown bigger and richer at depth. The Hidden Creek mine is showing signs of exhaustion and, unless new ore is developed, can last only a few more years. It has been operated steadily since 1913 and up to the end of 1928 had produced 440,531,000 lb. of copper, 4,760,000 oz. silver, and 88,200 oz. gold from 13,498,000 tons of ore. The conversion of the Great Northern Railway Company's locomotives from coal to oil burners was responsible for the closing of several mines in the Crow's Nest Pass district, throwing 300 men out of work, and the curtailment of operations at the remainder to three or four days weekly, which affects 450 men. Canadian Collieries has closed South Wellington mine and reduced work at No. 1 mine to three days weekly. Truly a chapter of disasters. The big metal producers, on the other hand, which are the backbone of the metal industry of the Province, are all operating at peak capacity. The Consolidated Mining and Smelting Company of Canada recently issued a notice informing its shareholders that, though there was some shortage of power on account of the extremely cold winter, operations were progressing satisfactorily and that the decline in silver and zinc prices so far has not been sufficient to imperil the usual distribution of dividends. As the usual distribution amounts to 50% on the par value of the shares, shareholders have little cause to grumble. Britannia, being a copper mine, is not affected by the adverse metal prices, but, in order to help its parent company, the Howe Sound Company, which owns silver-lead-zinc mines in Mexico, it is increasing its copper output. The Premier Gold Mining Company is operating the Premier and the Prosperity-Porter-Idaho mines at capacity, but, as the company is dependent on the sale of silver for a large part of its income, shareholders are awaiting the next quarterly dividend announcement with trepidation.

New Power Project.—Reeves-McDonald Mines, a subsidiary of Victoria Syndicate, of London, appealed against the decision of the Provincial Water Board, denying its application for water rights on the upper part of the Pend d'Oreille River, to the Minister of Lands and, though the Minister has confirmed the Water Board's decision, granting the rights on the whole of the river in British Columbia territory to the West Kootenay Power and Light Company, it has made the granting of the rights conditional on the supplying of Reeves-McDonald with all the power it requires for mining purposes immediately (that is, as soon as a transmission line can be extended to the property) at the same rate that the Consolidated Mining and Smelting Company is paying the East Kootenay Power Company for power at its Sullivan mine. Furthermore, if Reeves-McDonald shall erect an electrolytic-zinc plant, as it purposes to do, the West Kootenay company shall supply it with all the power it requires for that plant at the same rate that it supplies the parent company's Tadanac smelter. The West Kootenay company has agreed to the conditions and has started to extend its transmission line from the Yankee Girl mine, at Ymir, to the Pend d'Oreille River, to supply power to the Reeves-McDonald mine and for construction work at the new power plant. Both Col. H. H. Yuill, president of Reeves-McDonald, and the Provincial Government are to be congratulated on the decision, which is an eminently fair one. Water power rights are the property of the people of the Province, and should not all be granted to large companies without any restriction as to the rates at which they shall supply power.

Boundary.—At an extraordinary meeting of Granby Consolidated Mining, Smelting and Power Company, held in New York on March 3, the shareholders approved the appropriation of $4,000,000 from the depreciation and depletion reserve, for distribution among the shareholders during the current year.

The Supreme Court of Canada recently rendered a decision upholding the decision of the Exchequer Court in the case of the Electrolytic Zinc Process Company *v.* the French Complex Ore Reduction Company, nullifying the French Company's patents for the electrolytic production of zinc and for the rectification of the electrolyte by the use of atomized manganese dioxide. The Electrolytic Zinc Company is a holding company for Consolidated Mining and Smelting Company's and Anaconda Copper Mining Company's patents.

Dr. Victor Dolmage has been elected chairman of the British Columbia branch of the Canadian Institute of Mining and Metallurgy, succeeding Mr. J. D. Galloway. The executive for the ensuing year is composed of Messrs. George A. Clothier, R. R. Hedley, W. B. Knowles, P. W. Racey, and Col. C. W. Villiers.

TORONTO

March 18.

Sudbury District.—The base metal industry continues to occupy a leading place in mining activities, and operations in this district are steadily increasing in importance. Interest in this field has been greatly stimulated by the great advance made by the International Nickel Company as shown in the annual report for 1929, in which net earnings are given as $22,353,966, as compared with $12,399,317 for the previous year. The smelters at Copper Cliff and Coniston ran at capacity and produced 132,030 short tons of Bessemer matte At the Port Colbourne refinery production was kept in close balance with consumption; three additional electrolytic units were installed during 1929, and this refinery now has an annual capacity of 84,000,000 lb. electrolytic nickel, 36,000,000 lb. nickel oxide, and 120,000,000 lb. blister copper. The total proved ore reserves are estimated at 202,620,000 tons. At the Frood Mine underground development is progressing rapidly, employing about 2,000 men. The proved ore in this deposit now amounts to 134,673,000 tons, of which 43,562,000 tons is high grade below the 1,400 ft. level, the copper content increasing in depth. As the ore at depth contains a considerable platinum content, for which the present demand may be inadequate, the company's research department is endeavouring to find new uses for that metal. The Falconbridge nickel mine has gone into regular production, with an initial capacity of 250 tons daily of an average recovery of $21·90 per ton. Exploration is steadily adding to the indicated ore reserves, the value of which are now estimated at $30,000,000, sufficient to keep the smelter in operation at the present rate for 14 years. At the Errington Mine of the Treadwell Yukon Company enough ore has been placed in sight above the 500 ft. level to warrant additional milling equipment. Shaft No. 2 is being put down to the 1,500 ft. level, with stations at intervals of every 150 ft. It is expected that the objective will be reached about the middle of July when a development programme, duplicating the work accomplished on the upper horizons, will be undertaken, the result of which will enable the directors to arrive at a decision as to additional mill equipment. The company is now producing concentrates of copper, lead, and zinc, and pyrites will shortly be added to the list. Other companies which are carrying on development work with favourable results are the Sudbury Basin, Sudbury Offsets, Nickel Hill Syndicate, and Sudbury Nickel and Copper Mines.

Porcupine.—The output of bullion from seven producing mines in the Porcupine area during February was valued at $1,313,661, as compared with $1,460,600 in January. Hollinger Consolidated maintains its position at the head of the list of producing gold mines, though the mill has been working somewhat below capacity since the commencement of the year. Although the ore reserves have been somewhat encroached upon to maintain the current rate of production, this is not regarded as impairing the position of the mine, the reserves being sufficient to furnish a supply to the mill for about five years. The annual report of Dome Mines, Ltd., for 1929 shows net income of of $1,793,429, which is $145,793 below that of the previous year, due to the destruction of the mill by fire. During the year 452,900 tons was treated, averaging $7·57 per ton. Ore reserves at the close of the year were estimated at 1,300,000 tons, and operating costs were $4·48 per ton. The working force has been increased and it is planned to begin the erection of a new mill early in April. At the McIntyre Porcupine, underground development has made large additions to the ore reserves, and it is anticipated that the forthcoming annual report will place their value at approximately $20,000,000. Experiments which have been carried on for some months with the pilot mill to discover a new method for the more economic treatment of the ore have been discontinued, the results being inconclusive. During last year the Vipond Consolidated produced $817,000 from the treatment of 108,000 tons of ore. Diamond drilling has cut a new ore-body 4½ ft. wide, averaging $22 a ton in gold near the Hollinger boundary on the 400 ft. level. Cross-cutting on the 500 ft. level has been started, to prove the continuation of the ore at that depth and exploration is being carried on to encounter other veins of the Hollinger system. Surface work on the claim of Thomas Strin in the Shaw township has disclosed several promising veins yielding high assays.

Kirkland Lake.—During February the six producing mines of this area yielded bullion to the value of $1,296,246, as compared with $1,281,888 in January. The Lake Shore has lately been working on exception-

ally rich ore on the 3,875 ft. level, the average recovery per ton having recently been increased to $56. The projected increase of tonnage to 2,000 tons daily may not take place till June as late steel deliveries have delayed construction. The mill of the Wright-Hargreaves is treating 550 tons of $11 grade ore daily, which compares with an average of 450 tons of $9·50 ore treated in 1929. Preparations are being made to continue Nos. 1 and 3 shafts to 3,000 ft. The Sylvanite during 1929 treated 74,523 tons of ore with a recovery of $685,687. Shaft No. 4 is now down 1,300 ft., and is to be continued to 1,750 ft., which will make it possible to open up important ore-deposits indicated by diamond drilling, the zone extending from the adjoining Wright-Hargreaves property into the Sylvanite. Gold values at the Kirkland Lake mine show improvement at depth. On the 3,875 ft. level a remarkably rich vein of high-grade ore has been opened up for 100 ft., values running as high as $50 to the ton. Similar results were obtained in depth by the Lake Shore, Teck-Hughes and Wright-Hargreaves, and this factor will encourage sinking of deeper shafts. The Bidgood has been obliged to suspend operations owing to financial difficulties. The mill of the Barry-Hollinger is treating about 100 tons of ore daily, mill heads having recently been increased owing to the improvement in the grade of ore. High-grade ore is being opened up on the 1,625 ft. level.

Rouyn.—The annual report of Noranda Mines, Ltd., for 1929 shows gross earnings from metal recovery of $10,947,290 and miscellaneous income of $548,068, making a total revenue of $11,493,358 compared with $6,244,051 the year before. Net profits were $6,111,605, which compares with $3,018,247. The smelter treated 428,221 tons of smelting ore, concentrates and siliceous ore, producing 51,625,473 lb. of blister copper, as compared with 33,307,937 lb. in 1928. The Horne Mine shipped to the smelter 274,879 tons of sulphide ore with an average grade of 7·64% copper, 0·87 oz. silver, and $4·16 gold per ton. There were shipped to the concentrator 48,437 tons of ore with an average grade of 3·27% copper, 0·457 oz. silver, and $3·72 in gold. Ore reserves are estimated at 3,426,000 tons of direct smelting ore, in addition to 3,000,000 tons of concentrating ore. The copper refinery of the Noranda, it is announced, will be erected in Montreal at a cost of $3,500,000 and it will be operated by the Canadian Copper Refiners, Ltd., in which the British Metals Corporation of London, and the Nichols Copper Company of New York are associated with the Noranda.

CAMBORNE

April 5.

Mining and China-clay Leases.—The announcement made by the managing director of the Goonvean China-clay and Stone Company that Lord Falmouth had refused to renew the Goonvean lease, which terminates next September, caused both astonishment and alarm in mining and china-clay circles, for it has long been the custom to regard leases as renewable at the termination of the 21-years' period for which they almost invariably have been granted—the mining leases for centuries past and the china-clay leases from the early days of that industry, a little over a century and a half ago. Up to the present only one side of the Goonvean contretemps has been made known, that of the company, by its managing director, Mr. R. J. Varcoe, Lord Falmouth having declined to make any statement. It is obvious that in this instance more that ordinary difficulties have arisen. This in itself is unfortunate, though such difficulties are confined to the one case and can only be settled by the two parties immediately concerned—namely, the lessor and the lessees. It does not follow that the trouble which has arisen over the renewal of the Goonvean lease is the precursor of similar troubles elsewhere in Cornwall.

The system of granting and renewing mining leases in the county has evolved through the customs of succeeding generations. There is no undertaking to renew on either side. Consequently renewal is always a matter of arrangement between the two parties concerned. The wording of a lease seems to be unnecessarily arbitrary, but the more objectionable clauses are rarely, if ever, brought into practice. In the usual lease it is stipulated that cultivated land, if destroyed, must be paid for at the rate of £100 per acre and uncultivated or waste land at £50 per acre. In actual practice these payments were very rarely exacted by the old race of Cornish mining landlords—for example, on the Tehidy estates of the Basset family, those of Lord Falmouth, and others. It is noteworthy that in recent years, since mining rights have been split up into smaller parties through sales and acquired by smaller owners, claims for damaged lands have not only been

enforced, but in some cases the already extortionate price of £100 per acre has been raised to £160. In the matter of royalties, during periods of more than ordinary difficulties remissions have been made, and sometimes the entire royalties relinquished. In a recent case—that of the West Slip China-stone Company—where the royalties were fixed at 5s. per ton in 1924, they have been reduced to 2s. 6d. per ton from September last by Lord Falmouth, a concession made during a period of special difficulties in exploitation.

In 1883 the renewal of the Dolcoath lease was made the occasion for demanding a "premium" or "fine" of £25,000. This unusual proceeding caused much unpleasantness. It may be pointed out that in 30 years the landlords (the Basset family) have received in dues about £70,000, while the shareholders received over £320,000 in dividends. During a long period, covering numerous renewals of lease, Dolcoath paid as much as one sixth of the produce in royalties. At one period, while the lease specified one twelfth, only one fifteenth was actually paid and in later years the royalties according to lease were one twenty-fourth and these were not always exacted in full. It was the case in 1883 that payment of the "fine" was a condition of lowered dues in the future.

Experience of the past has gone to prove that arrangements for renewal of a lease have always been possible, subject to adjustments rendered necessary by altered conditions for the better, or for the worse. Numerous sales of mineral rights in recent years have altered circumstances and for this reason the whole subject of granting and renewing mining and china-clay leases calls for special attention.

A Receiver Appointed at Dolcoath.—The appointment of a receiver and manager, Sir William Peat, at Dolcoath, as from the 21st of March, aroused much interest and some little anxiety, although on consideration there is nothing surprising in the step taken by the Treasury. Nearly a year and a half ago, owing to financial difficulties which have proved to be insurmountable, operations in the mine—Roskear—were altogether suspended. Attempts to borrow sums on debentures, or to otherwise secure additional funds, have failed. The Trades Facilities Committee's balance of loan amounting to £75,000 remains unpaid and forms a first charge upon assets. It is recognized, not only in the district, but generally in mining circles, that the Roskear property is well worthy of vigorous prosecution. The way is now open, presumably, for the formation of a new company, which, unencumbered by ancient debts, would acquire a large area of great prospective value for tin, wolfram, arsenic, and copper.

Brisbane Letter.—Owing to the fire on the S.S. *Comorin*, the letter from Brisbane was not only damaged, but its delivery delayed, and it reached us too late for inclusion in this issue.

PERSONAL

F. M. Ball has left for Venezuela.

C. A. Banks has left for Vancouver.

W. H. Bassett has been elected president of the American Institute of Mining and Metallurgical Engineers.

H. Blackman has started in consulting practice in Montreal.

S. Bonds has returned to Mysore.

H. C. Boydell is here from Toronto.

R. R. Bradley has left for Northern Rhodesia.

G. W. Campion has left for West Africa.

W. R. N. Cheetham has returned from Burma.

W. R. Clarke is returning from Nigeria.

H. B. Cochran is returning from Nigeria.

W. H. Collins has left for Nigeria.

A. H. Cretch has left for Malaya.

J. S. De Lury, Professor of Geology in the University of Manitoba and Commissioner of Mines for that Province, has been elected president of the Canadian Institute of Mining and Metallurgy for the coming year.

A. R. Dewar has left for Nigeria.

P. St. John Dixon has returned from Tasmania.

A. Broughton Edge is home from Australia.

E. W. M. Elliott is returning from Northern Rhodesia.

Eric Evans has left for Singapore.

A. G. Glenister has returned to Malaya.

T. C. F. Hall has left for Yugo-Slavia.

W. B. Hawkes is home from Malaya.

W. Hope Henderson is here from Egypt.

Ross Macartney is home from Burma.

L. A. Mayo has left for Northern Rhodesia.

Dr. L. Mintrop, vice-chairman of the Geophysical Company, and Ernest H. Neville, the managing director, are at present in Egypt with Dr. John W. Evans, the chairman.

Leslie H. Ower has left for Northern Rhodesia.

A. M. Robinson is returning from France.

A. B. Rowe has left for Spain.

L. U. Salkield has left for Spain.

A. Leonard Thomas has left for Malaya.

G. W. Thompson is coming home from Japan.

W. E. Thorne is here from Venezuela.

Joseph B. Tyrrell has been awarded the Charles P. Daly gold medal of the American Geographical Society in recognition of his many achievements in the field of geology.

S. S. Webb-Bowen has left for Korea.

John Oliver Arnold, emeritus professor of metallurgy in the University of Sheffield, died at Oxford on March 27. He was a pioneer in the metallurgy of alloy steels, especially of the high-speed variety.

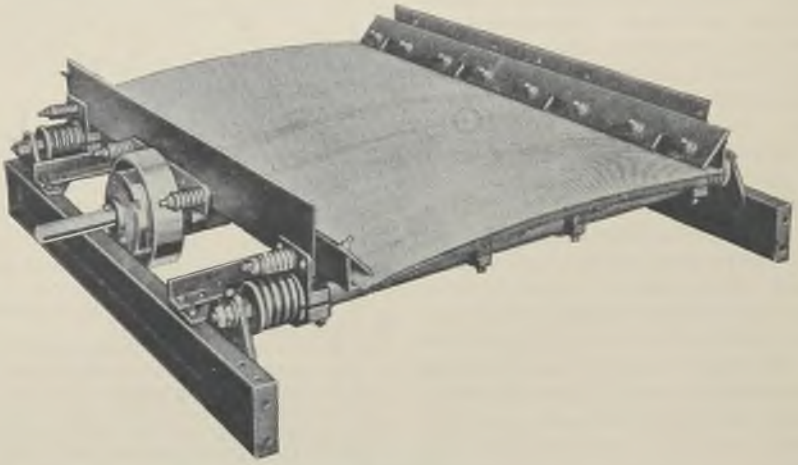
TRADE PARAGRAPHS

Head, Wrighton, and Co., Ltd., of Stockton-on-Tees, issue a new catalogue of their coal shippers and hoists such as are used for handling coal at dockside.

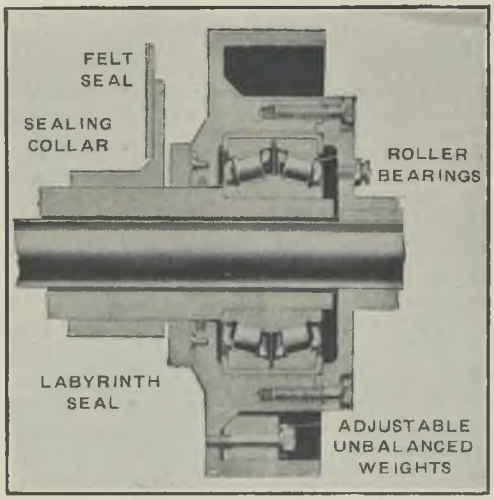
Ransomes and Rapier, Ltd., of Ipswich, issue a folder drawing attention to the essential features of the Ransomes-Rapier-Marion ½ yard shovel known as the 420. Also a booklet illustrating the various types of excavators made, varying from the ½ yard to enormous stripping shovels of 20 cubic yards bucket capacity. An important feature is that in all these mechanical shovels the dipper stick is inside the boom.

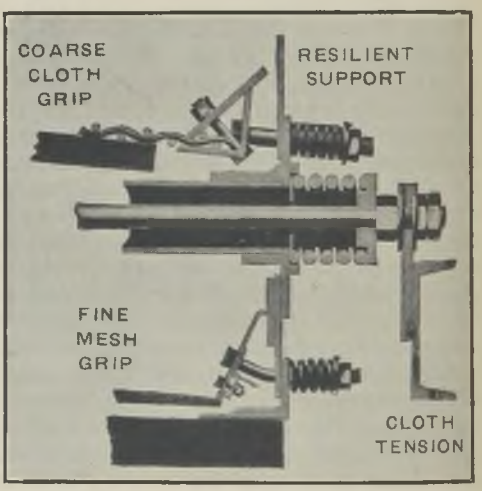
Wrights Ropes, Ltd., of Birmingham, the well-known firm of steel rope makers, which until 1927 was known as John and Edwin Wright, Ltd., publish a comprehensive catalogue of mining and other ropes, together with particulars of approximate weights and breaking strains, particulars as to drums and pulleys that can be used with these ropes, etc. A great many examples of winding ropes and locked coils are illustrated, the strands of wire having a variety of cross-sections.

Fraser and Chalmers Engineering Works, of Erith, and Magnet House, London, W.C. 2, have sent us a catalogue describing Robins screens which are manufactured at their works in association with Robins Conveying Belt Co. of New York. These screens are made in three kinds, designated by the words "Vibrex," "Savage," and "Gyrex," respectively intended for fine mesh materials, smaller capacities and smaller sizes, and for larger materials. The first type is shown in the accompanying illustration. The screen cloth is spring tensioned over arched supports, and is carried by the "live frame," which is spring cushioned at each corner to maintain its position and eliminate escaping vibration. The vibrator, connected to the live frame by heavy cast steel clamps, consists of a shaft, driven at high speed from a pulley on its extension, to which are keyed two flywheels containing adjustably unbalanced weights. Heavy duty roller bearings journal the "carrier," to which the live frame is clamped, within the flywheels. A combination felt and labyrinth seal effectively protects the bearings. The bearings are mounted in the same plane with the unbalanced weights and thus free the shaft from any bending stress. Sectional



ROBINS VIBREX SCREEN.

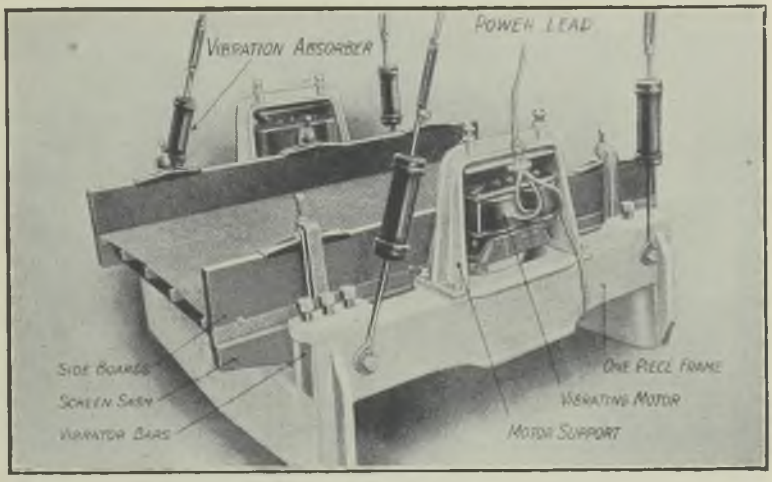




SECTIONAL VIEWS OF BEARINGS.

features of the mechanical parts are given in Fig. 2. The screen is placed at an angle of about 25° with the horizontal for counterflow rotation at 1,800 r.p.m. The base frame consists of two cross-connected channels on either side of the screen which can readily be bolted to any inclined supports. Less than 1 h.p. is required for operation, but a 2 h.p. motor should be fitted to allow for possible starting overloads. For very fine screening (50 mesh or more) speeds as high as 3,000 r.p.m. with stroke reduced to $\frac{1}{16}$ in. may be needed. If the layout permits, a two-strand Tex rope drive is recommended as being efficient.

Ruston and Hornsby, Ltd., of Lincoln, issue particulars of their pumping plant which will lift 4,000-5,000 gallons per hour. The pump is driven direct through gears by a 2 b.h.p. Ruston petrol engine which is totally enclosed. The entire outfit is remarkably compact. They also inform us that a private company has been formed under the title of Société Anonyme des Moteurs Ruston-Hornsby at 5, Avenue de la Republique, Paris, to exploit their oil engine business in France and the French Colonies.



Single Deck Screen "Supreme" FB 2.

Underfeed Stoker Co., Ltd., of Africa House, Kingsway, London, W.C. 2, have sent us a pamphlet describing the Duo-mass vibro-conveyor (Schenck-Heymann patents). This is a conveyor which consists either of a trough or tube which is caused to oscillate at high frequency and with small amplitude, being suspended from a number of spiral springs and mounted on flexible supports. The exciter is made to oscillate horizontally by the rotation of out-of-balance flywheels. The trough is connected to the exciter by an elastic coupling consisting of a number of coiled springs. This system of coupling ensures that energy is stored up when the spring is compressed or extended and this energy is devoted on the rebound to the conveyance of material.

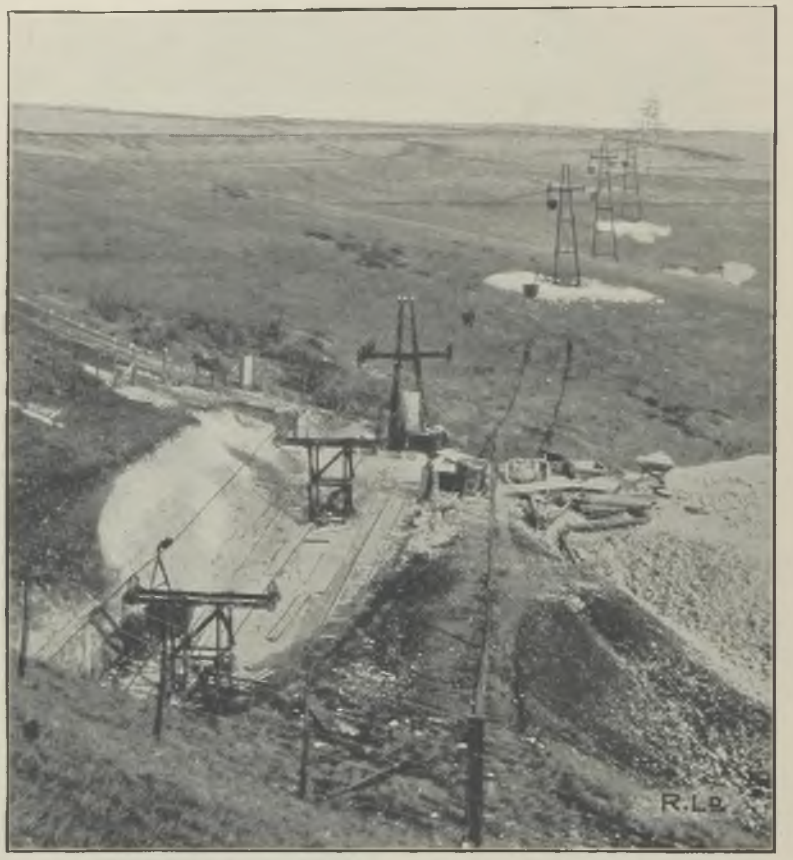
Gardner-Denver Co., Ltd., of 3, Wilson Street, Drury Lane, London, W.C. 2, issue catalogues as follows: One describing the features of their model 77/H automatically rotated stoper which is recommended for raising and stoping in hard rock; their model 107 powerful lightweight drifter, primarily designed for drifting and cross-cutting in medium and hard formations in which its high speed and light weight with lack of vibration make it a reliable machine; their model DS/3A drill sharpener capable of quickly forging all types of drill shanks from $\frac{7}{8}$ in. hex. up to and including $1\frac{1}{4}$ in. round and forging and sharpening bits up to $1\frac{1}{4}$ in. to $2\frac{1}{2}$ in. inclusive; their HP/20 hole puncher which may be mounted on all standard drill steel sharpeners; and model DF/1 high pressure drill forge which is a particularly noiseless when running at a forging temperature of 2,200° F.

Holman Bros., Ltd., of Camborne, and Broad Street House, London, E.C. 2, advise us that they have at their works plant for the testing of ores, and can arrange to have the necessary assays made. A nominal charge is made for the use of the tables and the assays, all or a certain amount of which is remitted in the event of plant being purchased on their recommendation. For a successful trial not less than one ton of about 15 mesh material should be submitted, and the work can be carried out either by the firm or under the supervision of the engineer interested. The installation consists of a James sand table, James slime table, hydraulic classifiers, and a small tube mill for grinding the middling products from the sand table, the overflow from which is elevated by a Frenier pump to a classifier for further table treatment. At present no stone breaker or rolls are installed but pneumatic stamps are available. As, however, they specify for a material of 15 mesh this is unimportant. Although this plant has been used mainly for the treatment of tin ores, nevertheless, other ores have been successfully handled.

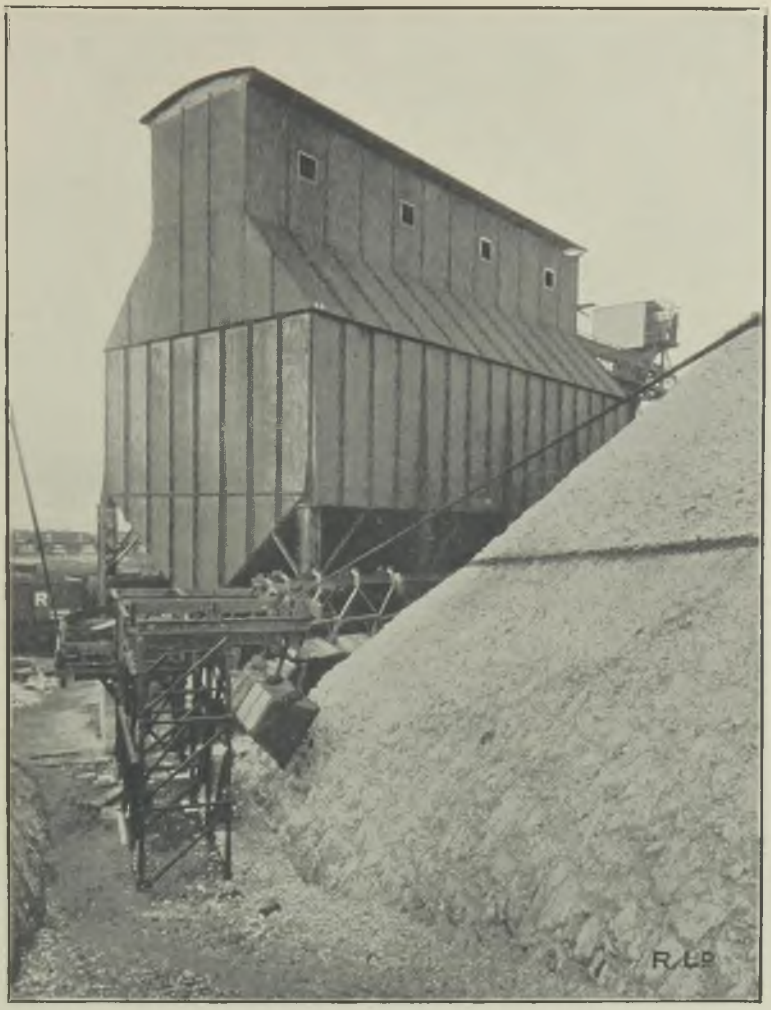
Thomas Locker and Co., Ltd., of Warrington, send us their fully illustrated catalogue of woven wire and perforated metal work which also contains details of the "Supreme" vibrator screen concerning which, and also the "Supreme" vibrating conveyor, they send us other descriptive literature. These specialities are manufactured in this country by arrangement with the Traylor Vibrator Co., of Denver, Colorado. The Supreme electric vibrating screen is made in four sizes, any of which may be used for fine, coarse, damp, wet, or dry screening. Steel sash construction is standard on all screens. This simple method of screen cloth application reduces time for screen changes to the minimum

and allows the operator immediate access to the tightening device during operation. The FB 2 (illustrated here) screen surface measures 41 in. by 68 in., and the screen is supplied with either the single or double deck. Minimum care and attention are required as there are no bearings, springs, or other moving parts requiring lubrication. Dampness and ordinary wet operating conditions, where spray pipes and flush water may be required, have no effect on the motors as there are no exposed wires to cause shorts. The motor coils are thoroughly insulated and constructed to operate under extreme working conditions. Vibration is imparted uniformly over the entire surface and may be easily regulated. Both surfaces on double-deck screens are vibrated with exactly the same amplitude of vibration and power requirements for double deck operations are no more than for single deck screens. Extensive head room and large floor space are not required. The FB 4 is constructed for heavy duty and large capacity operations, but it is equally satisfactory for fine mesh separation. The clear screen surface is 47 in. by 78 in. A projected lower deck gives the maximum useful screen surface because the feed end is properly located to receive the screenings from the top deck without waste of screen surface. The principle of the vibrator conveyor is the same as that of the screen except that the direction of vibration is at a different angle, being nearly parallel to the path of the conveyor. The conveyor may be open or in tubular form and may be either suspended or base supported. Under full load material will travel at a speed of from 40 to 50 feet per minute. It is especially designed for short conveying purposes.

Mining and Industrial Equipment, Ltd., of 11, Southampton Row, London, W.C. 1, beg to report that new orders have been received for the following equipment :—England : One 4 ft. by 5 ft. One-surface, type 39, Hummer screen for black coal to $\frac{1}{8}$ in. sepn. at 20 tons/hr. ; one 4 ft. by 5 ft. One-surface, type 39, Hummer screen for coke ; and one 4 ft. by 6 ft. One-surface, type 60, Hummer screen, for coke. S. Africa : Two 5-roller low side Raymond mills for grinding Morocco phosphate at 6 tons/hr. to 85% – 100. France : Three Hardinge mills, 6 ft. by 48 in., for grinding $1\frac{1}{2}$ tons/hr. coal or anthracite to 95% – 200 each ; one 5-roller Raymond mill with D.C. Sep. for grinding 4 tons coal per hr. to 95% – 100 ; two 5-roller Raymond mill with S.C. Sep. for grinding 5 tons coal/hr. to 95% – 100 each ; one 3-roller Baby Raymond mill for grinding $1\frac{1}{2}$ tons/hr. Gafsa phosphate to 90% – 100 ; three Leviathan Raymond mills for grinding 25 tons/hr. each to 100 ; one No. 0000 pulverizer for unnamed duty ; one Gayco separator for separating $2\frac{1}{2}$ tons/hr. phosphate to 96% – 180. 1 Hummer Screen S.S. Type 37, screening to 43% – 10, cement slurry ; 3 Hummer Screen S.S. Type 37.



TILMANSTONE ROPEWAY.—ENTRANCE TO TUNNEL.



TILMANSTONE ROPEWAY.—LOADING STATION AND BUNKER.

TILMANSTONE ROPEWAY

Ropeways, Ltd., of Aldwych House, London, W.C. 2, provide us with particulars of a ropeway and loading plant which has recently been completed to connect the Tilmanstone (Kent) Colliery with Dover Harbour. Special interest attaches to this installation as being the first of its kind for coal handling in this country where rail freights add considerably to the cost of coal to the consumer, frequently rendering the export of this commodity uneconomic.

The ropeway is designed to carry 120 tons an hour when running at a speed of 130 yards a minute. It starts at an altitude of 198 feet above sea-level and runs over open country and over the eastern breakwater at Dover Harbour to the unloading bunkers built thereon—a total distance of 7¼ miles. This length is too great to run in one section and therefore it was found necessary to introduce a divide station (from which both sections are driven) at a point about 6,040 yards from the loading terminal, the altitude being 261 feet above sea-level. A circuitous route for the second section is necessitated by having to miss certain lands adjoining the cliff, and the only method, therefore, was to go round these lands via Angles Nos 1 and 2 and through a tunnel, emerging on the sea-face of cliff. The length of this second section is roughly 6,600 yards.

For supporting the rope between stations a total of 177 trestles was required, the average height of which is about 30 ft., which results in a nett clearance underneath the buckets of 12 ft. at any point along the line, except where the ropes are brought down to the entrances or exits of stations. These are mounted with single, pair, or four wheels fitted into compensating balance beams for supporting the rope, which is 4 in. circumference and has an actual breaking strain of 58 tons. The tallest of these trestles is 70 ft., being built on the foreshore immediately at the exit of the tunnel. Fifteen roads and two railways are crossed in the whole route, and to conform with bye-laws all these

crossings are protected by girder type bridges. The nett load in the buckets is 14¼ cwt. and these are about 46 yards apart, giving a time interval between loads of 21·4 seconds. The boxheads or carrier heads are of the standard "Roe" type, in which saddle clips are used to effect the grip on the rope, whilst at stations the carrier is run, by means of auxiliary wheels, on shunt rails to any desired point.

The loading station is a ground level structure containing one plain terminal wheel around which the rope passes. A part of the shunt rail takes the form of an opened-out "L" to pass around the loading bunkers, which are built roughly at right angles to the ropeways centre line. These bunkers are 500 tons capacity, and are served by a series of belts from the screening plant. At the divide station twin sets of driving and tension gears are fitted for operating and tensioning the ropes on both the sections. The driving gears are coupled to one countershaft through a double clutch, so that the sections can be operated together or independently of each other. 60/65 b.h.p. is required to drive the ropeway, which is taken from a Bellis and Morcom engine and boiler. At this station provision is also made to garage the buckets and carriers of either section, so that the ropeway can be stripped of buckets and these can again be put on when required in the shortest possible time. This station is also built at ground level. No. 1 Angle is a simple ground level structure, the ropes being taken round angle sheaves 10 ft. 6 in. diameter. The shunt rails are graded at this as at all other stations, so that normally the buckets will run automatically from one rope to the other. No. 2 Angle in the tunnel was required to bring the ropeway back to its normal path—that is in direct line with the breakwater, and the arrangements here are similar to those at Angle No. 1. The tunnel starts on a grade of 1 in 7½—1,119 ft. from Angle No. 2. The total length of the tunnel is 1,245 ft., emerging on the cliff-side at 87 feet above sea-level. From the second Angle the line emerges from the tunnel and runs over the breakwater to the unloading and return terminal station built directly over the bunkers at the end of the breakwater. The arrangement here provides for the buckets being tipped automatically at any point over these bunkers, which are 250 ft. in length. At the back of the bunkers is arranged the return terminal, which contains the terminal wheel, and around which the emptied buckets are passed on to the return rope by means of graded shunt rails in the usual manner.

The loading plant at the harbour is designed to facilitate the shipment of coal at a maximum hourly rate and to reduce to a minimum the time the ship is tied up at the loading pier. The coal may be taken from any section of the bunker by a series of shoots and conveyors and delivered to any hold of the ship. The bunker of reinforced concrete construction is supported on two longitudinal rows of columns from the pier structure. The capacity of the bunker, as at present built, is 5,000 tons, the length being 250 ft., but the design allows of extending this to a further 250 ft.

CROSSLEY OIL ENGINES

Under the heading of Crossley Bros., Ltd., in notes here last month brief mention was made of oil engines exhibited by this firm at the British Industries Fair and as these represent some marked changes in design and were only placed on the market in 1929 some additional notes are appended. Two types are particularly referred to here and the photographs illustrating them serve to show how the new design has altered the general appearance.

The first is an enclosed horizontal, cold-starting engine, and prior to the introduction of this, very little advance had been made in the design of horizontal oil engines during the previous 10 years. The open type continued to represent general practice so far as concerned horizontal engines, and excepting for some minor points of difference in the general design, the performance and fuel consumptions remained practically at a standstill. As a result of a careful study and research made with a view to effecting improvements, a series of tests were conducted upon an experimental engine under very arduous and exacting conditions. These tests proved remarkably successful, and the present engine is the outcome. This engine consumes cheap grades of non-asphaltic fuel oil, is cold starting, and operates on the four-cycle principle. The advantages include the complete enclosing and self lubrication of all the main moving parts, a reduction in fuel and lubricating oil consumptions, improved turning moment, and the occupation of smaller space. Although the enclosed type engine is of higher revolving speed than the open type, the piston speed is less. In protecting all the moving parts from dust and dirt, the enclosed principle permits of more ample lubrication with correspondingly increased life to the moving parts.

The customary side-shaft and gear wheels have entirely been abolished, and, instead, a camshaft is mounted across the top of the cylinder, completely encased and fitted with a polished cover. This cover is instantly removable for inspection purposes. All the inlet, exhaust, and fuel cams revolve in an oil bath. The valve rollers, pins, and guides are likewise enclosed and lubricated from the oil bath. The camshaft is driven by a silent chain from a sprocket wheel on the crankshaft, and a corresponding sprocket wheel keyed on the end of the camshaft. The driving chain is enclosed inside a stationary casing, the base of which forms an oil bath, so that the chain is thoroughly lubricated. The governor is of the spring loaded centrifugal type and mounted on the end of the camshaft, also entirely enclosed, all working parts being thus protected and self lubricated. Chain tightening gear is provided so that any adjustment which is made shall not interfere with the valve timings.

The engine is built in single and multi-cylinder sizes from 16 b.h.p. up to 80 b.h.p. and a range of powers is thus offered having the same unit size of cylinder, piston, valves, connecting rod, and many other details, thus simplifying enormously the question of spare parts. Figure 1 shows the 4-cylinder engine, 80 b.h.p., of this type.

The other development is the vertical compressorless Diesel engine and here again the principles of design include the total enclosure of the engine mechanism—not only the main moving parts, but all the valve gear, camshaft, camshaft drive, etc. Easy access is afforded to the crankshaft and connecting rod bearings by means of large inspection doors arranged on both sides of the engine frame. Large cover plates are provided at the top of the engine, these being semi-hinged so that they can be opened immediately by hand or entirely detached without unfastening a single bolt. When these covers are removed, the fuel sprayers, valve

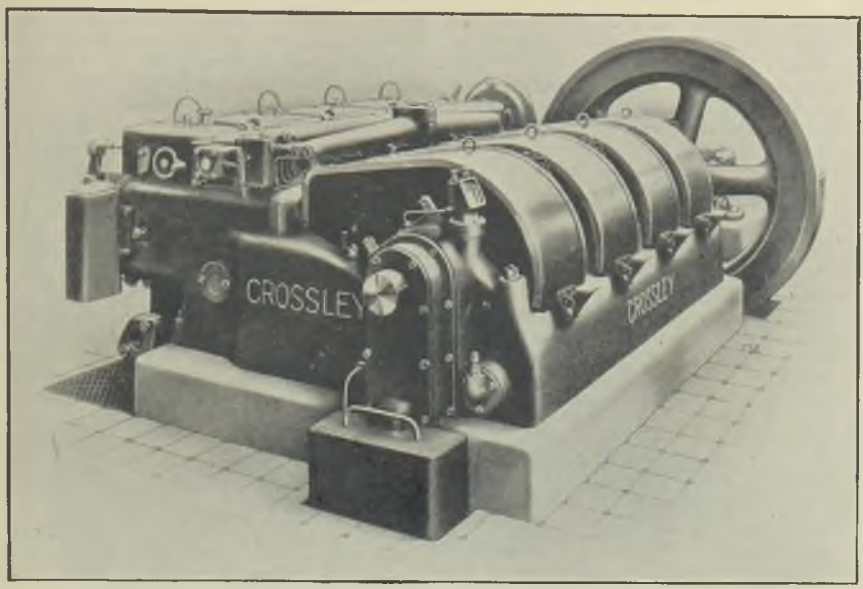


FIG. 1.—CROSSLEY ENCLOSED-TYPE HORIZONTAL OIL ENGINE, 80 B.H.P.

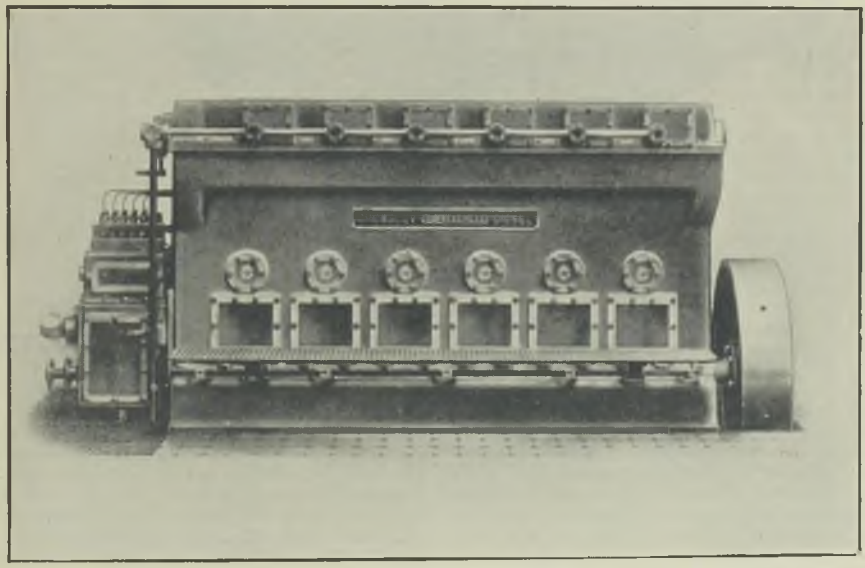


FIG. 2.—CROSSLEY 6-CYLINDER COMPRESSORLESS DIESEL ENGINE, 165 B.H.P.

levers, camshaft and operating gear are exposed to view. The engine can be operated with these cover plates either closed down or removed.

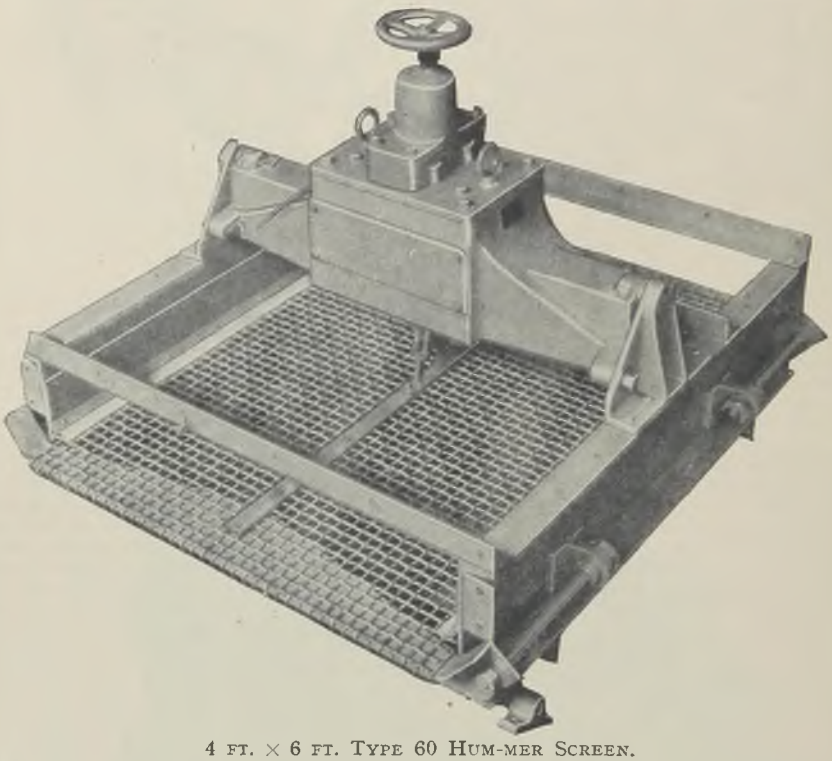
The inlet and exhaust valves are situated in the head of each cylinder, being operated directly from levers without the introduction of push rods. This is made possible by reason of the camshaft being mounted to one side at the top of the engine. Steel cams fitted on the camshaft actuate the valve levers direct. The camshaft is carried in suitable journals and is supplied with forced lubrication from the pressure system provided. A silent roller chain is used to drive the over-head camshaft. The chain is entirely enclosed and continuously lubricated, means being provided for tightening or correcting any chain stretch that may occur. The perfected system of lubrication is a distinct improvement, inasmuch as not only are the main bearings continuously lubricated under pressure, but also all the auxiliary moving parts such as camshaft, cams, valve levers, governor, etc. Moreover, this permits the continuous use of the oil over and over again, without contamination by dust or dirt. The oil pressure is maintained by a plunger pump which delivers the oil from an oil sump in the engine base to the oil pipe system after

filtration. The oil after passing through the engine bearings, drains back to the oil sump on the dry crankcase system.

Automatically controlled air starting valves are fitted to each cylinder and acceleration at starting is very quick, so that the time required from the engine being at rest to working at full speed is only a matter of seconds.

As will be seen from Figure 2, which shows the 6-cylinder, 165 b.h.p. type, the engine frame or housing is designed on the box girder principle which permits of cylinders being supported throughout their entire length and thereby avoids torsional strains, which otherwise are set up from side-sway when each cylinder is individually projected. The baseplate which carries the crankshaft and bearings is of massive proportions, well ribbed inside so as to give rigidity and maintain the crankshaft in perfectly true alignment. An individual fuel pump is provided for each cylinder, but it will be noticed that all the pumps are grouped together in one unit at one end of the engine—the opposite end to the flywheel. A centrifugal spring-loaded governor is provided and mounted directly on the crankshaft. Hand regulating or speeder gear is provided for varying the speed of the engine within limits and for synchronizing purposes in the case of alternators to be driven in parallel.

A special system of precision spraying is employed. The amount of fuel oil injected into the engine is positively and accurately measured according to the load on the engine. This is accomplished by the governor, which varies the moment when each fuel pump control valve is opened and following the injection of the fuel oil. The actual governing takes place at the precise moment when the injected fuel oil is being burned, and is producing power—consequently the governing is extremely sensitive and accurate under all working load conditions. This type of engine is built in single and multi-cylinder units up to 6 cylinders, from 27 to 330 b.h.p.



4 FT. × 6 FT. TYPE 60 HUM-MER SCREEN.

TYPE 60 HUM-MER ELECTRIC SCREEN

Mining and Industrial Equipment Ltd., the recently formed separate organization of the grinding and pulverizing department of International Combustion, Ltd., draw our attention to the special features of the Type 60 Hum-mer Screen, which is one of the products of the W. S. Tyler Co., of Cleveland, Ohio, they handle in this country. The Type 60 is an electric screen especially designed for handling coarse material and is in many respects similar to other Hum-mer screens as may be seen in the accompanying photograph. Its essential difference, however, lies in the mounting of the screening surface which affects the nature of the vibration imparted. This is stretched taut, but in an endwise direction (rather than transversely) and on a floating frame, which is supported on cantilevered spindles. The whole surface is thus free to vibrate with an amplitude which is only limited by the flexibility of the spindles. In effect a kind of double vibration is imparted; one of high frequency and the other of low, the latter resembling hammer blows at regular intervals.

The whole is massively built, special materials being used for the vibrator and spindles so that they shall stand up to severe usage without fracture. The power consumption is low, 1 h.p. being required for the middle sized vibrator and 2 h.p. for the heavy duty, while the capacity is increased so that a 4 ft. by 7 ft. screen will handle 250 tons per hour at 2½ in. separation. The upper limit for grading is about 3 in. to 3½ and this gives a machine which will start grading where the grizzley ceases to be efficient. Two of these new screens were recently put into operation on blast furnace coke in a Scunthorpe ironworks. The coke is handled hot direct from the benches, and is screened at 1½ in. The capacity of one 4 ft. by 7 ft. screen has been up to the rate of 65 tons an hour giving a good grade of coke. There is no sign of blinding of the coke on the screen meshing. It is anticipated that the cloth life will be about 20,000 tons, which is good when it is realized that ordinary woven wire mesh is used. Another of these machines will shortly be in operation on blast furnace slag, and the results are awaited with interest.

METAL MARKETS

Copper.—The standard copper market in London was comparatively tranquil during March, but although consumers did not take much interest in the metal, professional operators were able to advance the cash quotation somewhat, this manœuvre being, it was suspected, connected with the desire of American producers of electrolytic copper to maintain their own quotation firm at 18 cents per lb. Rumours that the latter was likely to be reduced have proved ill-founded and apparently, despite the reluctance of users all over the world to pay the present price, producers intend to maintain it as long as possible. The statistical outlook, however, is not too brilliant and if world trading conditions do not improve it would not be surprising if a reduction in the price of electro takes place quite soon.

Average price of standard cash copper: March, 1930, £69 5s. 10d.; February, 1930, £71 10s. 3d.; March, 1929, £89 4s. 4d.; February, 1929, £78 5s. 10d.

Tin.—After receding during the first half of March, tin values recovered subsequently and closed the month at a slight advance. Sentiment is becoming a little more optimistic, as it is felt that in view of the drop in the price and the better industrial indications in the United States the outlook is more hopeful, but the situation still contains some distinctly adverse factors, surplus stocks being heavy, for example. On the other hand, these are likely to diminish from now onwards as the curtailment in output undertaken by producers begins to make itself definitely felt.

Average price of standard cash tin: March, 1930, £164 19s.; February, 1930, £173 16s. 6d.; March, 1929, £220 17s. 4d.; February, 1929, £223 4s. 8d.

Lead.—Prices lost further ground during March, but at the lowest levels witnessed, consumers came into the market on quite a good scale and quotations recovered temporarily, only, however, to fall again later. Buying interest was, as a matter of fact, checked when consumers realized that prices were not likely to undergo any immediate substantial advance. The outlook seems rather more favourable now, as recent arrivals of fresh metal have been slow and it is understood that the members of the Lead Producers' Association are going to curtail their output.

Average mean price of soft foreign lead: March, 1930, £18 17s. 5d.; February, 1930, £21 2s. 10d.; March, 1929, £25 9s. 11d.; February, 1929, £23 2s. 10d.

Spelter.—Prices fluctuated quite appreciably during the past month, but the result of the movements was almost negligible on balance. Demand has been rather dull but sentiment has been supported by the fact that values are now comparatively low and that fresh negotiations are taking place with the object of re-establishing the International Zinc Cartel. Production has tended to fall off further as far as can be ascertained. The German producers are threatening to apply to their Government for an import duty on foreign spelter to be used as a lever in the new cartel discussions.

Average mean price of spelter: March, 1930, £18 11s. 1d.; February, 1930, £19 9s. 10d.; March, 1929, £27 3s. 5d.; February, 1929, £26 5s. 11d.

Iron and Steel.—The outstanding event during March, as far as the pig-iron market was concerned, was the reduction of 5s. per ton in the price of foundry grades, announced by Cleveland blast furnace owners. This had the immediate result of stimulating demand, and the outlook is consequently very much more hopeful than it was. Cleveland No. 3 foundry is now quoted at 67s. 6d., No. 1 at 70s., No. 4 foundry at 66s. 6d., and No. 4 forge at 66s. per ton. As regards hematite, in which market there are no minimum prices and unrestricted competition prevails, the tone was easy and East Coast mixed numbers were marked down to 76s. In the market for British finished iron and steel, conditions remained dull both as regards home and export business, but prices were maintained. Business in Continental steel was restricted by uncertainties connected with the reorganization of the Continental Raw Steel Cartel and its subsidiary offices. Owing to the world-wide slump in many commodities, the purchasing power of overseas countries has been severely curtailed.

Antimony.—At the close of March, English regulus was quoted at £40 to £46 10s. per ton, a reduction having been made during the month. Chinese regulus on spot was priced at £29 10s. to £30 ex warehouse and metal for shipment from China at £25 15s. to £26 c.i.f.

Iron Ore.—The past month has been characterized by extreme quietness and a further decline in values. Most ironmasters seem rather overbought and delays in deliveries against contracts are frequent. Best Bilbao rubio is worth only about 21s. to 21s. 6d. per ton c.i.f.

Arsenic.—A small business is still being done at about £15 17s. 6d. to £16 per ton f.o.r. mines for 99% Cornish white.

Bismuth.—Owing to considerable competition at cut prices, from makers outside the Trust, the official price was reduced in March to 5s. per lb. for 5 cwt. lots and over.

Cadmium.—Only a moderate demand is in evidence, for on the continent the appearance of some low-priced locally produced material has made buyers reserved. In this country the price stands at about 3s. 11d. to 4s. per lb.

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.		Electrolytic.	Best Selected.				Soft Foreign.	English.			
	Cash.	3 Months.			Cash.	3 Months.				Cash.	Forward.	
Mar.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	d.	d.	s. d.
12	69 17 6	68 7 6	83 17 6	—	166 6 3	168 7 6	18 3 9	18 8 9	20 0 0	19½	18 13/16	84 11½
13	69 10 0	67 11 3	83 17 6	—	161 17 6	164 2 6	17 17 6	18 10 0	20 0 0	19 1/16	18 13/16	84 11½
14	69 3 9	67 6 3	83 17 6	76 0 0	161 6 3	163 11 3	17 17 6	18 10 0	20 0 0	19 1/16	18 13/16	84 11½
17	69 1 3	66 18 9	83 17 6	—	160 16 3	162 18 9	17 18 9	18 10 0	20 0 0	19½	19	84 11½
18	68 6 3	66 18 9	83 15 0	75 15 0	162 1 3	164 3 9	18 5 0	18 11 3	20 0 0	19 3/16	19	84 10½
19	68 1 3	66 18 9	83 15 0	—	161 12 6	163 16 3	18 5 0	18 10 0	20 0 0	19⅝	19 3/16	84 10½
20	68 7 6	67 3 9	83 15 0	—	164 3 9	166 3 9	18 6 3	18 10 0	20 0 0	20	19 1/16	84 10
21	69 13 9	67 18 9	83 15 0	75 15 0	164 16 3	166 18 9	18 12 6	18 12 6	20 0 0	19 1/16	19½	84 11
24	70 7 6	68 6 3	83 15 0	—	169 12 6	171 12 6	19 2 6	18 13 9	20 0 0	19⅜	19⅝	84 11
25	70 8 9	67 18 9	83 15 0	75 15 0	170 2 6	171 17 6	18 10 0	19 0 0	20 10 0	19¼	19 7/16	84 10
26	70 18 9	68 8 9	83 15 0	—	168 15 0	170 1 3	18 12 6	18 18 9	20 10 0	19 7/16	19⅜	84 11
27	71 15 0	68 10 0	83 15 0	—	168 8 9	170 1 3	18 12 6	18 17 6	20 10 0	19⅝	19½	84 11
28	71 13 9	68 7 6	83 17 6	75 15 0	169 17 6	171 7 6	18 11 3	18 16 3	20 10 0	19½	19⅝	84 11½
31	71 2 6	68 6 3	83 17 6	—	170 12 6	172 5 0	18 8 9	18 16 3	20 10 0	19 7/16	19 7/16	84 11½
Apr.												
1	70 6 3	68 15 0	83 17 6	75 15 0	166 8 9	168 3 9	18 2 6	18 16 3	20 10 0	19 7/16	19⅜	84 10½
2	69 19 4½	68 11 3	83 15 0	—	165 3 9	166 18 9	18 7 6	18 15 0	20 10 0	19⅜	19 7/16	84 10
3	70 3 9	68 6 3	83 15 0	—	164 12 6	166 8 9	18 5 0	18 15 0	20 10 0	19 7/16	19 7/16	84 11
4	69 17 6	67 18 9	83 15 0	75 5 0	163 8 9	165 3 9	18 6 3	18 11 3	20 0 0	19 7/16	19 7/16	84 11
7	69 1 3	67 1 3	83 12 6	—	162 6 3	164 3 9	18 6 3	18 3 9	19 15 0	19⅜	19 7/16	84 11
8	69 7 6	67 7 6	83 12 6	74 15 0	163 13 9	165 13 9	18 6 3	18 5 0	19 15 0	19⅜	19 7/16	84 10½
9	68 2 6	67 8 9	83 12 6	—	165 17 6	167 13 9	18 3 9	18 7 6	19 15 0	19 7/16	19⅜	84 11½

Cobalt Metal.—The official price is still 10s. per lb., but this figure is shaded for good contracts.

Cobalt Oxides.—A fair enquiry continues at the unaltered quotations of 8s. per lb. for black and 8s. 10d. for grey.

Chromium.—Metallic chromium is in moderately good request for plating purposes at about 2s. 6d. per lb.

Tantalum.—About £40 to £50 per lb. is quoted for this metal, which is still used only in very small quantities.

Platinum.—Only a small demand has been seen recently and prices have been persistently easier. At the moment the official figure for refined metal is £10 per oz., with merchants offering at less.

Palladium.—A fair enquiry has continued for palladium but prices are slightly easier in sympathy with platinum, current quotations being about £5 10s. to £6 5s. per oz.

Iridium.—Lack of demand has led to lower prices of this article, sponge and powder now being priced at about £30 to £32 per oz.

Osmium.—There is only a quiet interest in this metal at the moment, the price keeping steady at £13 15s. to £14 10s. per oz.

Tellurium.—Quotations are quite nominal at 12s. 6d. to 15s. per lb.

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

Manganese Ore.—No revival of demand has been seen, the only features of interest being the shipment of 100,000 tons of Russian ore to Rotterdam on consignment, as a reserve stock against German contracts, and the closing down of one or two Indian mines owing to the unremunerative prices. In the absence of business, quotations remain rather nominal at about 1s. 1½d. per unit c.i.f. for best Indian ore and 1s. 0½d. to 1s. 1d. for Caucasian washed ore.

Aluminium.—There has not been very much demand just recently, but it is interesting to note that the high price of copper still reacts in favour of aluminium by fostering the use of aluminium cables in place of copper. Prices are unchanged at £95 delivered, less 2% for ingots and bars.

Sulphate of Copper.—Rather easier conditions have prevailed and quotations now stand at £26 10s. to £27 per ton, less 5%.

Nickel.—Quite a good business is reported at £170 to £175 per ton.

Chrome Ore.—Consumers are still taking very fair quantities, and with adequate supplies, prices are unchanged at £4 2s. 6d. to £4 7s. 6d. per ton c.i.f. for good average 48% ore.

Quicksilver.—Only small lots are in request and owing to the limited turnover prices have eased slightly to £22 17s. 6d. per bottle, full terms, for spot material.

Tungsten Ore.—This market has been almost unprecedently quiet recently, practically no transactions taking place. Buyers have consistently reduced their bids as sellers have offered to meet them, and at the moment forward shipment from China is worth only around 25s. 6d. to 26s. 6d. per unit c.i.f.

Molybdenum.—Demand is at a minimum and prices rather nominal, with 80% concentrates offering at around 32s. 6d. per unit c.i.f.

Graphite.—No change is apparent in prices, which are about £25 to £28 per ton c.i.f. for good average 85 to 90% raw Madagascar flake, and £25 to £26 c.i.f. for 90% Ceylon lumps.

Silver.—The downward movement of prices was continued early in March when, owing to Eastern selling on news of the new Indian duty, spot bars declined from 19d. on March 1 to 18⅝d. on March 4, which is the lowest price ever recorded. At this point some revival of interest was seen, and prices recovered to 19¼d. on March 15, rising further to 20d. on March 20 on some Chinese and Indian buying. Subsequently very quiet conditions prevailed and prices eased off, spot bars closing at 19 7/16d. on March 31.

STATISTICS

PRODUCTION OF GOLD IN THE TRANSVAAL.

	Rand.	Elsewhere.	Total.
	Oz.	Oz.	Oz.
March, 1929	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
March	852,089	37,281	889,370

TRANSVAAL GOLD OUTPUTS.

	February.		March.	
	Treated Tons.	Yield Oz.	Treated Tons.	Yield Oz.
Brakpan	74,000	£122,977	90,000	£141,009
City Deep	88,000	22,963	97,000	25,647
Cons. Main Reef	54,600	19,546	60,000	21,023
Crown Mines	216,000	68,837	237,000	75,710
D'rb'n Roodepoort Deep	38,500	12,690	41,200	13,681
East Rand P.M.	137,000	37,135	150,000	40,987
Geduld	80,000	25,577	86,000	27,310
Geldenhuis Deep	58,700	14,111	64,900	15,148
Glynn's Lydenburg	6,000	2,107	6,400	2,224
Government G.M. Areas	189,000	£359,371	203,000	£389,179
Kleinfontein	48,200	£11,042	54,000	11,607
Langlaagte Estate	75,000	£111,134	81,000	£118,819
Luipaard's Vlei	23,000	5,775	26,500	6,387
Meyer and Charlton	16,500	£18,014	17,600	£19,919
Modderfontein New	140,000	67,437	154,000	72,729
Modderfontein B	66,000	24,079	72,500	25,940
Modderfontein Deep	41,400	21,323	44,200	22,763
Modderfontein East	63,500	18,615	70,000	20,493
New State Areas	72,000	£138,183	78,000	£151,128
Nourse	57,000	16,774	63,500	18,769
Randfontein	191,000	£202,880	218,000	£224,162
Robinson Deep	123,800	33,395	132,000	35,742
Rose Deep	55,500	11,431	62,000	12,281
Simmer and Jack	69,500	19,128	78,000	20,286
Springs	64,000	£133,055	69,000	£143,855
Sub Nigel	26,500	20,670	29,200	22,746
Transvaal G.M. Estates	13,400	4,735	14,620	5,115
Van Ryn	38,000	£38,670	42,000	£42,472
Van Ryn Deep	60,000	£102,741	65,000	£108,580
West Rand Consolidated	82,000	£91,755	90,000	£99,640
West Springs	63,000	£72,543	68,000	£78,205
Witw'tersr'nd (Knights')	51,000	£48,692	55,900	£52,001
Witwatersrand Deep	39,000	11,548	44,200	12,260

COST AND PROFIT ON THE RAND, Etc.

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

	Tons milled.	Yield per ton.	Work'g cost per ton.	Work'g profit per ton.	Total working profit.
		s. d.	s. d.	s. d.	£
January, 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	2,530,370	28 2	19 10	8 4	1,056,839
October	2,658,100	28 1	19 8	8 5	1,115,744
November	2,559,450	28 3	19 11	8 4	1,071,199
December	2,528,000	28 3	19 11	8 4	1,058,231
January, 1930	2,618,600	28 2	19 9	8 5	1,103,718
February	—	—	—	—	1,019,482

NATIVES EMPLOYED IN THE TRANSVAAL MINES.

	Gold Mines.	Coal Mines.	Diamond Mines.	Total.
March 30, 1929	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	190,663	15,288	5,889	211,840
February 28	196,752	15,495	6,584	218,831
March 31	200,134	15,250	7,002	222,386

PRODUCTION OF GOLD IN RHODESIA.

	1927	1928	1929	1930
	oz.	oz.	oz.	oz.
January	48,731	51,356	46,231	46,121
February	46,461	46,286	44,551	43,385
March	50,407	48,017	47,388	—
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.

	February.		March.	
	Tons.	Oz.	Tons.	Oz.
Cam and Motor	22,400	10,218	24,000	10,896
Globe and Phœnix	5,751	5,753	6,048	5,572
Lonely Reef	5,500	3,847	6,200	3,905
Luiri Gold	1,056	£2,637	1,480	£3,000
Rezende	6,000	2,537	6,400	2,718
Sherwood Starr	4,600	£10,525	5,000	£11,920
Wanderer Consolidated	10,670	2,667	12,200	3,256

WEST AFRICAN GOLD OUTPUTS.

	February.		March.	
	Tons.	Oz.	Tons.	Oz.
Ariston Gold Mines	7,006	£11,343	—	—
Ashanti Goldfields	9,979	11,484	10 517	11,772
Taquah and Abosso	8,750	£14,719	9,310	£15,615

AUSTRALIAN GOLD OUTPUTS BY STATES.

	Western Australia.	Victoria.	Queensland.	New South Wales.
	Oz.	Oz.	Oz.	Oz.
March, 1929	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	1,459	1,636	—
January, 1930	25,472	952	—	—
February	31,307	—	—	—
March	27,946	—	—	—

AUSTRALASIAN GOLD OUTPUTS.

	February.		March.	
	Tons	Value £	Tons	Value £
Associated G.M. (W.A.)	4,859	8,400	5,282	9,114
Blackwater (N.Z.)	2,935	5,575	3,507	6,127
Boulder Persev'ce (W.A.)	6,404	14,618	6,616	15,889
Grt. Boulder Pro. (W.A.)	9,146	21,871	10,044	24,285
Lake View & Star (W.A.)	6,987	19,248	—	—
Sons of Gwalia (W.A.)	12,960	11,116	13,924	13,829
South Kalgurli (W.A.)	8,055	14,292	8,638	16,300
Waihi (N.Z.)	17,857	7,080* / 40,956†	—	— / —

* Oz. gold. † Oz. silver.

GOLD OUTPUTS, KOLAR DISTRICT, INDIA.

	February.		March.	
	Tons Ore	Total Oz.	Tons Ore	Total Oz.
Balaghat	3,800	2,153	3,550	2,054
Champion Reef	7,310	5,136	8,350	5,595
Mysore	16,482	8,023	17,225	8,382
Nundydroog	11,000	6,907	11,515	6,968
Ooregum	13,500	6,168	13,500	5,707

MISCELLANEOUS GOLD, SILVER, AND PLATINUM OUTPUTS.

	February.		March.	
	Tons	Value £	Tons	Value £
Chosen Corp. (Korea)	9,030	10,039	9,560	11,680
Frontino& Bolivia (C'lbia)	1,770	5,079	2,500	7,700
Lena (Siberia)	—	11,065	—	10,126
Lydenburg Plat. (Trans.)	3,230	818*p*	3,500	710*p*
Marmajito (Colombia)	630	2,505	870	3,554
Fresnillo	86,142	66,864*d*	—	—
Onverwacht Platinum	2,900	554*p*	3,090	251*p*
Oriental Cons. (Korea)	20,809	98,141*d*	—	96,234*d*
St. John del Rey (Brazil)	—	43,000	—	46,000
Santa Gertrudis (Mexico)	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	5,763
October	5,966	April	—
November	6,135	May	—
December	5,849	June	—

OUTPUTS OF MALAYAN TIN COMPANIES.

In Long Tons of Concentrate.

	Jan.	Feb.	Mar.
Ayer Hitam	50½	65½	83¼
Batu Caves	26	16	24
Changkat	55	42	17
Chenderiang	27¾	28	26
Gopeng	77½	68½	62½
Hongkong Tin	137	113	83¼
Idris Hydraulic	32¾	26¾	26½
Ipoh	31	29½	17½
Jelapang	34	29	23
Kampar Malaya	55	45	40
Kampong Lanjut	60	35	43
Kamunting	89½	70	109
Kent (F.M.S.)	33	30	30
Kepong	40	37	33
Kinta	30	24	20
Kinta Kellas	53½	29¾	29¾
Kuala Kampar	75	45	62
Kundang	23	15	12
Lahat	14½	13¾	14½
Larut Tinfields	42	40	34½
Malaya Consolidated	59	44½	66
Malayan Tin	148¾	142¾	113
Meru	19½	20¾	18
Pahang	222	222	226
Penawat	77	69¼	65½
Pengkalen	51	48	45
Petaling	202½	202½	190
Rahman	65½	65½	59½
Rambutan	10¾	9½	9½
Rantau	31	15	28
Rawang	100	80	90
Rawang Concessions	70	15	30
Renong	93	76½	40¾
Selayang	31	26	24
Southern Malayan	172½	154¾	160¾
Southern Perak	68½	56½	80½
Southern Tronoh	54	38½	50
Sungei Besi	48	43	45
Sungei Kinta	33½	20½	18½
Sungei Way	83½	83½	77½
Taiping	24	15	19
Tanjong	38¾	33	33
Teja Malaya	15¾	21½	10½
Tekka	42	46	48
Tekka-Taiping	31	33	36
Temoh	37½	31½	36½
Tronoh	107	95½	71

OUTPUTS OF NIGERIAN TIN MINING COMPANIES.

In Long Tons of Concentrate.

	Jan.	Feb.	Mar.
Amari	6	4½	—
Anglo-Nigerian	103½	82½	8¼
Associated Tin Mines	200	200	200
Baba River	3¾	4	5
Batura Monguna	2½	1½	2
Bisichi	122	120	95
Daffo	6	6	—
Ex-Lands	55	55	55
Filani	4½	2¾	1¾
Jantar	35	30	35
Jos	21¾	22½	22½
Juga Valley	20	16	16
Junction	6	6	6
Kaduna	40	27	25½
Kaduna Prospectors	26	21	21½
Kassa	18	15½	17¾
London Tin	270	260	220
Lower Bisichi	6½	4½	5½
Naraguta	21	17	20
Naraguta Durumi	21	19	—
Naraguta Extended	10	7	4
Naraguta Karama	29½	—	17¾
Naraguta Korot	13	12½	10
Nigerian Consolidated	18	18	18
Offin River	8½	7½	7
Ribon Valley	20½	15¾	16¾
South Bukeru	13	10	10
Tin Fields	2¾	2⅝	4¾
Tin Properties	17	16	19
United Tin Areas	23½	20	21
Yarde Kerri	8	9	—

OUTPUTS OF OTHER TIN MINING COMPANIES.

In Long Tons of Concentrate.

	Jan.	Feb.	Mar.
Anglo-Burma (Burma)	15	12½	—
Aramayo Mines (Bolivia)	240	241	183
Bangrin (Siam)	59½	64¼	61¼
Berenguela (Bolivia)	33	—	—
C'nsolidated Tin Mines (Burma)	100	90	100
East Pool (Cornwall)	82½	82½	82¼
Fabulosa (Bolivia)	177	177	147
Geevor (Cornwall)	65	56	75
Jantar (Cornwall)	26	24	—
Kagera (Uganda)	25	20	28
Northern Tavoy	40	25	30
Polhigey (Cornwall)	31	28	—
San Finx (Spain)	21¼*	24*	—
Siamese Tin (Siam)	138	134¼	153
South Crofty (Cornwall)	55¼	54¾	65
Tavoy Tin (Burma)	25	20	20
Theindaw (Burma)	4	5	6
Tongkah Harbour (Siam)	50	40	60
Toyo (Japan)	27½	20	—
Wheal Kitty (Cornwall)	40	36	—
Zaaiplaats	35	22	—

* Tin and Wolfram.

COPPER, LEAD, AND ZINC OUTPUTS.

		Feb.	Mar.
Broken Hill South	Tons lead conc.	5,538‡	5,904†
	Tons zinc conc.	5,330‡	5,424†
Burma Corporation	Tons refined lead	6,750	6,750
	Oz. refined silver	607,945	607,000
Bwana M'Kubwa	Tons copper oxide	665	622
Electrolytic Zinc	Tons zinc	4,253	—
Indian Copper	Tons copper	206	202
Messina	Tons copper	495	585
Mount Lyell	Tons concentrates	4,023	3,507
Namaqua	Tons copper	150	161
North Broken Hill	Tons lead conc.	7,910	—
	Tons zinc conc.	6,200	—
Poderosa	Tons copper ore	—	804
Rhodesia Broken Hill	Tons lead	—	—
	Tons slab zinc	1,461	1,654
San Francisco Mexico	Tons lead conc.	3,637	3,750
	Tons zinc conc.	3,201	3,252
Sulphide Corporation	Tons lead conc.	1,880	2,093
	Tons zinc conc.	2,517	2,725
Tetiuhe	Tons lead conc.	1,245	1,195
	Tons zinc conc.	2,215	2,631
Union Minière	Tons copper	—	—
Zinc Corporation	Tons lead conc.	4,788‡	—
	Tons zinc conc.	4,568‡	—

† Four weeks to April 5. ‡ Four weeks to March 8.

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

		Jan.	Feb.
Iron Ore	Tons	419,137	409,240
Manganese Ore	Tons	32,666	23,002
Iron and Steel	Tons	310,316	259,396
Copper and Iron Pyrites	Tons	35,721	23,626
Copper Ore, Matte, and Prec.	Tons	7,696	2,964
Copper Metal	Tons	11,114	10,710
Tin Concentrate	Tons	7,357	6,722
Tin Metal	Tons	1,917	1,170
Lead Pig and Sheet	Tons	35,868	25,706
Zinc (Spelter)	Tons	12,991	11,471
Zinc Sheets, etc.	Tons	3,167	2,735
Aluminium	Tons	1,839	1,987
Mercury	Lb.	96,299	46,650
Zinc Oxide	Tons	1,014	782
White Lead	Cwt.	12,300	14,282
Red and Orange Lead	Cwt.	4,090	4,090
Barytes, ground	Cwt.	49,747	39,365
Asbestos	Tons	3,044	2,482
Boron Minerals	Tons	1,292	964
Borax	Cwt.	24,600	21,440
Basic Slag	Tons	2,626	3,854
Superphosphates	Tons	6,947	13,224
Phosphate of Lime	Tons	46,711	42,541
Mica	Tons	266	220
Sulphur	Tons	13,655	10,800
Nitrate of Soda	Cwt.	142,767	180,220
Potash Salts	Cwt.	264,312	264,953
Petroleum : Crude	Gallons	30,719,872	16,234,940
Lamp Oil	Gallons	29,970,808	15,541,386
Motor Spirit	Gallons	89,954,539	81,351,316
Lubricating Oil	Gallons	8,855,071	6,413,067
Gas Oil	Gallons	11,293,539	4,257,530
Fuel Oil	Gallons	40,383,333	31,776,575
Asphalt and Bitumen	Tons	13,055	13,565
Paraffin Wax	Cwt.	158,711	109,423
Turpentine	Cwt.	50,681	12,240

OUTPUTS REPORTED BY OIL-PRODUCING COMPANIES

In Tons.

	Jan.	Feb.	Mar.
Anglo-Ecuadorian	14,805	14,583	17,978
Apex Trinidad	34,760	29,370	31,010
Attock	3,111	2,921	2,855
British Burmah	5,359	5,030	5,559
British Controlled	32,220	23,293	34,376
Kern Mex	753	655	821
Kern River (Cal.)	932	1,100	2,564
Kern Romana	2,768	2,600	3,940
Kern Trinidad	4,726	4,987	5,368
Lobitos	28,815	25,581	28,497
Phœnix	50,110	45,612	45,263
St. Helen's Petroleum	6,107	6,352	6,796
Steaua Romana	71,890	64,870	75,610
Tampico	2,936	2,546	3,331
Trinidad Leaseholds	32,100	28,300	44,450
Venezuelan Consolidated	7,288	4,876	—

QUOTATIONS OF OIL COMPANIES SHARES.

Denomination of Shares £1 unless otherwise noted.

	Mar. 10, 1930	Apr. 10, 1930
	£ s. d	£ s. d.
Anglo-American	3 12 6	2 11 3
Anglo-Ecuadorian	13 9	17 6
Anglo-Egyptian B	2 6 3	2 11 9
Anglo-Persian 1st Pref.	1 5 9	1 7 6
" " Ord.	3 18 0	4 7 6
Apex Trinidad (5s.)	1 3 0	1 3 9
Attock	1 12 6	1 14 3
British Burmah (8s.)	5 9	5 9
British Controlled ($5)	3 6	4 3
Burmah Oil	3 16 9	4 7 6
Kern River, Cal. (10s.)	5 0	6 0
Lobitos, Peru	1 16 3	2 7 6
Mexican Eagle, Ord. (4 pesos)	11 6	14 3
" " 8% Pref. (4 pesos)	11 3	13 6
Phœnix, Roumania	11 9	12 6
Royal Dutch (100 fl.)	31 10 0	34 10 0
Shell Transport, Ord.	4 11 3	4 18 0
" " 5% Pref. (£10)	9 15 0	9 17 6
Steaua Romana	8 0	8 9
Trinidad Leaseholds	3 15 0	3 11 9
United British of Trinidad (6s. 8d.)	6 3	6 9
V.O.C. Holding	2 13 0	2 15 6

PRICES OF CHEMICALS. April 10.

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

		£ s. d.
Acetic Acid, 40%	per cwt.	16 6
" 80%	"	1 16 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	10 10 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 8½
Copper Sulphate	per ton	26 0 0
Hydrofluoric Acid	"	6
Iodine	per oz.	1 0
Iron, Nitrate	per ton	6 0 0
" Sulphate	"	1 15 0
Lead, Acetate, white	"	38 0 0
" Nitrate	"	32 0 0
" Oxide, Litharge	"	34 10 0
" White	"	43 0 0
Lime, Acetate, brown	"	7 5 0
" " grey, 80%	"	15 0 0
Magnesite, Calcined	"	9 10 0
Magnesium, Chloride	"	6 15 0
" Sulphate, comml.	"	3 15 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.	4½
" 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 0 0
" Permanganate	per lb.	5½
" Prussiate, Yellow	"	6½
" " Red	"	1 8
" 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.	3¾
" 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 3
Turpentine	per cwt.	2 6 6
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:	Mar. 10, 1930. £ s. d.	April 10, 1930. £ s. d.
SOUTH AFRICA:		
Brakpan	2 11 3	3 1 3
City Deep	5 0	7 0
Consolidated Main Reef	14 6	16 6
Crown Mines (10s.)	3 2 6	3 6 9
Daggafontein	1 1 3	1 3 9
Durban Roodepoort Deep	10 0	11 6
East Geduld	1 16 9	1 15 0
East Rand Proprietary (10s.)	9 0	11 0
Geduld	3 5 0	3 10 0
Geldenhuis Deep	5 3	6 0
Glynn's Lydenburg	3 6	2 6
Government Gold Mining Areas (5s.)	1 13 0	1 15 6
Langlaagte Estate	1 0 6	1 2 9
Meyer & Charlton	10 0	11 3
Modderfontein New (10s.)	4 0 0	4 3 9
Modderfontein B (5s.)	14 0	14 6
Modderfontein Deep (5s.)	1 3 9	1 6 9
Modderfontein East	1 3 9	1 6 3
New State Areas	1 11 9	1 13 9
Nourse	8 9	9 6
Randfontein	5 6	6 3
Robinson Deep A (1s.)	13 9	15 6
" " B	7 6	8 3
Rose Deep	4 0	4 3
Simmer & Jack (2s. 6d.)	2 9	3 0
Springs	3 1 9	3 6 3
Sub Nigel (10s.)	1 16 3	1 18 9
Van Ryn	6 3	6 6
Van Ryn Deep	1 10 6	1 12 6
Village Deep	7 9	8 0
West Rand Consolidated (10s.)	5 3	6 3
West Springs	12 9	14 6
Witwatersrand (Knight's)	9 0	9 0
Witwatersrand Deep	3 6	3 6
RHODESIA:		
Cam and Motor	1 1 9	1 4 3
Gaika	4 0	3 6
Globe and Phœnix (5s.)	16 0	14 6
Lonely Reef	16 9	18 9
Mayfair	12 6	10 0
Rezende	1 2 6	1 2 6
Shamva	1 6	1 9
Sherwood Starr	1 0 0	1 0 0
GOLD COAST:		
Ashanti (4s.)	1 6 6	1 10 3
Taquah and Abosso (5s.)	2 6	2 6
AUSTRALASIA:		
Golden Horseshoe (4s.), W.A.	2 6	2 9
Great Boulder Proprietary (2s.), W.A	1 6	1 3
Lake View and Star (4s.), W.A.	11 6	11 9
Sons of Gwalia, W.A.	1 3	1 3
South Kalgurli (10s.), W.A.	13 0	13 0
Waihi (5s.), N.Z.	12 9	13 0
Wiluna Gold, W.A.	17 0	18 3
INDIA:		
Balaghat (10s.)	4 0	3 6
Champion Reef (10s).	9 0	7 9
Mysore (10s.)	12 0	11 0
Nundydroog (10s.)	16 9	15 9
Ooregum (10s.)	6 0	5 3
AMERICA:		
Camp Bird (2s.), Colorado	1 0	1 0
Exploration (10s.)	6 0	6 0
Frontino and Bolivia, Colombia	7 6	7 6
Mexican Corporation, Mexico	7 3	7 3
Mexico Mines of El Oro, Mexico	1 6	3 9
Panama Corporation	19 6	19 6
St. John del Rey, Brazil	18 6	18 9
Santa Gertrudis, Mexico	8 0	9 6
Selukwe (2s. 6d.), British Columbia	3 9	4 3
MISCELLANEOUS:		
Chosen, Korea	6 3	5 0
Edie (5s.), New Guinea	14 0	15 0
Lena Goldfields, Russia	6	9

COPPER:		
Bwana M'Kubwa (5s.) Rhodesia	1 1 0	1 0 3
Esperanza Copper, Spain	1 1 3	1 1 6
Indian (2s.)	1 9	1 9
Loangwa (5s.), Rhodesia	5 3	5 9
Luiri (5s.), Rhodesia	4 9	4 6
Messina (5s.), Transvaal	16 0	16 6
Mount Lyell, Tasmania	1 10 6	1 11 6
Namaqua (£2), Cape Province	13 0	15 0
N'Changa, Rhodesia	2 12 6	3 0 0
Rhodesia-Katanga	1 18 9	2 0 0
Rio Tinto (£5), Spain	43 12 6	45 10 0
Roan Antelope (5s.), Rhodesia	1 8 0	1 10 0
Tanganyika, Congo and Rhodesia	1 17 6	2 6 3
Tharsis (£2), Spain	4 11 3	5 5 0

LEAD-ZINC:	Mar. 10, 1930. £ s. d.	April 10, 1930. £ s. d.
Amalgamated Zinc (8s.), N.S.W.	9 0	10 0
Broken Hill Proprietary, N.S.W.	1 0 6	1 0 9
Broken Hill North, N.S.W.	3 1 3	3 5 0
Broken Hill South, N.S.W.	2 0 0	2 5 0
Burma Corporation (10 rupees)	12 6	14 0
Electrolytic Zinc Pref., Tasmania	1 3 9	1 7 6
Mount Isa, Queensland	1 2 6	1 3 9
Rhodesia Broken Hill (5s.)	2 3	3 0
San Francisco (10s.), Mexico	1 0 6	1 2 9
Sulphide Corporation (15s.), N.S.W	13 9	13 9
ditto, Pref.	1 0 6	1 0 6
Zinc Corporation (10s.), N.S.W.	1 5 0	1 7 6
ditto, Pref.	3 5 0	3 8 9

TIN:		
Aramayo Mines (25 fr.), Bolivia	1 13 0	1 17 6
Associated Tin (5s.), Nigeria	6 0	7 3
Ayer Hitam	13 6	14 3
Bangrin, Siam	1 1 3	1 6 3
Bisichi (10s.), Nigeria	8 0	8 9
Chenderiang, Malay	2 0	1 6
Consolidated Tin Mines of Burma	5 0	6 0
East Pool (5s.), Cornwall	1 0	9
Ex-Lands Nigeria (2s.), Nigeria	2 0	2 3
Geevor (10s.), Cornwall	4 9	5 0
Gopeng, Malaya	2 5 0	2 6 3
Hongkong	18 9	1 1 9
Idris (5s.), Malaya	10 9	11 3
Ipoh Dredging (16s.), Malay	19 0	1 1 0
Kaduna Prospectors (5s.), Nigeria	7 6	8 0
Kaduna Syndicate (5s.), Nigeria	13 9	15 0
Kamunting (5s.), Malay	8 0	10 3
Kepong, Malay	18 0	1 1 3
Kinta, Malay	12 6	13 0
Kinta Kellas, Malay	8 3	9 0
Kramat Pulai, Malay	1 16 3	1 15 0
Lahat, Malay	10 0	10 0
Malayan Tin Dredging (5s.)	1 5 9	1 7 6
Naraguta, Nigeria	10 0	10 0
Nigerian Base Metals (5s.)	1 3	1 6
Pahang Consolidated (5s.), Malay	9 3	10 0
Penawat ($1), Malay	1 6	1 6
Pengkalen (5s.), Malay	15 6	16 3
Petaling (2s. 4d.), Malay	12 9	13 9
Rambutan, Malay	11 3	11 3
Renong Dredging, Malay	1 2 6	1 5 6
Siamese Tin (5s.), Siam	11 3	12 9
South Crofty (5s.), Cornwall	3 6	4 0
Southern Malayan	16 3	16 9
Southern Perak, Malay	2 1 9	2 7 6
Southern Tronoh (5s.), Malay	8 6	9 6
Sungei Besi (5s.), Malay	11 6	12 0
Sungei Kinta, Malay	19 0	19 9
Tanjong (5s.), Malay	13 0	13 0
Tavoy (4s.), Burma	6 6	9 0
Tekka, Malay	1 0 0	1 0 0
Tekka Taiping, Malay	1 1 6	1 2 6
Temengor, Malay	1 6 3	1 5 6
Toyo (10s.), Japan	5 3	5 6
Tronoh (5s.), Malay	1 0 6	1 2 6

DIAMONDS:		
Consol. African Selection Trust (5s.)	1 6 3	1 5 0
Consolidated of S.W.A.	10 0	9 6
De Beers Deferred (£2 10s.)	9 10 0	9 7 6
Jagersfontein	2 0 0	2 0 0
Premier Preferred (5s.)	5 0 0	5 0 0

FINANCE, ETC.:		
Anglo-American Corporation	1 8 0	1 6 6
Anglo-French Exploration	18 9	1 0 0
Anglo-Continental (10s.)	10 9	8 9
Anglo-Oriental (Ord., 5s.)	5 6	9 0
ditto, Pref.	14 3	16 9
British South Africa (15s.)	1 9 3	1 19 3
Central Mining (£8)	18 0 0	18 5 0
Consolidated Gold Fields	1 18 9	2 5 6
Consolidated Mines Selection (10s.)	16 9	17 0
Fanti Consols (8s.)	13 0	13 0
General Mining and Finance	12 6	16 3
Gold Fields Rhodesian (10s.)	9 0	9 9
Johannesburg Consolidated	2 2 9	2 2 9
London Tin Syndicate	1 0 6	1 7 3
Minerals Separation	6 12 6	7 2 6
National Mining (8s.)	1 3	1 0
Rand Mines (5s.)	2 15 0	3 2 6
Rand Selection (5s.)	11 6	12 3
Rhodesian Anglo-American (10s.)	1 8 0	1 8 9
Rhodesian Congo Border	13 15 0	15 2 6
Rhodesian Selection Trust (5s.)	2 8 9	2 12 6
South African Gold Trust	1 5 0	1 11 9
Southern Rhodesia Base Metals	13 0	1 5 6
Tigon (5s.)	1 6 3	1 8 0
Union Corporation (12s. 6d.)	3 5 0	3 13 9
Venture Trust (10s.)	5 9	6 3

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 NORANDA SMELTER

The *Canadian Mining and Metallurgical Bulletin* for March contains an article by W. G. Boggs and J. N. Anderson on the Noranda Smelter. Full extracts from their paper are given here.

The smelter was built by Noranda Mines, Limited, from the designs of A. E. Wheeler, consulting metallurgist, New York, for the reduction of ores and concentrates from the Horne mine, and to treat, on a custom basis, ores and concentrates from other mines in the Rouyn district. It is situated at Noranda in western Quebec, about 330 miles directly north of Toronto. Ground was first broken for construction in November, 1925, before the completion of the branch railway into the district, which was not finished until October, 1926. After many difficulties and delays due to the lack of transport and the severe weather during the winter months, the smelter was started in December, 1927, and the first blister copper was poured on December 17.

The smelter was built throughout in two duplicate units, each with a rated capacity of 500 tons of ore per day. Operations were started with only one unit, and after several months it was found that one unit alone would smelt 1,000 tons of ore per day. At this time only one shaft, No. 3, existed, and its hoisting capacity and the capacity of the original crushing plant were insufficient to supply ore for two units at the increased tonnage. Accordingly No. 4 shaft was sunk and a new crushing plant provided to handle the ore hoisted there. This work was completed in the latter part of November, 1929, and since that time both smelter units have been operating.

The high tonnage of ore that the single unit handled daily was due to several causes: first, a relatively easy smelting ore; second, elimination of the use of barren limestone; third, alterations made to the firing end and the flue end of the reverberatory furnace; and fourth, and most important, the improvement of the firing practice on the reverberatory furnace. Operating two units at this increased capacity involved increasing the tonnage of the roasters and installing two more converters for handling the additional quantity of matte produced.

The operation of the coal pulverizing plant gave considerable trouble, and in June, 1929, when an explosion destroyed the storage tank of the indirect system then in use, it was changed over to the direct system. Due to mechanical defects, the heat recuperator with which No 1 reverberatory furnace was equipped was not a success and had to be rebuilt. Since its reconstruction it has not been in operation long enough to give complete data on the results that will be obtained with it.

When it was decided to construct the smelter, the greater part of the ore then developed in the mine was sufficiently high grade to be smelted direct. Later, large bodies of concentrating ore were discovered and a 500-ton mill for treating these ores was built. An account of its operation has been given by G. C. McLachlan, mill superintendent. The mill is now being enlarged and will have a capacity of 1,000 to 1,200 tons a day, of which part will be used for treating concentrating ore from the Waite-Montgomery mine.

In 1926, when the design of the smelter was decided on, it was known that there was ore in the mine of such a grade that it would have to be concentrated, and that there was the probability of finding more ore of similar grade. Consequently, roaster and reverberatory furnaces were the choice rather than blast furnaces, since the latter are not suited for handling concentrates. The extremely cold winter weather had to be considered in designing the smelter. Where conditions permit, a bedding system for mixing the ores before roasting is standard copper smelter practice. This could not be done at Noranda because the ore beds would freeze in the winter months. Instead, the crushed ore, after being weighed and sampled, goes directly to storage bins over the roasters. There are 26 of these bins, of which 18, with a capacity of 325 tons each, are used for sulphide ore and concentrates, and 8, with a capacity of 140 tons each, are used for siliceous ore. The roaster, reverberatory furnace, and converter buildings were all placed under one roof, so that the maximum effect of the heat from the various processes could be utilized in keeping the buildings at a comfortable temperature during the cold weather. It is now realized that close grouping of the roaster, reverberatory, and converter buildings, with no dividing walls, was a mistake. Unavoidably, there is always a certain amount of gas in the converter aisle. It was found that this gas drifted into the roaster and reverberatory furnace buildings and made working conditions bad. Dividing walls have been put in, so that now, in effect, the three buildings are separate. The roasters are placed in two rows, which are at right angles to the long axis of the reverberatory furnaces. This necessitates considerable switching in drawing the roasted ore from hoppers under the roasters, which could have been avoided had the roasters been placed in a double row, with the long axis parallel to the long axis of the reverberatory furnace, with a single track running under calcine bins placed on the centre line of the two rows of roasters.

The roaster building is enclosed on two sides by the reverberatory building and the Cottrell plant, and the reverberatory furnace balloon flue passes alongside of the roaster building. This was done with the object of keeping the building warm in the winter time, but it makes it too hot in the summer. It would have been better had the roaster building been placed at some distance from the furnace building. It has been found that grouping all the

building together, as was done at Noranda, is a disadvantage, because it makes for bad working conditions on account of the gas and heat, and does not permit room for alterations and expansion.

For roasting the ore, eight Wedge-type roasters with seven internal hearths were provided, four for each of the two reverberatory furnaces. Since the reverberatory furnaces were rated at 500 tons of ore each, the roasters were designed to handle up to 150 tons of feed daily. It was expected that ore to be treated would be self-roasting, and therefore no provision was made for using the hot air from the cooling of the rabble arms for combustion, as is usual modern practice with this type of roaster. Since it has been found possible to smelt 1,000 tons of ore a day in one reverberatory furnace, the roaster feed has been increased to 250 tons per roaster day. Although the roasters are handling this quantity of feed with satisfactory sulphur elimination, it is believed that a ten- or eleven-hearth roaster, designed for tonnages up to 300 tons a day, and utilizing the air from the cooling of the arms for combustion, would be more satisfactory.

The roasted ore falls into hoppers under the roasters and is drawn to the reverberatory furnace charge hoppers in 5-ton calcine cars by storage battery locomotives. The reverberatory furnaces measure 25 ft. by 100 ft. inside the brickwork, are side feeding, and burn pulverized coal. The reverberatory furnace slag is skimmed into pots holding 20 tons of slag, which are drawn to the slag dump in trains of three or four pots.

The reverberatory furnace matte is tapped into ladles of 12 tons capacity and is sent to the converters. For converting the matte, Pierce Smith converters, 12 ft. by 26 ft., were originally provided. Since a larger tonnage is now being handled than was then planned for, and since the matte is comparatively low grade, containing from 20% to 24% copper, additional converter capacity became necessary, and two converters 13 ft. by 30 ft. were added. To treat the matte from two furnaces, three converters are required, the fourth being kept as a spare unit. The Horne ore does not contain any antimony or arsenic; consequently Noranda blister is free from such impurities. The blister contains about 99·25% copper. It is cast in straight-line casting machines into blocks weighing 400 lb. each. The moulds used are cast from blister copper. The bars, after being trimmed and weighed, are loaded into box cars and shipped to the refinery.

The smelter flow-sheet is shown in an accompanying figure. With a bedding system, it is usual to calculate the roaster charge that should be used to produce a desired reverberatory furnace slag. This predetermined charge is obtained by mixing in the beds the correct proportions of the various ores and fluxes and is then fed to the roasters. At Noranda, where there is no bedding system, this procedure cannot be followed, and, in order to make a smelting mixture, low-grade siliceous ore is added to the sulphide ore as fed to the roasters. This fluxing ore is mined in the Horne mine and consists of rhyolite, mineralized with sulphides. A typical analysis of this ore is given in Table I. Storage is provided over the roasters for siliceous ore as well as sulphide ore, and the silica content of the furnace charge is altered by changing the quantity of siliceous ore added to the roaster feed. A special sample of the reverberatory furnace slag, in addition to the regular shift samples, is taken every morning, and the amount of siliceous ore added to the roaster feed is increased or decreased as may be necessary. This method of control is arbitrary and results in considerable variations in the analyses of the slags made, but it is a limitation imposed by the impossibility of using a bedding system. In extreme cases, when the ore storage bins are nearly empty, ore may be received and smelted before its composition is known, so the judgment of the operators must be relied on to keep the analysis of the slag correct.

On account of the low copper tenor of the reverberatory furnace charge as compared with smelters where concentrates form a large part of the feed, the slag fall is high. An increase of 0·10% copper in the reverberatory furnace slag will decrease the smelter recovery by 1%. For this reason, clean slags are essential. Within reasonable limits, the higher the silica content of the slag, the lower the copper content; on the other hand, if the charge be too siliceous, it is more refractory and the resulting slag is viscous and difficult to skim. Under present conditions at Noranda, the best furnace results and the most economical operations are obtained with about 36% SiO_2 in the slag. A typical slag, of which the complete analysis is given in Table I, contains 0·35% Cu. This is a furnace sample taken by the operators, and since experience has shown that slag dump samples commonly run about 10% higher in copper than furnace samples of the same slag, the copper content of the slag as shown by the furnace samples is arbitrarily increased by $\frac{1}{10}$ in calculating the slag loss.

It had originally been intended that lime-rock should be used as a flux, by adding it to the roaster feed, but this has been found to be both unnecessary and undesirable. At Noranda, the sulphide ores and concentrates being smelted are basic, so that siliceous fluxing ore must be added in sufficient quantity to make a smelting mixture and to give the required amount of silica in the reverberatory furnace slags.

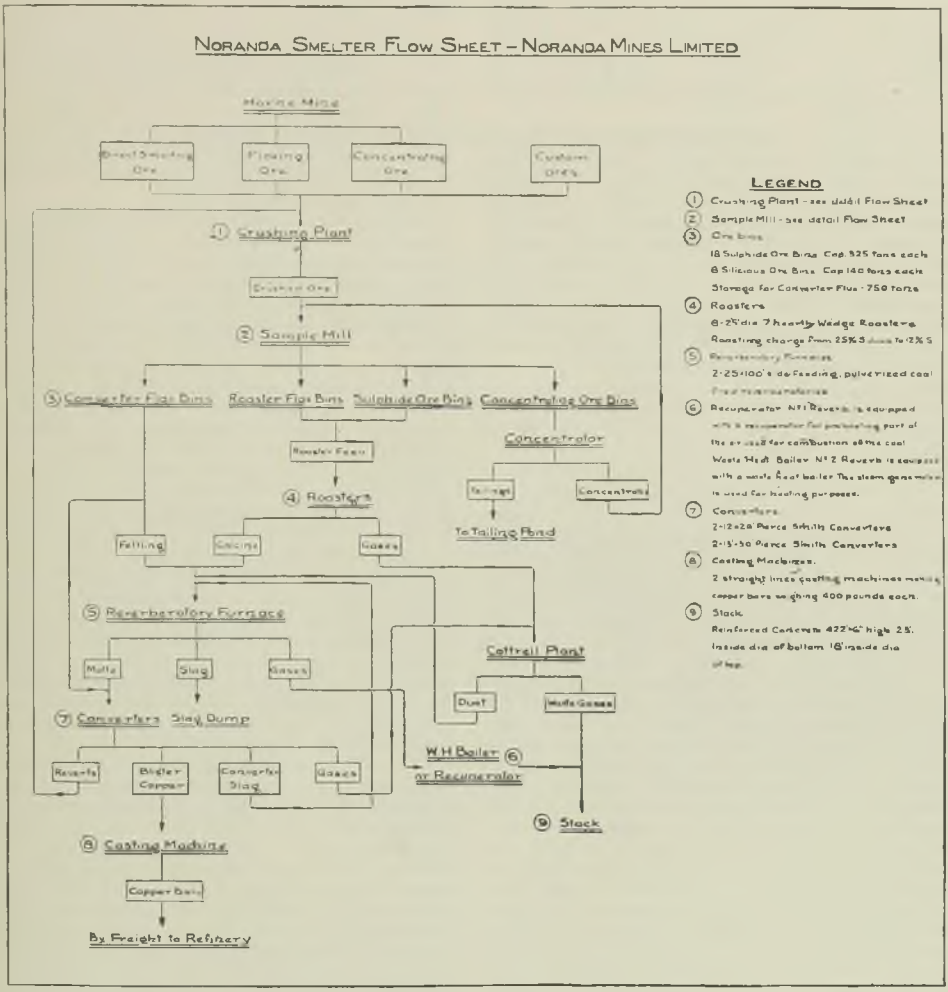
Under present conditions, the matte made in the reverberatory furnace contains from 20% to 24% copper. The copper content of the matte is subject to considerable variations on account of changes in the composition of the feed. At Noranda, the copper content of the roaster feed is comparatively low, varying from 6% to 8% copper, and to produce

TABLE I

	Cu %	SiO_2 %	Fe %	FeO %	Al_2O_3 %	S %	CaO %	MgO %
Average roaster feed	7·08	19·4	34·5	—	4·6	25·7	1·3	1·1
Noranda smelting ore	7·1	16·3	37·3	—	4·9	25·6	1·4	1·1
Noranda siliceous ore	1·5	59·3	9·1	—	9·5	5·6	2·0	1·8
Noranda concentrates	15·28	1·8	41·7	—	—	37·3	—	—
Typical calcine	7·8	21·6	38·3	—	5·1	12·0	1·4	1·2
Typical reverb. slag	0·35	35·8	—	49·4	7·7	1·2	2·0	2·0

high-grade matte it would be necessary to secure high sulphur elimination in the roasters and in the reverberatory furnace.

The elimination of sulphur in a reverberatory furnace depends on reactions between oxides, sulphides, and sulphates of the charge, and on the oxidation of the sulphides of the charge by oxygen in the gases in the furnace. The latter can be increased by using a great excess of air and carrying fuel ratio of the reverberatory furnace, and at Noranda these two factors have a far greater effect on the treatment cost than have the grade and the quantity of matte produced. With the type of roasters in use, handling tonnages greatly in excess of their original rated capacity, it has been found that matte containing 20% to 24% copper gives conditions which result in high tonnage and minimum costs. It is expected that the finer ore



a high draught, but this does not give good firing conditions. Sulphur elimination in the roasters is a more complex problem. The sulphides of the Horne ore are chalcopyrite, pyrite, and pyrrhotite in varying proportions. Probably due to the presence of a considerable percentage of pyrrhotite, the ore does not decrepitate on roasting, as most pyritic ores do. Decrepitation favours more complete roasting by presenting a larger surface for oxidation, and as the heat of combustion for pyrrhotite is less than for pyrite, the ore is not always self-roasting.

The roasting operation cannot be carried too far without seriously affecting the capacity and produced in the new crushing plant, and the increasing quantity of concentrates in the feed, will enable a matte containing from 24% to 28% copper to be made without decreasing the efficiency of the reverberatory furnaces. In Table I is given the weighed average analysis of the roaster feed for a period of months. This feed is made up of Noranda smelting ore, Noranda concentrates, Waite-Montgomery smelting ore, miscellaneous sulphide custom ores, and Noranda fluxing ore. The average analysis of the first two and the last of these ores is also given in Table I. A typical analysis of the roasted ore, also given in Table I, shows it to contain about 12% sulphur.

THE CRUSHING PLANT.—The flow-sheet of this plant is shown in detail in the accompanying figure. The primary crusher building measures 46 ft. by 66 ft. and is situated about 750 ft. from No. 3 shaft. Separate bins are provided over the primary crushers for domestic and custom ores. The custom-ore bins are equipped for handling standard-gauge railway cars, and the Company bins with an electrically operated rotary car dumper for unloading the mine cars. Custom ore, after being weighed, is unloaded from the railway cars directly into the custom ore receiving bins. Two sets of conveyor belts are provided throughout the crushing plant and sample mill, so that custom and domestic ores may be kept separate until they are discharged into the storage bins.

As will be seen from the flow-sheet, the roll crushing is done in open circuit. It has been found impossible to maintain a fine uniform product when crushing, in open circuit, such a tough ore as the sulphides and included rock material from the Horne mine. In order to increase capacity and to obtain a finer product, a 5½ ft. Symons cone crusher was added to one of the units, as shown in the flow-sheet. With this addition, the crushing plant has handled as much as 2,000 tons of ore in one day, operating 24 hours, but this is considerably more than its average daily capacity.

After being crushed, the ore passes through the sample mill, and is then weighed by Merrick weightometers and taken by conveyor belts to be distributed in the storage bins.

The crushing plant for No. 4 shaft was designed by J. R. Bradfield, construction superintendent, in conjunction with the operators and the management, and embodies principles learned from the operation of the original plant. The details of the flow-sheet are shown in the accompanying figure. There is an ore pocket with a capacity of 3,000 tons extending 65 ft. down from the surface, and below this is a 36 in. by 48 in. jaw crusher. The ore is broken to about 5 in. in size in the jaw crusher, and is then taken by an inclined belt-conveyor, 500 ft. long, to the cone crusher building on the surface, which measures 44 ft. by 34 ft. It has been found that fines, and especially wet fines, must be kept out of the cone crusher if high tonnages are to be obtained, and for this reason a grizzly and a double-deck vibrating screen were installed. The oversize from the grizzly and screens goes to the 7-foot cone crusher. The undersize from the bottom screen, together with the cone crusher product, is taken by a belt conveyor to a surge bin over the set of rolls. This surge bin has a capacity of 100 tons, and its function is to ensure a constant feed to the rolls.

The rolls are located in a building 63 ft. by 48 ft. Each roll of the set is driven by a 100 h.p. motor through a tex-rope drive. The roll product is delivered to the combined screen house and sample mill, which measures 30 ft. by 108 ft. The crushed ore is distributed in a long narrow bin and is drawn out by rotary feeders and passes over the surface of vibrating screens with a ⅜ in. mesh. Four screens, arranged in parallel, are used, and space has been left for the installation of four more, if needed. The oversize from the screens is returned to the surge bin over the rolls, and the undersize is sampled, weighed, and delivered to the storage bins over the roasters.

The main advantages of the new crushing plant over the original plant are as follows: (*a*) The presence of adequate storage ahead of the primary crushers makes crushing independent of hoisting. (*b*) Roll crushing is done in closed circuit, and the finer and more uniform product thus obtained ensures better roasting and smelting conditions. (*c*) The capacity of the new plant is twice that of the original plant, and there are only three crushers as compared with eleven crushers in the original plant. The same number of operators are required in both plants and the installed h.p. is about the same.

THE ROASTERS.—The roasters are located at the eastern end of the main smelter building, which is 377 ft. by 254 ft., the roaster building proper occupying a space 162 ft. by 86 ft. The roaster charge is drawn from the storage bins by pan feeders, which drop the ore onto the top hearth of the roasters. There are eight Wedge-type roasters. They have an inside diameter of 25 ft., with seven internal hearths and one drying hearth.

In the first few months of smelter operation, when comparatively low tonages were being treated, the tonnage per operating roaster day was about 150 tons. After it was found possible to smelt 1,000 tons a day in one reverberatory furnace, it became evident that, when the second unit was started, it would be necessary to increase materially the tonnage per roaster day, since there are only four roasters for each reverberatory furnace. Accordingly, much experimental work was done to find the maximum tonnage of feed that the roasters were capable of handling with satisfactory sulphur elimination. The original speed of rotation of the rabble arms was 1 rev. in 80 seconds. On the advice of the manufacturers, this speed was increased to 1 rev. in 60 seconds. This made it possible to put a greater tonnage through the roasters without having too deep a bed of ore on the hearths, which is a controlling factor in the amount of iron and sulphur that can be oxidized. To further increase the capacity of the roasters, the speed of rotation was finally increased to 1 rev. in 48 seconds. It was found that at this speed, with the use of an increased draft, the roasters would handle up to 250 tons of feed per day and still produce a calcine containing not more than 12% sulphur.

The above increase of feed above the original rated capacity of the roasters brought with it some attendant troubles. Air for combustion is admitted through the doors on the bottom hearth. The result of admitting this cold air at the bottom of the roaster is to give a temperature gradient through the roasters which shows a maximum on the fourth and fifth hearths. With the increased feed, the high temperatures on these two hearths and the high gas velocity through the ports of the third hearth, caused the fine particles carried up by the gases to sinter on the bottom of the second hearth. Chemical analysis showed that this material was mostly pyrite fines, which "flashed" in the blast of gas and collected as a fused mass on the bottom of the second hearth. It abraded the air-cooled rabble arms and was a source of constant trouble until a mechanical means was found for removing it, by devising a plough to be attached to the top of the rabble arm. The plough was designed jointly by H. Nicholson, general roaster foreman, and R. C. McQuire, then roaster shift foreman.

An attempt was made to reduce the gas velocity through the ports by "bleeding" a part of the gases from the fourth hearth directly into the roaster uptake. This experiment proved unsuccessful,

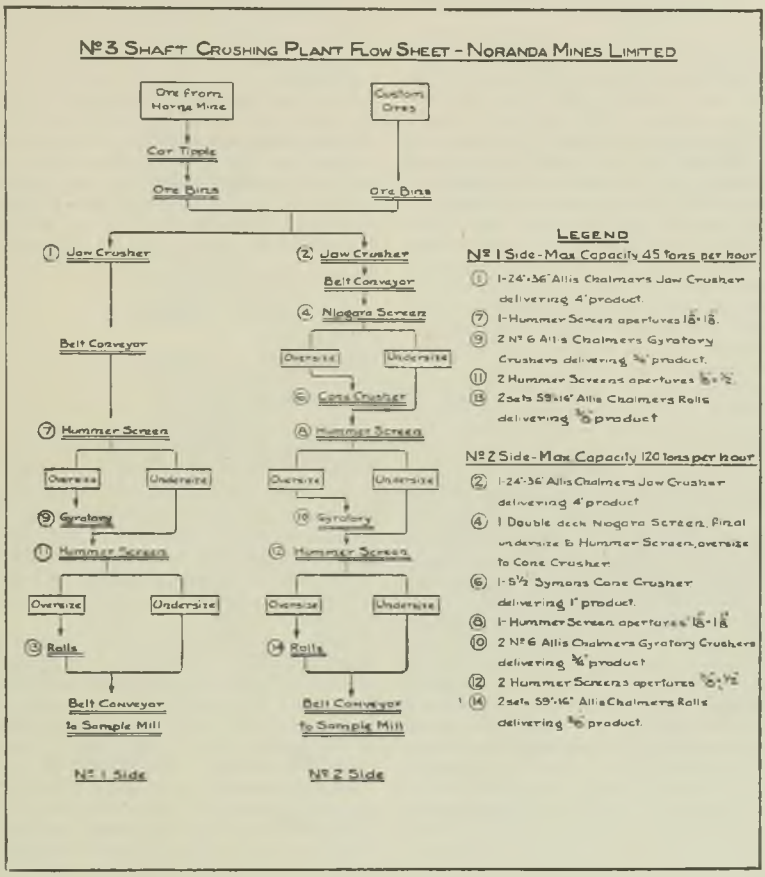
because it lowered the temperature of the top hearths and consequently reduced the efficiency of the roaster.

With the increased feed, the roasters had to be shut down frequently due to the necessity of replacing worn rabble blades and to the breaking of lute rings, which form the seal between the hearths and the rotating column. It was recognized that when two reverberatory furnaces were in operation these delays would have to be reduced to a minimum. Accordingly, several roasters were equipped with rabble blades and lute rings made from an alloy of nickel, chromium, and iron instead of the usual cast-iron. The results have been so successful in reducing forced shut-downs that in future all replacements will be made with these alloy castings. The additional cost of the alloy castings is more than justified by the extra wear and the freedom from shut-downs that is obtained by their use.

THE REVERBERATORY FURNACES.—The reverberatory furnace building measures 152 ft. by 162 ft. The two reverberatory furnaces have the following dimensions: 29 ft. 6 in. wide outside brickwork, 25 ft. wide inside brickwork; 104 ft. long outside brickwork, 100 ft. 6 in. long inside of brickwork; the side walls are 2 ft. 3 in. thick, the firing wall is 18 in. thick, the skimming wall is 2 ft. thick, and the roof or arch is 20 in. thick. Originally, both furnaces were built entirely of silica brick, but recently, while No. 2 furnace was undergoing repairs, the wall of the skimming bay and the side wall at the tap holes were built of magnesite brick up to a point above the slag line. The skewbacks are hollow castings resting on channel irons riveted to the buckstays, so that the arch is supported independently of the side walls. The furnace bottoms consist of high-grade silica sand fused in place. The furnaces are provided with four burners for pulverized coal firing and are side fed.

The slag is skimmed into pots of 20 tons capacity, which run on standard railway tracks in a tunnel at the skimming end of the furnace. The reverberatory furnace matte is drawn off through tap holes near the skimming end of the furnace. The matte ladles are of cast steel with a capacity of 12 tons of matte. These ladles are placed on a transfer car which runs on tracks in a tunnel between the two furnaces below the level of the furnace floor. When filled, the ladle of matte is drawn out to the converter aisle by an electrically driven car puller and is then picked up by cranes which serve the converters.

The present firing practice on the reverberatory furnaces is the result of considerable experimental work done by the operators. Experience has shown that the most important requirements for good firing conditions are as follows: first, finely pulverized coal; second, a short flame; third, a proper and thorough mixture of coal and air at the firing end of



the furnace; and fourth, a uniform supply of coal. Coarsely pulverized coal causes less rapid combustion, which results in less intense heat and reduces the capacity of the furnace. In May, 1928, J. Howard, the general foreman, succeeded in obtaining a short, intensely hot flame by introducing converter air at a pressure of 10 lb. per sq. in. into the furnace burners. The effect of the high-pressure air is to mix thoroughly the coal and air stream, and it gives a short flame without the use of an undue excess of air. This change has been the greatest improvement made at Noranda in pulverized coal firing, and its effect was to increase the capacity of the furnace from 700 tons of solid charge daily to over 900 tons daily.

With the direct system of pulverized-coal firing now in use, the amount of coal fed to the furnace is controlled by rheostats regulating the speed of the screw conveyors which deliver the coal from the dryers to the pulverizers. This method is not entirely satisfactory, since the rates of feeding and pulverizing are affected by such variable factors as the size, the hardness, and the moisture-content of the coal. This defect of irregular coal supply is characteristic of the unit system and is one of its main disadvantages. The pulverized coal is blown by a fan from the coal plant to the burners, a distance of some 150 ft. The air required for burning the coal is secured from three sources: primary air, that is, the air used for conveying the coal to the furnace; hot secondary air, which is blown into the furnace under the burners; and tertiary or high-pressure air. Very little other air gets into the furnace, since the firing end is kept closed up except for narrow cracks around the burners. With No. 1 furnace, the secondary air is hot air from the pre-heater; with No. 2 furnace, the secondary air is hot air from the cooling of the roaster arms. This air is brought down from the roaster building through a large pipe and has a temperature of 170° F. The quantity of primary air is practically constant, and the secondary and tertiary air are controlled by dampers and valves, so that the amount of air admitted to the furnace is under positive control. Operating results have shown that complete combustion of the coal without an undue excess of air is a vital factor in securing high furnace tonnages and good fuel ratios. Firing is controlled and checked by periodically sampling the furnace gases and analysing them with an Orsat apparatus for CO_2 plus SO_2, O_2, and CO. Samples are taken through the furnace arch at a point about 75 ft. from the firing wall, using a water-cooled sampling tube. Recently, an indicating and recording CO_2 meter was installed and is giving satisfactory results. It is especially valuable in that it makes a continuous record of firing conditions in the furnace.

Experience has shown that, other things being equal, the best fire is obtained with from 0·5% to 1·0% oxygen and no carbon monoxide in the gas sample. With lower oxygen content, or with no oxygen, carbon monoxide is usually present, and this indicates a long flame and incomplete combustion in the smelting zone; while the excess of air shown by higher ogygen content decreases the flame temperature and thus the rate of smelting. The reverberatory gases commonly contain from 1·0% to 1·5% SO_2, depending on the character of the charge. An Orsat analysis of a typical gas sample is as follows: CO_2 plus SO_2 18·2%, O_2 0·8%, CO 0·0%.

The reverberatory furnaces are operated on a very low draught, which varies from 0·01 to 0·02 in. water gauge measured in the furnace uptake. This is possible because of the use of forced draught and because the flue area is unusually large, 132 sq. ft. to each furnace. In 1928, 271,926 tons of ore were smelted in one furnace; while in 1929, 393,560 tons of ore were smelted in one furnace, most of this increase being due to improvements made in the firing practice.

The total solid charge includes calcines, siliceous fettling, an occasional quantity of unroasted sulphide ore, and Cottrell dust. In addition to the solid charge, about 400 tons of liquid converter slag are poured into the furnace each day. The fuel ratio is the percentage ratio of the coal burned to the dry tons of solid charge, exclusive of liquid converter slag. The weight of coal used is based on the railway wet weights of the coal received and includes the coal used for drying the coal. During the first eleven months of 1929, the average tonnage of solid charge per operating furnace day was 910 tons; the average fuel ratio for the same period was 12·0%.

For the period August, 1929, to December, 1929, inclusive, the distribution of the reverberatory furnace solid charge was as follows:—

Noranda direct smelting ore	67·6 %
,, siliceous ore	8·0 ,,
,, concentrates	3·6 ,,
Custom ores	10·5 ,,
Siliceous ore for fettling	1·8 ,,
Reverts from converters	4·9 ,,
Cottrell roaster dust	2·8 ,,
Cottrell converter dust	0·4 ,,
Dust from converter balloon flue	0·1 ,,
Sulphide ore charged direct to furnace	0·3 ,,

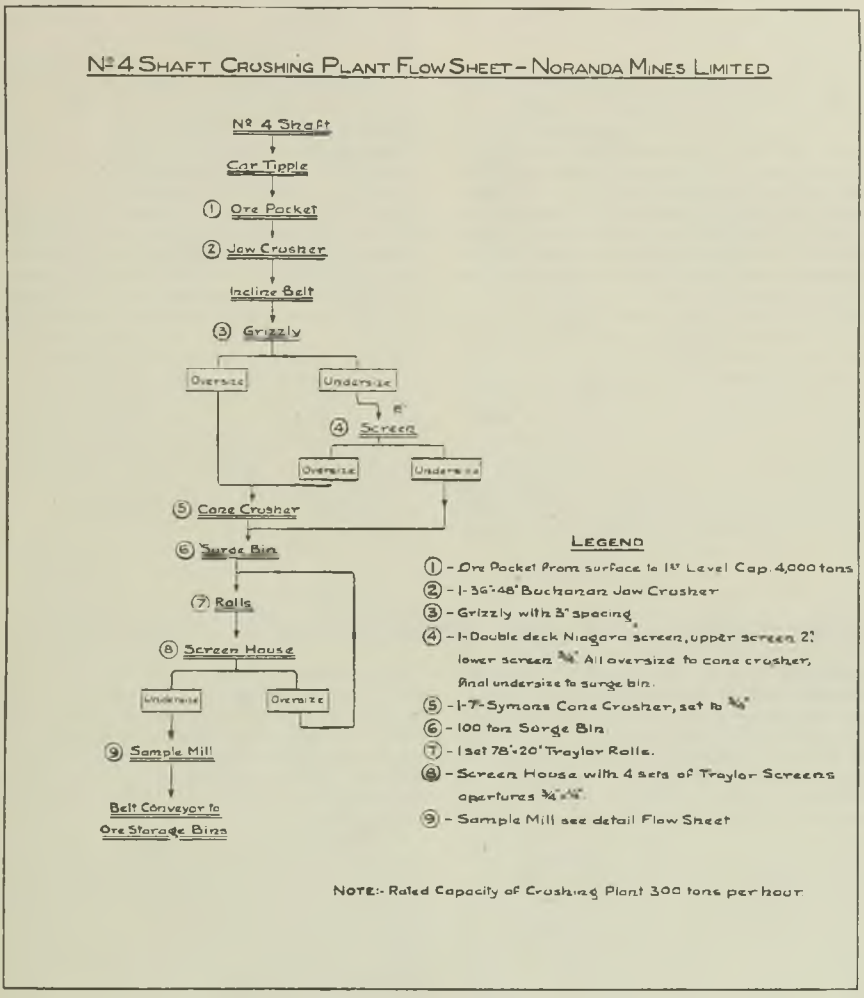
The only materials in the solid charge that can be classed as secondary products are the converter reverts present in the calcine, the converter Cottrell dust, and the dust from the converter balloon flue. The total of these products is 5·4%; therefore, 94·6% of the furnace charge is new revenue-bearing material.

THE CONVERTERS.—The converter building measured 252 ft. by 124 ft., with part of one side extending across the firing end of the reverberatory furnaces. Originally, the converter building was equipped with two Peirce Smith converters, 12 ft. in diameter and 26 ft. long; two straight-line casting machines; two 40-ton d.c. electric double-wired cranes and one 10-ton d.c. electric crane in the shipping room just back of the converters. The converter building was extended 170 ft. to make room for two Peirce Smith converters, 13 ft. by 30 ft., which were installed in 1929. No increase was made in the number of cranes or casting machines.

As has already been described, the matte from the reverberatory furnaces is brought out to the converter aisle and is poured into the converter by one of the cranes. The converter is then tilted back into the blowing position and the converter air-valve opened. The pressure of the converter air at the converters is about 12 lb. per sq. in. Sufficient converter flux is blown in by a Garr gun to make a slag containing from 24% to 26% SiO_2, which is skimmed off into ladles and poured into reverberatory furnaces through launders which extend from the crane aisle through the firing walls of the furnaces. After the slag has formed and has been skimmed off, more matte and flux are added, and the converter is blown again. This procedure is

continued until there is enough "white metal" in the converter to make from 30 to 40 tons of copper. The charge is then blown to blister copper, or "finished." The copper is poured into ladles, which are then set in the casting machine cradles. The casting machine consists of a series of moulds on an endless chain, much like the pans on a Dwight and Lloyd sintering machine. When filled, the moulds pass under water sprays which solidify the copper. As the moulds pass over the end of the casting machine, the bars of copper fall out and are stacked. When cool, the bars are trimmed, weighed, and loaded into box-cars to be sent to the refinery. the moulds used in the casting machine are made from blister copper. The converter flux used is the same siliceous ore that is added to the roaster charge.

The analysis of a typical converter slag shows it to contain 25·8% SiO_2. The object of keeping the SiO_2 content so high is to prevent, as far as possible, the formation of magnetite (Fe_3O_4) in the converters. The converter slag is poured into the reverberatory furnaces, and it has been found that magnetite, if present in excessive quantities, gives trouble by building up in the furnace bottom and by increasing the copper loss in the reverberatory furnace slag.



Typical Converter Analyses

	Cu %	SiO_2 %	Fe %	S %
Matte . . .	22·3	—	44·8	23·8
Converter slag . .	2·05	25·8	51·1	2·1
Blister . . .	99·17	—	—	—

It is a common converter practice to protect the converter lining with a coating of magnetite, formed by deliberately making a converter slag which contains much magnetite. This cannot be done at Noranda because it is necessary to make a converter slag which is high in silica, and it would not be practicable to maintain a magnetite coating on the converter lining when such slags are made. The increased lining cost is more than justified by the freedom from troubles in the reverberatory furnace caused by excessive magnetite in the converter slag. Converter linings are protected by keeping the temperature in the converter low with the use of cold material such as floor cleanings, matte

skulls, and flue dust. It has been found that under these conditions the lining along the tuyeres has to be replaced at intervals of from three to six months. Only once in the two years of operation has it been necessary to patch the ends of the converters.

Provision is made for preventing the converter tuyeres from filling with metal or copper, in case of a sudden failure of the converter air supply. There is a large set of storage batteries which are so arranged that, if the power goes off on the motors which drive the converter blowers, the converters are automatically tilted so that the tuyeres are clear of the molten bath in the converter.

The Cottrell Plant.—The roaster gases and converter gases are treated in a Cottrell plant. The efficiency of recovery of this plant is high. Tests showed that three roaster units treating 110,000 c.f.m. of gas at 670° F. recovered 96% by weight of the dust in the gases. Recovery of copper was 98%. Two converter units treating 130,000 c.f.m. of gas at 480° F. recovered 80% of the dust. Recovery of copper was 95%. The difference between dust and copper recoveries is explained by the fact that the dust recovered contains a greater percentage of copper than does the dust lost.

The Stack.—The stack is 422½ ft. high and is set on a carefully prepared concrete base on solid rock.

Power House and Supply.—Power is brought from the Quinze plant of the Northern Quebec Power Company, a distance of about 60 miles. The 25-cycle current is received at 110,000 volts and is reduced to 12,000 volts in the Power Company's own sub-station, which serves as a distributing point for the surrounding district. The current is received by the smelter at 12,000 volts and is distributed to several separate transformer stations at convenient points in the plant and reduced to 550 volts for use in the motors. Other transformers are located where necessary, to reduce the 550-volt current to 110 volts for lighting purposes.

The power house is a brick building, 65 ft. by 182 ft., situated west of and parallel to the converter building. It contains the following equipment: (1) Three Bellis and Morcom air compressors, capacity 2,500 c.f.m. at 100 lb. per sq. in., for supplying compressed air for use in the mine. Each is direct-connected to a 500 h.p. synchronous motor. (2) Two Ingersoll-Rand air compressors, capacity 500 c.f.m. at 100 lb. per sq. in., for supplying compressed air for use in the shops, the Cottrell plant, and other departments of the smelter. Each is belt-driven by a 100 h.p. motor. (3) Two Ingersoll-Rand blowers, capacity 21,750 c.f.m. at 20 lb. per sq. in., for supplying air to the converters. Each blower is direct-connected to a 1,300 h.p. synchronous motor. (4) One Bellis and Morcom blower, capacity 15,000 c.f.m. at 15 lb. per sq. in., added to supply air for the third converter. It is direct-connected to a 1,100 h.p. synchronous motor. (5) Two motor generator sets for supplying d.c. current for synchronous motor excitation and for supplying the cranes and the storage battery charging panels. Each set consists of a 575 h.p. induction motor direct-connected to a 60 k.w. 125-volt d.c. generator and to a 430 k.w. 250-volt d.c. generator. (6) One motor generator set, recently installed for the new trolley system. It consists of a 600 h.p. induction motor direct-connected to a 400 k.w. 600-volt d.c. generator. (7) A large set of storage batteries for emergency service.

THE GEOLOGY OF THE BOULDER BELT, KALGOORLIE

The Geological Survey of Western Australia have published in Bulletin No. 94 an account of the geology and ore deposits of the Boulder belt, Kalgoorlie, by Dr. F. L. Stillwell. It is said that the need of a geological examination of the Kalgoorlie gold mines was recognized by Kingsley Thomas in 1925 in the report of the Royal Commission into the mining industry of Western Australia. The Commonwealth Development and Migration Commission confirmed it in their interim report, dated May 11, 1927, on the Gold Mining Industry. In order to satisfy the need, the Chairman of the Development and Migration Commission proposed that the work should be expedited and treated as urgent by the loan of Dr. Stillwell's services from the Council of Scientific and Industrial Research to the West Australian Government. This proposal was eventually carried into effect and work commenced in August, 1927.

The investigation comprised the preparation of a series of composite mine plans of the Boulder Belt at 100 ft., 800 ft., 400 ft. above sea level, at sea level, and at 400 ft., 800 ft., 1,200 ft., 1,600 ft., and 2,000 ft. below sea level. These horizons correspond on the average to levels at depths of 100 ft., 400 ft., 800 ft., 1,200 ft., 1,600 ft., 2,000 ft., 2,400 ft., 2,800 and 3,200 ft. Average assay values have been inserted on the mine levels to indicate the lodes and their variation in values. The relationship of the lodes to the main rock types has been illustrated by the boundaries of the calc schist, porphyry and porphyrite dykes, and a uralitic-quartz-dolerite, mapped in relation to the quartz-dolerite greenstone. The geological picture has been completed by a surface geological map covering nine square miles of the immediate neighbourhood.

The important mining area is situated in a bulge of coarse-grained quartz-dolerite greenstone which has been derived by the metamorphism and albitization of a quartz-dolerite. The quartz-dolerite greenstone is normally a dark rock which assumes several variations in colour with varying degrees of vein alteration, and the vein-altered forms are known as "bleached greenstones." The quartz-dolerite is part of the same intrusion as a uralitic quartz-dolerite which flanks the greenstone on the west and which also appears within it as isolated residual masses. Bands of hornblendite appear within the western uralitic quartz-dolerite, and appear to represent a basic differentiation of the quartz-dolerite. East and west of the quartz-dolerite intrusion are bands of fine-grained greenstone or fine-grained amphibolite derived from the alteration of basic lava flows. The eastern rocks of the mining belt consist of seriticized and carbonated forms of the fine-grained greenstone with intrusive dykes of albite porphyry and basic porphyrite, forming a belt known locally

as "calc schist." The intrusive dykes have been so highly altered that their individuality is often obscured and the alteration is thus subsequent to the dykes. Similar dykes of albite porphyry and basic porphyrite are intrusive into the quartz-dolerite greenstone, but are on the whole in a much less altered state. The dykes are rich in soda and are characterized by numerous grass-green xenoliths composed of carbonate and fuchsite. Numerous alternations of graphitic schist or slate occur in association with a large dyke through the Great Boulder lease and the whole has been mapped as a composite belt of dyke and slate.

A genetic relationship is indicated between the intrusive dykes and the lodes which appear to have been derived from emanations and solutions, partly intruded with the dykes and discharged on cooling, and partly intruded as an aftermath along the course of the dykes and the fractures opened by their intrusion. The broad relationship is indicated by the positions of the lodes and the dykes. It is signified in more detail by lodes in association with tongues of dykes, by the occurrence of lode matter on the walls of the dykes, by the occasional presence of lode matter in the dykes and by the frequent occurrence of tourmaline with both lodes and dykes.

Lines of shearing, formed prior to the intrusion of the dykes, govern to some extent their intrusion and the later circulation of mineral solutions. The outcome of the early shearing and the intrusion of the dykes is the development of two sets of fractures, forming an acute angle with each other. Impregnation by the mineral solutions and replacement of the country rock along these fractures produced the network of lodes of the Golden Mile. Some of the shearing movements are subsequent to the intrusion of the dykes which are themselves at times highly sheared. This later shearing is aided by the development of sericite accompanying the vein alteration and is thus more or less contemporaneous with ore disposition.

The circulation of the mineral solutions was aided by pre-existing fault planes and cross fracturing. Most of the observed faults in the mines are, however, younger than the lodes which may be cut and displaced for short distances. The majority of these younger faults are westerly dipping, although a few dip east. The prominent fractures along which lodes have been formed are mostly confined to the coarse-grained quartz-dolerite greenstone, thus leading to the early generalization that the quartz-dolerite greenstone is the productive rock and the calc schists are barren. The wide alteration of the calc schists and the absence of sustained values within them indicate a dispersion of the mineral solutions rather than the localized circulation necessary for the production of ore shoots. The alteration is less intense in the fine-grained greenstone in the Croesus Proprietary, about a mile north of the chief mining area, and the presence of an ore-body along the walls of a basic dyke suggests a freer and localized circulation of the mineral solutions and forms an occurrence genetically similar to the lodes of the Boulder Belt.

The margin of the calc schist contains several important ore-bodies of which the Oroya shoot has been the best known. This ore-body occurred close to the contact of the quartz-dolerite greenstone and the calc schist, above a large intrusive dyke which has hitherto escaped recognition. The shoot had the form of a pipe which pitched about 14° to the south, and after being followed from the surface for 3,700 ft. to an approximate depth of 1,050 ft., it left the contact and entered an underlying shelf of calc schist, and then gradually lost its values.

The lodes in the quartz-dolerite greenstone consist of an Eastern and a Western group separated by a wide belt of slate and porphyry. In the Eastern group the lodes appear more diverse and numerous, while in the Western group, which includes the Ivanhoe, Golden Horseshoe, and Great Boulder, the ore-bodies have been fewer in number and more continuous, but at the same time more disturbed by later faulting. The dip of the lodes is generally steep and is rarely less than 70°. In consequence, the network of lodes with their acute intersections is more clearly depicted on the horizontal plans than on the vertical cross sections. The latter indicate clearly the contour of the westward dipping calc schist and illustrate the intersection of the Australia East lode with the calc schist in depth. The lodes show considerable variation in composition, depending on the variable replacement of the greenstone. In places they are highly siliceous on account of the development of secondary quartz, while at other times they consist of little-altered greenstone impregnated with sulphides and tellurides. It is probable that the introduction of the tellurides was one of the final phases of the lode formation and the values in the lode are in some measure independent of the nature and extent of the replacement of the greenstone. At the same time the more extensively vein-altered belts are always liable to contain the larger lodes.

The variation of values along a lode channel has been illustrated by the averaged assay values on the composite mine plans. The study of these values shows that a number of remarkable enrichments have occurred at the intersection of lodes. The occurrences are most marked on the Boulder Perseverance lease, but cases can be found on the western side of the belt. Enrichments of a similar type occur at times where prominent cross joints and cross fractures intersect a lode channel and the main ore-bodies of the Kalgurli mine are an example. The pitch of this type of ore shoot is approximately vertical and frequently a little southing is gained in depth. In other cases the pitch is slightly to the north.

Another type of enrichment occurs in association with the termination of tongues of porphyry and is believed to be due to a concentration from solutions discharged towards the blind upward edge of a mass of porphyry. The Hainault ore-body surrounds the feather edges of two tongues of basic porphyrite. The Lake View lode in the South Kalgurli and the Perseverance is an extension beyond the termination of the Hainault albite porphyry dyke. The Ivanhoe East and the Boulder-Horseshoe lodes constitute in depth a somewhat similar example on the western side of the belt and the occurrence is well brought out by the horizontal plans and cross sections. These two lodes appear to rise from the wide composite mass of dyke and slate at the base of narrow branching tongues. In the case of the Ivanhoe East lode, the dyke tongue is observed from the 2,240 ft. level to the 3,020 ft. level of the Ivanhoe. In the case of the Boulder-Horseshoe lode the dyke tongue has been traced from the 1,000 ft.

level of the Great Boulder to the 3,140 level of the Golden Horseshoe. The behaviour of these main ore-bodies in depth is governed more by the southerly pitch of these tongues than by the westerly dip of the main porphyry. The southerly pitch of the base of the Great Boulder tongue is approximately 60° in the plane of the lode and the base of the tongue appears opposite the main shaft of the Great Boulder at the 2,200 ft. level, and opposite the main shaft of the Golden Horseshoe, 450 ft. further south, at the approximate depth of 3,050 feet. The lode is likely to maintain its southerly pitch while the dyke tongue maintains its regularity in depth.

A comprehensive picture of the Boulder Belt has been revealed by the composite mining plans and it indicates that the scope of future mining at Kalgoorlie is subject to limitations. The scope in depth is restricted on the Eastern side of the belt partly by the underlying calc schists and partly by the less intensive rock alteration which is indicated by the presence of residual patches of uralite-quartz-dolerite in the lower levels of the Eastern mines. The northern extensions in depth of the main lodes on the western belt are limited by the westerly dipping dyke and its southerly pitching tongues. The southern limits in depth of the western lodes have not been reached and the main hope of the future discovery of payable ore at depth lies at the south-western end of the field. The composite plans, however, show considerable areas of insufficiently prospected ground and lateral prospecting within the limits of the Boulder Belt gives more hope of discovery of appreciable quantities of ore.

The report is accompanied by a separate book containing maps and sections.

Solution of Cuprite.—Cuprite is usually considered to be a mineral which is not adaptable to sulphuric acid leaching. To ascertain the conditions whereby all the copper in cuprite could be converted into the soluble sulphate a series of experiments with ore samples from Bisbee, Arizona, has been conducted by the United States Bureau of Mines at the Southwest Experiment Station, Tucson, Arizona, in co-operation with the University of Arizona. The results of these experiments are set forth in Report of Investigations 2967, by John D. Sullivan and G. L. Oldright.

The cuprite, in pieces up to 4 mesh in size, is treated in open bottles with sulphuric acid and approximately 100% of the total copper is converted into the soluble sulphate in 20 days. With a −3, +4, mesh product, approximately 94% of the copper is converted in the same time. For sizes of 100 mesh or smaller, 24 hours is sufficient for complete solution.

When cuprite is treated with acidified ferric sulphate, particles up to 3 mesh in size entirely dissolve in eight days and in three days 99% is dissolved. For particles of 100 mesh or smaller, one hour is sufficient for complete solution. Particles of − 100, + 200, mesh are almost completely dissolved in one hour by neutral ferric sulphate.

The mechanism of solution of cuprite in sulphuric acid, neutral ferric sulphate, and acidified ferric sulphate, is discussed. The tests on − 100, + 200 mesh cuprite in the open and closed bottles showed the necessity of the presence of oxygen to obtain complete solution of the mineral. This indicates the desirability of introducing air into the solutions in leaching copper ores containing cuprite, if the leaching agent is sulphuric acid alone.

On leaching, ores containing a very appreciable percentage of their copper content as cuprite, particularly where little ferric sulphate is present to act as a solvent and air is relied upon to furnish oxygen, the material should be finely divided, in addition to using large amounts of air. From the practical standpoint, this would mean that such an ore, if coarse and leached by percolation, would need ferric sulphate in its leach liquors to take care of most of the copper. If it were not desired to use ferric sulphate in the solvent, but sulphuric acid alone, in order to have the current efficiency high on electrodeposition, percolation leaching, if successful, would have to be carried out in a carefully sized porous column of very fine sand. If the cuprite ore were rich, there would be much in favour of trying slime leaching and the use of air agitators.

The Alaska Juneau Concentrator.—The concentrator of the Alaska Juneau Gold Mining Co. is located on the steeply sloping shore of Gastineau Channel, near Juneau, Alaska. The Alaska Juneau mine is in Gold Creek Basin, about 2 miles from the mill. The ore is mined by a caving system, dropped through ore passes, and trammed in 10-ton cars through the haulage level to the tipple at the top of the mill. Full information regarding this plant is given by P. R. Bradley, in Information Circular 6236 of the Bureau of Mines, Washington.

The mill is an example of an extreme type of hillside construction, the difference in elevation between the tipple and the bottom floors being 263 ft., and very little elevating of material is required. The ore is free milling and does not require very fine grinding to free the values; the flow sheet is quite simple, consisting primarily of crushing, sorting, grinding, and table concentration. Approximately 11,000 tons of run of mine material is trammed to the mill daily, and 46 to 48% of this is rejected as waste by hand sorting. Gold, the principal economic metal, is mostly native and usually associated with small quantities of galena and sphalerite. The principal sulphide, by volume, is pyrrhotite with some pyrite. The gold is quite coarse, an occasional particle weighing over 1 gram.

The metallurgical operations consist of coarse crushing and hand sorting, grinding and concentrating. The present fine-grinding capacity of the mill is about 6,000 tons per 24 hours. The principal concentrating operations are made with Deister and Wilfley tables. The table tailing, before final disposal, is treated by flotation, using potassium amylxanthate and cresylic acid as flotation reagents. Two products are made: a shipping concentrate which averages about $350 per ton in gold, 35 oz. in silver, 60% lead, and 20% iron; and a high grade concentrate assaying $20,000 to $30,000 per ton in gold. The latter is treated by amalgamation. During cold weather, when the supply of fresh water is inadequate, salt water is used in the concentrator as the freezing point of salt water is lower than that of fresh water.

The outstanding operations of the Alaska Juneau concentrator are: rejection by screening and hand sorting of approximately 50% of the material mined at a cost of $0·13 to $0·15 per ton rejected; and milling of the sorted ore at a cost of $0·31 to $0·33 per ton milled, giving a total operating cost of $0·51 to $0·57 per ton trammed from the mine.

SHORT NOTICES

Shaft Sinking.—Vertical and incline shaft sinking at the North Star mine are described by Arthur B. Foote in Technical Publication No 324 of the American Institute of Mining and Metallurgical Engineers.

Ventilation on the Kolar Gold Field.—*Bulletin* No. 26 of the Kolar Gold Field Mining and Metallurgical Society contains two short papers by H. M. Kernick, one on the use of rail plates for ventilation doors in the Balaghât mine, and the other on collaring an abandoned upcast shaft for ventilation.

Cardox Blasting Device.—In the *Iron and Coal Trades Review* for March 14, W. Payman describes the use of the Cardox blasting shell which uses liquid carbon dioxide.

Aerial Ropeway for Tilmanstone Colliery.—This ropeway, used for shipping coal at Dover, is described, more fully than in this issue, in the *Iron and Coal Trades Review* for February 28.

The Rosebery (Tasmania) Concentration Mill.—The design of this mill, together with factors influencing the choice of equipment, is described by Harry Hey in the *Proceedings* of the Australian Institute of Mining and Metallurgy for December 31, 1929.

Classification of Difficult Ores.—W. H. Coghill, in Technical Paper 456 of the United States Bureau of Mines, Washington, deals with the classification and tabling of difficult ores, with particular attention to fluorspar.

Ball Milling.—A laboratory investigation of ball milling was undertaken by A. M. Gow, A. B. Campbell, and W. H. Coghill, and their results are given in Technical Paper No. 326 of the American Institute of Mining and Metallurgical Engineers.

Bauxite.—The description of float-and-sink fractionations and flotation experiments on bauxite, by B. W. Gandrud and F. D. De Vaney, form the subject matter of *Bulletin* 312 of the United States Bureau of Mines, Washington.

Anodes for Electrolytic Zinc Production.—Technical Publication No. 321 of the American Institute of Mining and Metallurgical Engineers describes the results of an investigation of anodes for the production of electrolytic zinc, undertaken by H. R. Hanley, C. Y. Clayton and D. F. Walsh.

Sponge Iron in Canada.—The economic aspects of sponge iron production in Canada are discussed by Bradley Stoughton in the *Canadian Mining and Metallurgical Bulletin* for March.

Manganese-Carbon Relation in Steel.—B. M. Larsen describes the effect of manganese on the distribution of carbon in steel, in Technical Paper 466 of the United States Bureau of Mines, Washington.

Bradford Sulphur Dioxide Process.—The application of this process to treatment of weathered dump slime at Broken Hill, N.S.W., is described by A. Lowry in the *Proceedings* of the Australian Institute of Mining and Metallurgy for December 31 last.

The Sundberg Method of Geophysical Prospecting.—Theodor Zuschlag, in Technical Paper No. 313 of the American Institute of Mining and Metallurgical Engineers, deals with the mapping of oil structures by the Sundberg method.

Geophysical Investigations.—The depth attainable by electrical methods in applied geophysics is discussed by A. S. Eve, D. A. Keys and F. W. Lee in Technical Paper 463 of the United States Bureau of Mines, Washington. Similar work, on the results in depth attainable by potential methods of electrical exploration and also on the results of electrical studies of the earth's crust at great depths, is described by C. and M. Schlumberger in Technical Paper No. 315 of the American Institute of Mining and Metallurgical Engineers. A. S. Eve also discusses the absorption of electromagnetic induction and radiation by rocks in Technical Paper No. 316 of the same Institute.

Sudbury Basin.—E. S. Moore gives an account of the geological structure of the south-west portion of the Sudbury basin in the *Canadian Mining and Metallurgical Bulletin* for March.

Copper in Northern Rhodesia.—A description of the copper deposits of Northern Rhodesia and the Katanga is given by Dr. Ing. F. Ahlfeld in *Metall und Erz*, 2 Märzheft.

Electrical Power in the F.M.S.—Developments in the preparation of a proposed super-power system for the F.M.S. are described in the *Far Eastern Review* for January.

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.*

7,954 of 1928 (307,708). Soc. pour l'Enrichissement et l'Agglomeration des Minerais, Brussels. The construction of a special furnace for the roasting and agglomeration of fine ores or residues.

22,625 of 1928 (324,902). H. Skappel, Oslo, Norway. Smelter charges are adjusted in such a manner that the melt separates into three or more molten layers, namely, slag, matte and crude metal, these layers being in chemical equilibrium with each other.

25,305 of 1928 (324,685). S. Tamaru and Y. Koizumi, Japan. A process for the extraction of tin from its low-grade ores in which the ore is heated with an alkaline-earth base in the presence of an activator, such as carbon, and afterwards treated with weak acid or caustic soda, to extract the stannate of the alkaline-earth metal.

27,746 of 1928 (324,382), and **29,444 of 1928 (324,363).** I. G. Farbenindustrie A.-G., Frankfort-on-Main. Improvements in the manufacture and industrial application of metal carbonyls.

31,122 of 1928 (300,637). H. G. Flodin, Stockholm. Chrome-iron sponge is obtained by mixing finely divided iron-ore and chrome-ore in the requisite proportions, adding carbon and ferro-silicon as binders, pressing into briquettes, and subjecting to controlled treatment in furnaces of special design.

108 of 1929 (303,789) and **819 of 1929 (303,805).** Dr. W. P. Jenny, Berne, Switzerland. Improvements in the design of torsion balances.

4,664 of 1929 (325,386). Chance Bros. and Co., Ltd., and J. English, Smethwick. Glass sands are cleaned free from detrimental impurities by subjecting them, at a suitable temperature, to the action of a reducing gas and, at the same time, or subsequently, to the action of chlorine.

13,543 of 1929 (310,885). Fried. Krupp A.-G., Essen. An alloy of the carbide of tungsten or molybdenum and a lower melting metal or metalloid is prepared by melting down cast alloy of the required composition with carbon, as the element or carbide, pulverizing the alloy, preparing pressed

bodies of the powder and sintering. The strength of the resultant alloy is very great compared with that prepared from the molten state.

19,765 of 1929 (325,455). Soc. Anonyme la Nouvelle Montagne, Engis, Belgium. Finely divided zinc ore, which may have been subjected to a preliminary roast, is moistened with a solution of zinc sulphate, and passed through an extrusion press, prior to sintering. The process enables sintering to be carried out under favourable conditions.

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.

Elements of Optical Mineralogy. By N. H. and A. N. Winchell. Part III. Determinative Tables. 2nd edition. Cloth, octavo, 204 pages, with coloured chart and 2 diagrams. Price 22s. 6d. London: Chapman and Hall, and New York: John Wiley and Sons.

Economic Geology. By Dr. H. Ries. 6th edition. Cloth, octavo, 860 pages, illustrated. Price 30s. London: Chapman and Hall, and New York: John Wiley and Sons.

Asphalts and Allied Substances. By Herbert Abraham. 3rd edition. Cloth, octavo, 891 pages, illustrated. Price 42s. London: Crosby Lockwood and Son.

Mining Methods. By Charles A. Mitke. Cloth, octavo, 195 pages, illustrated. Price 15s. London and New York: McGraw-Hill.

The Use of Chains and Other Gear for Hauling and Lifting. Mines Department, Safety Pamphlet No. 6. Paper backs, 48 pages, illustrated. Price 6d. London: H.M. Stationery Office.

Placer Mining in British Columbia. Compiled by J. D. Galloway, with special reports by H. Carmichael and C. W. Moore. Paper backs, 66 pages, illustrated. Bulletin No. 2, 1930, of the British Columbia Department of Mines, Victoria.

Gold Coast. Report on Three Chains of Triangulation surveyed in the Southern Part of the Colony during the years 1924, 1925 and 1926. By Captain J. Calder Wood. Records of the Gold Coast Survey Department, Vol. I. Paper boards, folio, 116 pages, illustrated. Price 12s. 6d. London: Crown Agents for the Colonies.

Permissible Storage-Battery Locomotives and Power Trucks. By L. C. Ilsley, E. J. Gleim, and H. B. Brunot. Paper backs, 120 pages, illustrated. Price 45 cents. Bulletin 313, Washington: Bureau of Mines.

Annual Report of the Director of the U.S. Geological Survey. For year ended June 30, 1929. Paper backs, 87 pages, with key-map. Washington.

Pend Oreille District, Northern Idaho. Contact Metamorphism of the Rocks of the District. By J. L. Gillson. Paper, folio, illustrated. Price 10 cents. Pages 111–121, Shorter Contributions to General Geology, 1929. U.S. Geological Survey, Washington.

Lincoln County, Nevada. Petrography of the Pioche District. By J. L. Gillson. Paper, folio, illustrated. Price 10 cents. Pages 77–86, Shorter Contributions to General Geology, 1929, U.S. Geological Survey, Washington.

Mineral Resources of the United States, 1928. Part I. pp. 145–167, Secondary Metals, by J. P. Dunlop; pp. 261–284, Mercury, by P. M. Tyler. Part II, pp. 67–80, Feldspar, by O. Bowles and J. Middleton; pp. 81–88, Graphite, by J. Middleton; pp. 113–126, Salt, Bromine and Calcium Chloride, by A. T. Coons; pp. 127–153, Magnesium and its Compounds, by P. M. Tyler; pp. 197–204, Talc and Soapstone, by O. Bowles and B. H. Stoddard. Each part in paper backs, price 5 cents. Washington: Bureau of Mines.

California, Mineral Production in 1928. By H. H. Symons. Paper backs, 215 pages, illustrated. San Francisco: State Division of Mines.

Mining in California. October quarter, 1929. Report 25 of the State Mineralogist. Paper backs, pp. 415–588. San Francisco: State Division of Mines.

Rhodesian Manual. Agricultural, Industry and Mining, 1929–30. Edited by C. Carlyle-Gall. Cloth, octavo, 798 pages, illustrated. Price 21s. London: Mining and Industrial Publications of Africa.

Tin, World Statistics, 1930. Cloth, pocket size, 133 pages. Price 2s. 6d. London: Anglo-Oriental Mining Corporation.

Industrial and General Administration. By Henri Fayol. Paper backs, folio size, 84 pages, illustrated. Price 3s. 6d. London: Sir Isaac Pitman and Sons.

COMPANY REPORTS

Crown Mines.—This company was formed in 1892 as the Rand Deep Level Gold Mining Co., to work a property on the dip of the Crown Reef mine in the central Rand. The present name was adopted in 1909, when many adjoining properties were absorbed. The report for the year ended December 31 last shows that during the year a record tonnage of 2,643,000 tons was milled, which was 32,000 tons greater than the total for the previous year, but is still far short of the capacity of the mill. Shortage of native labour was the main factor in restricting the output. The gold recovered totalled 856,005 oz., equal to 6·478 dwt. per ton, which is 0·062 dwt. lower than the value per ton in the previous year. The value of the gold was £3,630,229 or 27s. 6d. per ton milled, while silver and osmiridium recovered brought the total value of bullion to £3,642,770, or 27s. 7d. per ton. This revenue shows a decrease of 3d. per ton milled as compared with that of the year before. Working costs amounted to 20s. 5d. per ton and the total working profit was £947,113 as compared with £969,093 in the previous year. Dividends totalling £599,991, equal to 65%, were paid during the year. The available ore reserves at the end of the year were 8,896,270 tons averaging 6·45 dwt. in value, as compared with 8,799,100 tons and 6·4 dwt. at the end of the previous year. Certain additions to the treatment plant were completed in April last and these raised the capacity of the three mills to a total of over 245,000 tons per month. The ventilation system of the mine has been improved and sandfilling was continued on a larger scale.

Modderfontein B.—This company belongs to the Central Mining-Rand Mines group and was formed in 1908 to work gold mining property situated east of the New Modderfontein in the far east Rand. The report for the year 1929 shows that 987,430 tons of ore was raised and, after sorting 15·1% of waste, 836,700 tons averaging

7·553 dwt. per ton was sent to the treatment plant, where 302,726 oz. of gold was extracted, worth £1,284,002. Silver and osmiridium brought the total revenue to £1,294,618, or 31s. per ton. The working cost was £720,055, or 17s. 3d. per ton, leaving a working profit of £574,563, or 13s. 9d. per ton. Dividends amounting to £560,000 were paid, equal to 80%. The tonnage milled showed an increase of 6,000 tons when compared with the previous year, but the revenue declined by 1s. 3d. per ton, which was largely offset by an improvement of 1s. per ton in working costs. The total working profit was lower by £5,717. Development work was principally confined to prospecting areas of doubtful value. The available ore reserves at the end of the year are estimated to be 1,445,400 tons averaging 7·3 dwt. as compared with 1,740,200 tons and 7·5 dwt. at the end of the previous year.

Geldenhuis Deep.—This company, belonging to the Central Mining-Rand Mines group, has worked a deep-level mine in the near east Rand since 1893. The report for the year 1929 shows that 861,383 of tons of ore was raised and, after the rejection 11·6% of waste, 761,550 tons, averaging 4·954 dwt. per ton, was sent to the mill. The yield of gold was 176,169 oz., worth £747,063, and silver and osmiridium brought the revenue to £750,145, or 19s. 9d. per ton. The working cost was £709,879, or 18s. 8d. per ton, leaving a working profit of £40,266, or 1s. 1d. per ton. Dividends of 5%, absorbing £28,333, were paid during the year. The ore milled is less by 13,600 tons than in 1928, the decrease being partly accounted for by increased waste. The available ore reserves at the end of the year are estimated to be 504,200 tons averaging 5·7 dwt. in value as compared with 512,100 tons and 5·6 dwt. the year before. Alterations made in the Western reduction plant during the year have increased its capacity by 2,000 tons per month, and will tend to cut down future maintenance cost on this plant.

Village Deep.—This company, belonging to the Central Mining-Rand Mines group, has worked a deep-level property in the central Rand since 1898. The property has lately been merged with the Robinson Deep. The report for the year 1929 shows that 760,026 tons of ore was raised and, after sorting out 8% of waste, 699,500 tons was sent to the mill, where 184,293 oz. of gold were recovered, worth £781,577 or 22s. 4d. per ton. Silver and osmiridium recovered brought the total revenue to £784,052 or 22s. 5d. per ton. Working costs amounted to £724,483, or 20s. 9d. per ton, and the working profit to £59,569 or 1s. 8d. per ton. Dividends paid during the year absorbed £50,006, equal to 5%. The available ore reserves at the end of the year were estimated to be 1,031,100 tons averaging 5·8 dwt. over 53·4 in., as compared with 1,011,900 tons, value 5·7 dwt. over 50·5 in. in 1928. The increased working profit, from £37,876 to £59,569, was primarily due to increased tonnage milled and lower working costs, the tonnage milled constituting a record for the company. The West Sub-incline Shaft was completed in June of the year under review.

Government Gold Mining Areas.—This company was formed in 1910 to develop gold mining property lying to the dip of New Modderfontein and Modderfontein B and is controlled by the Johannesburg Consolidated group. The report for the year 1929 shows that during the year 2,771,109 tons of ore was mined from the stopes and together with 100,291 tons from development faces was sent to the mill, where 15·895% of waste was sorted. The ore crushed amounted to 2,416,000 tons, averaging 9·336 dwt., and the gold recovered was 1,086,165 oz., worth £4,613,734, or 38s. 2d. per ton milled. In addition 1,200 oz. of osmiridium was recovered. The total working costs were £1,977,189, equal to 16s. 4d. per ton milled, and the working profit £2,636,545, or 21s. 10d. per ton. During the year £1,260,000 was distributed as dividends, equal to 90%. The ore reserves at the end of the year were estimated to be 10,876,000 tons averaging 8·9 dwt. over 63 in., as compared with 10,973,000 tons, 8·9 dwt. and 65 in. stoping width at the end of the previous year. The mine has worked smoothly during the year although a scarcity of native labour, which became acute towards the end of the year, tended to disorganize the underground work. One of the bore-holes sunk for the purpose of sand-filling has been completed and a second is approaching the workings.

New State Areas.—This company belongs to the Johannesburg Consolidated group and was formed in 1918 to work a Government lease-area in the far east Rand to the south-east of Government Areas. The report for 1929 shows that 1,121,000 tons was raised and, after the rejection of 18·11% of waste, 918,000 tons was sent to the mill, where 391,430 oz. of gold was abstracted, worth £1,662,688, or 36s. 3d. per ton. The working cost was £957,510, or 20s. 10d. per ton, leaving a working profit of £705,178, or 15s. 4d. per ton. The Government's share of the profits was £384,974, and the shareholders received £189,255, the rate being 12½%. The ore reserves at the end of the year were estimated to be 2,696,000 tons averaging 8·9 dwt. over 50 in., as compared with 2,678,000 tons, 8·7 dwt. and 51 in. a year ago. Recent development in adjoining mines has indicated that the eastern area may be more important than has been anticipated, and a haulage way is being driven to facilitate exploitation.

Van Ryn Deep.—This company was formed in 1902 to work property in far east Rand. The report for the year 1929 shows that 985,822 tons was mined and sent to the mill, where 24·134% of waste was sorted out, and 747,900 tons averaging 7·98 dwt. sent for treatment. Gold recovered totalled 294,909 oz., worth £1,252,693 or 33s. 6d. per ton. Working costs were £755,067, or 20s. 2d. per ton, and the working profit £497,626, or 13s. 4d. per ton. Dividends paid during the year absorbed £418,912, equal to 35%. The ore reserves at the end of the year were estimated to be 3,022,000 tons, averaging 7·3 dwt. over 50 in., as compared with 3,110,700 tons, value 7·4 dwt. over 50 in., a year ago. Operations were somewhat affected by shortage of native labour, but the tonnage crushed was only decreased by 11,000 tons as compared with 1928. The proportion of waste raised is high, mainly owing to difficulties in mining the Upper Leaders. Compressor plant has been increased and sand-filling proceeds satisfactorily.

Randfontein Estates.—This company, originally formed in 1889, now belongs to the Johannesburg Consolidated group and operates a gold mining property in the far west Rand. The report for the year 1929 shows that 2,621,608 tons of ore was raised and, after the rejection of 3·49% waste, 2,530,096 tons, averaging 5·017 dwt. per ton was sent for treatment, yielding 595,249 oz. gold,

worth £2,528,456. With osmiridium the total revenue was increased to £2,534,302. The working cost was £2,291,595, and the working profit £246,705, out of which £30,490 was paid as debenture interest. In addition £130,000 was set aside for the redemption of debentures and £83,848 for capital expenditure. The ore reserves at the end of the year were estimated at 4,505,000 tons, averaging 5·8 dwt. over 41 in., as compared with 4,196,800 tons, 5·8 dwt., and 42 in. a year ago. Preliminary work in connexion with the re-sinking of the North Shaft of the Old Randfontein Deep property is well in hand. When in commission it is expected that the additional shaft capacity will enable exploration to be advanced more rapidly.

Witwatersrand Gold.—This company, commonly known as "Knights," belongs to the Barnato group and has worked a gold mine in the middle east Rand since 1887. The report for the year 1929 shows that 707,593 tons of ore was mined and, after sorting out 9·38% waste, 641,200 tons of ore was sent to the mill, where 134,982 oz. of gold was recovered, worth £574,743, or 17s. 11d. per ton. Working costs amounted to £559,396 or 17s. 5d., and the working profit was £15,347 or 6d. per ton. A dividend equal to 2½% was paid during the year and absorbed £11,741. The ore reserves at the end of the year were estimated to be 372,000 tons, value 5·4 dwt. over 53 in., as compared with 404,000 tons, 5·2 dwt., and 53 in. at the end of 1928. The supply of labour was fairly good, with the result that the reduction plant was fully employed during the year.

Langlaagte Estate and Gold.—This company was formed in 1888 to work a gold mine in the central Rand. It is controlled by the Johannesburg Consolidated group. The report for the year 1929 shows that 968,500 tons of ore averaging 6·739 dwt. per ton was sorted and sent to the mill, where 313,105 oz. of gold was extracted, worth £1,329,985, or 27s. 5d. per ton. The working cost was £1,022,864, or 21s. 2d. per ton, leaving a working profit of £311,832, or 6s. 3d. per ton. Dividends absorbed £227,975, equal to 15%. A small improvement in the total profit was recorded, and development work has been favourably advanced. The ore reserves at the end of the year were estimated to be 1,596,000 tons, averaging 7·4 dwt., over 42 in., as compared with 1,567,500 tons, 7·1 dwt. and 42 in. the year before.

Geduld Proprietary Mines.—This company belongs to the Union Corporation group and was formed in 1899 to work a gold mine in the far east Rand, south of Modderfontein B. The report for 1929 shows that 1,211,768 tons of ore was mined and, after sorting 16·78% waste, 1,008,400 tons, averaging 7·143 dwt., was sent to the mill, where 318,991 oz. of gold was recovered, worth £1,353,822, or 26s. 10d. per ton. Working costs amounted to £831,635 or 16s. 6d. per ton, and the working profit was £522,188, or 10s. 4d. per ton. Dividends absorbed £456,518, equal to 31¼%. The tonnage milled was the highest on record, exceeding the 1928 figure by 29,100 tons. In addition, the yield was better by 4d. per ton and reduction costs decreased slightly. The working profit, in consequence shows an increase of £36,525 as compared with 1928. The ore reserves as estimated at the end of the year were 5,900,000 tons averaging 6·7 dwt. over 58 in. This represents a decrease of 200,000 tons as compared with 1928, but the stoping width has decreased by 2 in.

Modderfontein Deep.—This company belongs to the Union Corporation group, and was formed in 1899 to work gold mining property in the far east Rand. The report for the year 1929 shows that 664,740 tons of ore was mined and, after the separation of waste, 531,500 tons of ore, assaying 10·651 dwt., was milled, and 280,664 oz. of gold recovered, worth, together with a little silver and osmiridium, £1,194,605, or 44s. 11⅓d. per ton. Working costs amounted to £417,203, or 15s. 8⅓d. per ton, and the working profit was £777,402, equal to 29s. 3d. per ton. Dividends absorbed £675,000, equal to 135%. The ore reserves, re-calculated at the end of the year, totalled 2,550,000 tons, average value 8·8 dwt. over 79 in. These figures show a decrease of 450,000 tons and the average value is lower by 0·2 dwt. per ton from those of the year before. During the year a change in reduction practice was made, amalgamation being given up and the use of all cyanide extraction installed.

Robinson Deep.—This company belongs to the Consolidated Gold Fields of South Africa group and has worked a deep-level property in the central Rand since 1915. The company has now been merged with the Village Deep. The report for 1929 shows that 1,034,906 tons of ore was raised, and, after the rejection of 11·11% waste, 919,900 tons was sent for treatment, the 253,148 oz. gold recovered being worth £1,074,959, or 23s. 4d. per ton. The working cost was £902,128, or 19s. 7d. per ton, leaving a working profit of £172,830, or 3s. 9d. per ton. Dividends totalling 3s. per share were paid on the "A" shares during the year, absorbing £75,000, and £47,387 was allocated to capital expenditure account. As compared with the previous year the tonnage milled showed a slight increase which helped to compensate for a lower yield. The ore reserves at the end of the year were estimated to be 1,307,000 tons averaging 6 dwt. over 60 in., as compared with 1,407,000 tons, value 6·1 dwt. a year ago. The taking over of the Village Deep workings is expected quickly to improve the position of the mine.

Rose Deep.—This company belongs to the Central Mining-Rand Mines group and was formed in 1894 to work a gold property in the middle east Rand. The report for the year 1929 shows that 764,300 tons of ore was raised and, after sorting out 73,800 tons as waste, 690,100 tons, averaging 4·486 dwt. in value, was sent for treatment, the gold yield being 143,558 oz., worth £608,867. Silver and osmiridium worth £2,496 were recovered, the total revenue being £611,363, or 17s. 9d. per ton. The working costs were £575,832, or 16s. 8d. per ton, and the working profit £35,532, or 1s. 1d. per ton. No dividend was declared during the year. The tonnage milled was increased by 26,700 tons, and there was an improvement in working costs of 2d. per ton, the working profit being increased by £6,625. The ore reserves at the end of the year are estimated at 963,700 tons, averaging 4·9 dwt. over 64 in., as compared with 922,700 tons, 4·9 dwt. and 65 in. the year before. The output from the Southern Section of the mine averaged about 10,000 tons per month, but operations were somewhat hampered by inadequate labour supply.

Simmer and Jack Mines.—This company, which belongs to the Consolidated Gold Fields of South Africa group, has worked a gold property in the east-central Rand since 1887. The report for 1929 shows that 1,000,291 tons of ore was mined

and, after sorting 105,191 tons of waste, 895,100 tons was sent to the mill, where 224,796 oz. of gold was recovered, worth £954,907 or 21s. 4d. per ton. Working costs amounted to £884,919 or 19s. 9d. per ton and the working profit was £69,988 or 1s. 7d. per ton. 26·62 oz. of osmiridium were sold during 1929. No dividend was paid during the year. The ore reserves at the end of the year were estimated to be 1,581,000 tons, averaging 5·9 dwt. over 51 in., as compared with 1,814,000 tons of the same value over 48 in. the year before. Satisfactory progress has been made during the year in the sinking of the Milner Shaft sub-incline. Other operations were somewhat hampered by a continued shortage of native labour.

East Rand Proprietary Mines.—This company was formed in 1893 and is now controlled by the Central Mining-Rand Mines group. The report for the year 1929 shows that 1,868,400 tons of ore was raised and, after sorting 7⅞% waste, 1,723,500 tons, averaging 5·641 dwt. gold, was sent for treatment. The output of gold was 461,605 oz., worth £1,958,035, or 22s. 9d. per ton. Silver and osmiridium brought the revenue up to £1,965,788, or 22s. 10d. per ton. The working cost was £1,830,482, or 21s. 3d. per ton, leaving a working profit of £135,306, or 1s. 7d. per ton. The ore milled was 35,800 tons more than the year before, and the revenue increased by 7d. per ton, but the working costs increased by 2d. per ton. No dividends were paid during the year. Payable ore developed was estimated at 1,256,290 tons, averaging 5·9 dwt. The decrease in value, when compared with the previous year, is largely due to the lower value of the ore developed in the Driefontein-Comet Deep Section, and to the inclusion of a considerable tonnage of the low-grade Main Reef in the area west of the Driefontein incline. The available ore reserves are estimated to be 3,414,270 tons, averaging 6·3 dwt. over 56 in., as compared with 3,286,740 tons averaging 6·4 dwt. a year ago.

Durban Roodepoort Deep.—This company was formed in 1895 to work deep-level property in the middle west Rand. The report for the year 1929 shows that the amount of ore raised was 553,632 tons, of which 154,993 tons came from the Main Reef and 398,639 tons from the South Reef. Waste amounted to 12·9%, and 482,100 tons, averaging 7·218 dwt. per ton, was sent to the treatment plant, where 164,808 oz. of gold was recovered, worth £699,080. Silver and osmiridium brought the total revenue to £701,650, or 29s. 2d. per ton. The working cost was £655,010, or 27s. 3d. per ton, leaving a working profit of £46,640, or 1s. 11d. per ton. No dividend was paid during the year. Compared with the previous year, working costs decreased by 11d. per ton milled, and the tonnage milled increased by 14,000 tons. The available ore reserves are estimated to be 1,626,800 tons, averaging 7·4 dwt., as compared with 1,488,600 tons and 7·3 dwt. a year ago.

Meyer and Charlton Gold.—This company belongs to the Albu group and has worked a mine on the central Rand since 1888. During 1929 six additional claims were purchased from the liquidators of the Wolhuter Gold Mine and six claims formerly belonging to the Village Main Reef were abandoned. The report for the year 1929 shows that 251,074 tons of ore was mined and 203,200 tons of ore, averaging 5·59 dwt., was sent for treatment. The gold yield was 54,529 oz., worth £231,238 or 22s. 9d. per ton. Working costs amounted to £210,105 or 20s. 8d. per ton, and the working profit was £21,132, or 2s. 1d. per ton. This shows an increase of £4,252 on 1928, mainly due to a slight increase in value of the ore crushed and also to a decrease in working costs. No dividend was paid during the year. The ore reserves at the end of the year consisted of certain blocks of South Reef, which have been opened up in the claims leased from the City Deep, together with isolated areas in other sections, which are being mined at the present time.

West Rand Consolidated.—This company belongs to the Albu group and was formed in 1903 to consolidate a number of gold mining properties in the far west Rand. The report for the year 1929 shows that 1,304,641 tons of ore was mined and, after sorting out 19·65% of waste, 1,043,300 tons of ore was milled, yielding 266,115 oz. gold worth £1,128,448 or 21s. 7d. per ton. In addition, £1,329 was realized from the sale of osmiridium. Working costs totalled £940,976, or 18s. per ton, and the working profit was £187,471, or 3s. 7d. per ton. No dividend was paid during the year, £164,204 being appropriated for capital expenditure. The ore reserves at the end of the year were estimated to be 4,005,000 tons, averaging 5·6 dwt. over a stoping width of 48 in., as compared with 3,502,000 tons, value 5·6 dwt. over 49 in., a year ago. Over 1,000,000 tons of low-grade ore is not at present included in the reserves.

New Kleinfontein —This company was formed in 1894 to work a gold property in the far east Rand and subsequently other properties have been absorbed. It belongs to the Anglo-French Exploration group. The report for the year 1929 shows that 716,178 tons was raised and that, after the rejection of 13·806% of waste, 617,300 tons averaging 4·676 dwt. gold was sent for treatment, yielding 135,148 oz. gold, worth £574,630. The working cost was £562,882, leaving a working profit of £11,748. The tonnage mined during the year shows a decrease of 2,465 tons, although during the period 42,000 tons more were obtained from the Apex Section than in 1928. The working profit is considerably better than in the previous year, when it was only £5,217, very favourable results being obtained in the last quarter of the year. An estimation of the ore reserves available at the end of the year shows that there were 311,000 tons averaging 4·9 dwt. over 53 in., a decrease of some 220,000 tons as compared with 1928. As the position now stands, the mine will have to depend in an increasing degree upon the values contained in the ore from reclamation and sources other than ore reserves.

Witwatersrand Deep.—This company was formed in 1895 to work a gold-mining property in the middle east Rand. The report for the year 1929 shows that 512,820 tons of ore, averaging 4·769 dwt., was raised and, together with 380 tons from the East Shaft dump, sent to the mill, where 113,643 oz. of gold was recovered. The total revenue from gold, silver and osmiridium was £481,602, equal to 18s. 9d. per ton. Working costs amounted to £501,126, or 19s. 6d. per ton, resulting in a net loss of £19,524, or 9d. per ton. The payable ore reserves as estimated at the end of the year were 674,300 tons, value 6·1 dwt. over 54 in., showing an increase of 27,000 tons, a decrease of 0·1 dwt., and an increase of 7 in. over 1928. Development during the year exposed 345,000 tons at 5·7 dwt. over 63 in., most of which was developed in the area below the dyke, while the proportion of payable ore was high.

Gopeng Consolidated.—This company was formed in 1912 and works alluvial tin property situated in the Kinta district, State of Perak, F.M.S. The report for the year ended September 30 last shows that 2,097,100 cu. yd. of ground was treated and 962 tons of tin concentrates recovered. This is an increase of 138,100 cu. yd. as compared with the previous year and the ground was running 1·03 lb. as against 0·85 lb. per cu. yd. in the year before. The value of the tin concentrates was £119,629 and revenue from other sources increased the total to £120,307. Working costs were £29,665, and the total profit was £90,642. Dividends amounting to 3s. per share were paid during the year, absorbing £59,365. It is anticipated that a high level of output and low working costs will be maintained during the current year.

Balaghat Gold Mines.—This company belongs to the group operating gold mines in the Kolar district of Southern India under the management of John Taylor and Sons and was formed in 1886. The report for the year 1929 shows that 50,100 tons of current ore was treated, yielding 32,468 oz. of gold which realized £138,123. The tonnage crushed was 2,150 tons more than in 1928 and the gold recovered showed an increase of 2,490 oz. Working expenditure was £105,983 leaving a profit of £26,043. During the year 1s. 6d. per share was distributed as dividends on the Preference shares, while ordinary shares received 6d., as in 1928. The ore reserves at the end of the year were estimated to be 56,008 tons, showing a decrease of 18,123 tons when compared with the previous year. The contraction in the ore reserve tonnage and the concentrated nature of those below the 44th level, are restricting the availability of stoping faces and, in consequence, a decline in the tonnage crushed and in the gold return is expected during the current year.

Nundydroog Mines.—This company also belongs to the group of gold mines in the Kolar district of Southern India which are managed by John Taylor and Sons, being formed in 1880. The report for 1929 shows that 129,857 tons of current ore was treated, producing 66,541 oz. of gold. In addition, 214,384 tons of accumulated tailings was re-treated, yielding 13,579 oz. of gold. The value of the total production of 80,120 oz. was £340,897, as compared with 75,427 oz. realizing £321,791 in 1928. Expenditure during the year amounted to £217,319 and the profit was £108,081, an increase of £14,914 on the previous year. The total dividend distribution for the year was 2s. 6d. per share equal to 25%. Working costs were higher by 1s. per ton owing to increase in stoping costs and the necessity for heavier expenditure on ventilation. The ore reserves at the end of the year were estimated to be 265,595 tons, an increase of 19,131 when compared with 1928. Favourable developments in the lowest level of the mine have continued.

DIVIDENDS DECLARED

Anglo-French Exploration.—1s. 6d., less tax, payable April 10.

Broken Hill South.—1s. 6d., less tax, payable May 23.

Globe and Phoenix.—1s., free of tax, payable April 23.

Gopeng Consolidated.—9d., less tax, payable April 7.

Hongkong Tin.—6d., less tax, payable March 31.

Idris Hydraulic Tin.—2½%, less tax, payable March 27.

Jelapang Tin Dredging.—6d., less tax, payable March 29.

Kepong Dredging.—6d., less tax, payable March 28.

Kinta Tin Mines.—6d., less tax, payable March 28.

Koffyfontein Mines.—5s., less tax, payable April 30.

Mason and Barry.—2s. 6d., less tax, payable May 24.

Minerals Separation.—5s., less tax, payable April 8.

Ooregum Gold Mining.—Pref. and Ord., 6d., less tax, payable April 26.

Pengkalen.—Pref. 9d., Ord. 3d., less tax, payable April 25.

Petaling Tin.—10%, payable April 26.

Rio Tinto.—30s., less tax, payable May 1.

Sungei Besi.—2½%, less tax, payable March 29.

Sungei Kinta.—1s. 6d., less tax, payable April 17.

Tanjong Tin Dredging.—3d., less tax, payable March 28.

Tharsis Sulphur and Copper.—5s., less tax, payable May 5.

Transvaal Gold Mining Estates.—6d., less tax, payable May 3.

Tronoh Mines.—7½%, less tax, payable March 31.

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

NEW COMPANIES REGISTERED

Complex Research Company (Spain).—Registered as a private company. Capital: £100 in £1 shares. Objects: To acquire the right to use in Spain a process of formula for the scientific manufacture of gold from chemical and other compounds and to carry on business as gold and silversmiths, etc.

Consolidated Copper.—Registered March 19. Nominal capital: £100 in £1 shares. Objects: To acquire concessions in Turkey, Asia Minor and elsewhere, and to carry on the business of mining and mine owners, dredgers, smelters, etc. Office: 3, London Wall Buildings, E.C. 2.

Grecian Mining and Development.—Registered as a private company March 6. Nominal Capital: £25,000 in £1 shares. Objects: To adopt an agreement with Capt. J. G. Bennett for the purchase of rights in certain mining concessions in Greece and to carry on the business of iron-masters, colliery proprietors, etc. Office: 1, 2, 3 and 4, Morley House, Regent Street, W. 1.

Mica Fields of Rhodesia.—Registered April 4. Nominal Capital: £75,000 in 10s. shares. Objects: To acquire and turn to account any property, concessions, mining areas containing mica, asbestos, or other minerals, etc. Office: 7 Victoria-street, S.W.1.

Oil Mining Syndicate.—Registered as a private company on March 20. Capital: £1,000 in 1s. shares. Objects: To purchase and work any property in India, Burma, or elsewhere. Office: Finsbury Pavement House, Moorgate, E.C. 2.

United Mining and Chemical Industries.—Registered as a private company February 15. Nominal Capital: £5,000 in 1s. shares. Objects: To purchase or obtain concessions of or otherwise acquire mine workings and mining grounds, etc., and to carry on the business of a mining, smelting and refining company. Office: Bush House, Aldwych, W.C.

COMPANY MEETINGS AND REPORTS SECTION

ANGLO-FRENCH EXPLORATION CO., LTD.

Directors: F. A. Robinson (*Chairman*), W. T. Anderson, William Frecheville, L. Ochs, F. Shipton, George R. Airth (*Managing Director in London*), Sir W. Dalrymple (*Managing Director in South Africa*). *Manager in South Africa:* E. H. Read. *Advisory Engineer:* John A. Dennison. *Secretary:* S. D. Thomson. *Office:* Salisbury House, London, E.C. 2. *Formed* 1889. *Capital:* £500,000; debentures £90,000.

Business: Finance of and investment in mining properties in South Africa and other parts of the world.

ANNUAL REPORT FOR THE YEAR ENDED DECEMBER 31, 1929.

The Directors submit their Fortieth Annual Report, being for the year ended December 31, 1929, together with the Audited Accounts.

The Profit and Loss Account shows a net realized profit, after payment of Debenture Interest, of	£55,078	13	9
To which has to be added the balance brought forward from last year, viz. . . .	69,783	11	10
	£124,862	5	7
Less—Amount written off against depreciation	19,899	1	2
Leaving a balance of . . .	£104,963	4	5
The directors recommend the payment of a dividend of 7½%, equal to 1s. 6d. per share (*less* Income Tax at the rate of 2s. 6d. in the £), which, with commissions payable thereon, will amount to . . .	40,200	0	0
Leaving a balance to be carried forward to next year's account of	£64,763	4	5

The capital remains as before, viz. £500,000 in shares of £1 each, fully paid. The fourteenth drawing of Debentures took place on November 29 last, when Debentures to the amount of £15,000 were drawn in accordance with the Trust Deed, thereby reducing the amount of undrawn Debentures to £90,000.

The assets, valued at the end of the year, are classified below, showing a surplus of £138,230.

British Government Securities .	£19,967	16	2
British Government Guaranteed Securities	5,081	1	0
Foreign Government and other Securities	6,727	12	6
Union of South Africa Treasury Bills	1,971	7	5
Cash, Loans, and Sundry Debtors after providing for Current Liabilities	86,757	13	8
Shares, etc., in Companies paying Dividends	517,864	16	10
Shares, etc., in Companies at present non-dividend paying .	60,059	6	6
Farms and Land in Rhodesia .	26,313	16	9
Debtors for Land sold in Rhodesia	3,486	16	1
Total	£728,230	6	11

The assets appear as usual in the balance sheet in the aggregate at or under cost after making allowances for amounts written off. Attention is drawn to the statement in the Auditor's certificate to the effect that about 94% of the Company's investments have quoted prices.

The Company's holdings have not undergone any material change during the year, and include shares in Crown Mines, Government Gold Mining Areas, New Modderfontein and McIntyre Porcupine Mines, Ltd. The Company continues to hold a very substantial interest in the Apex (Trinidad) Oilfields, Ltd., to which reference is made below. The Company maintains its holdings in some of the best known Tin Mines in the Federated Malay States, and has acquired a moderate interest in the new Copper Fields of Northern Rhodesia.

Apex (Trinidad) Oilfields, Ltd. The production of crude oil during the year ended September 30, 1929, amounted to 414,328 tons, which was approximately 120,000 tons above the record output of the previous year. This output was obtained from 110 Wells. The net profits, after making liberal provision for amortisation and depreciation, were £313,208 against £246,429 for the year before. Lower prices ruled for oil, and the factors contributing to the improved profits were the larger output and a reduction in production costs. Dividends amounting to 52½% were paid for the year. During the first five months of the current year to February 28, production has amounted to the satisfactory figure of 168,000 tons.

The Anglo-Burma Tin Company, whilst not fulfilling early expectations, has made progress, and it is expected that the output of tin ore will be about 200 tons for the year ending June 30. A scheme for the rearrangement of its finances is now receiving consideration.

The Staff Fund has enabled substantial assistance to be rendered to present and past members of the staff during the year, and it is proposed to ask shareholders to vote a further sum of £1,000 to the Fund.

In terms of the Articles of Association, Mr. Francis Shipton retires from office, and, being eligible, offers himself for re-election.

The Auditors, Messrs. Cooper Brothers & Co., retire, and offer themselves for re-election.

For the Board of Directors,

F. A. ROBINSON, *Chairman.*
W. T. ANDERSON, *Director.*
S. D. THOMSON, *Secretary.*

LONDON, E.C. 2.
March 31, 1930.

GOVERNMENT GOLD MINING AREAS (MODDERFONTEIN) CONSOLIDATED, LIMITED.

(Incorporated in the Union of South Africa.)

Issued Capital: £1,400,000, in 5,600,000 Shares of 5s. each.

Directorate: S. B. Joel, J.P. (*Chairman*), J. H. Crosby (*Deputy-Chairman*), Sir Reginald A. Blankenberg, K.B.E., J. G. Lawn, C.B.E., G. Imroth, D. Christopherson, C.B.E., and G. J. Joel, M.C.

EXTRACTED FROM THE ANNUAL REPORT TO DECEMBER 31, 1929.

				Per ton, based on tonnage crushed.
Tons crushed, 2,416,000, yielding **1,086,165** fine ounces of gold.				
Total Working Revenue	£4,645,001 4 7			£1 18 5
Total Working Costs	1,977,188 19 8			0 16 4
Working Profit	£2,667,812 4 11			£1 2 1
Rents, Interest and Sundry Revenue	61,673 14 10			
Balance at December 31, 1928, brought forward	141,071 19 11			
		£2,870,557	19 8	
This amount has been dealt with as follows:—				
Government's share of Profits	£1,448,863 5 0			
Taxation—Union and Provincial	9,383 6 6			
Miners' Phthisis Sanatoria, Donations and Depreciation	3,631 12 6			
Provision in respect of Outstanding Liabilities, Miners' Phthisis Compensation Fund	11,376 9 8			
Capital Expenditure	62,452 10 2			
Dividends Nos. 24 and **25** of **45%** each	1,260,000 0 0			
		2,795,707	3 10	
Leaving a balance carried forward of ...		£74,850	15 10	

The **Ore Reserves** at the end of the year were estimated to amount to **10,876,000** tons, with an average value of **8·9** dwt. over a stoping width of 63 inches. The reserves exclude ore of a value less than **4** dwt. over the stoping width.

The full Report and Accounts may be obtained from the London Agents, The Johannesburg Consolidated Investment Company, Limited, 10–11, Austin Friars, London, E.C. 2.

NEW STATE AREAS, LIMITED.

(Incorporated in the Union of South Africa.)

Issued Capital: £1,514,037 in Shares of £1 each. Six per cent. Debentures £279,900.

Directorate: S. B. Joel, J.P. (*Chairman*), J. H. Crosby (*Deputy-Chairman*), Sir Reginald A. Blankenberg, K.B.E., J. G. Lawn, C.B.E., G. J. Joel, M.C., A. J. Anderson, and W. S. Webber.

EXTRACTED FROM THE ANNUAL REPORT TO DECEMBER 31, 1929.

				Per ton, based on tonnage crushed.
Tons crushed, 918,000, yielding **391,430** fine ounces of gold.				
Total Working Revenue	£1,667,784 15 6			£1 16 4
Total Working Costs	957,510 9 11			1 0 10
Working Profit	£710,274 5 7			£0 15 6
Rents, Interest and Sundry Revenue	16,462 5 6			
Balance at December 31, 1928, brought forward	41,755 9 0			
		£768,492	0	
This amount has been dealt with as follows:—				
Government's Share of Profits	£384,973 17 4			
Taxation—Union and Provincial	33,416 15 6			
Debenture Interest and Expenses	18,392 0 0			
Miners' Phthisis Sanatoria, Donations and Depreciation	2,055 12 7			
Provision on account of Outstanding Liabilities, Miners' Phthisis Compensation Fund	1,924 15 0			
Capital Expenditure and Debentures Redemption	72,190 7 9			
Dividends Nos. 9 and **10** of **7½%** and **5%** respectively	189,254 12 6			
		£702,208	0 8	
Leaving a balance carried forward of ...		£66,283	19 5	

The **Ore Reserves,** which exclude ore of less value than **4·5** dwt., were estimated to amount to **2,696,000** tons at the year end, with an average value of **8·9** dwt. over a stoping width of 50 inches.

The full Report and Accounts may be obtained from the London Agents, The Johannesburg Consolidated Investment Company, Ltd., 10–11, Austin Friars, London, E.C. 2.

VAN RYN DEEP, LIMITED.

(Incorporated in the Union of South Africa.)

Issued Capital: £1,196,892, in Shares of £1 each.

Directorate: J. H. Crosby (*Chairman*), S. B. Joel, J.P., Sir Reginald A. Blankenberg, K.B.E., J. G. Lawn, C.B.E., Sir Wm. Dalrymple, K.B.E., Sir Abe Bailey, Bart., G. J. Joel, M.C., and A. J. Anderson

Extracted from the Annual Report to December 31, 1929.

Tons crushed, 748,000, yielding **294,908** fine ounces of gold.

			Per ton, based on tonnage crushed.
Total Working Revenue	£1,257,283 11 4	£1 13 7	
Total Working Costs	755,066 13 11	1 0 2	
Working Profit	£502,216 17 5	£0 13 5	
Rents, Interest and Sundry Revenue	11,335 0 8		
Balance at December 31, 1928, brought forward	43,520 13 1		
		£557,072 11 2	
This amount has been dealt with as follows :—			
Taxation—Union and Provincial	£66,442 8 0		
Miners' Phthisis Sanatoria—Donations and Depreciation	1,742 19 10		
Provision on account of outstanding Liabilities, Miners' Phthisis Compensation Fund	18,233 6 4		
Capital Expenditure	17,801 11 0		
Dividends Nos. 32 and **33** of 17½% each	418,912 4 0		
		523,132 9 2	
Leaving a balance carried forward of		£33,940 2 0	

The **Ore Reserves** at the end of the year were estimated to amount to **3,022,000** tons, with an average value of **7·3** dwt. over a stoping width of 50 inches.

The full Report and Accounts may be obtained from the London Agents, The Johannesburg Consolidated Investment Company, Limited, 10–11, Austin Friars, London, E.C. 2.

THE LANGLAAGTE ESTATE & GOLD MINING Co., LTD.

(Incorporated in the Union of South Africa.)

Issued Capital: £1,519,833, in Shares of £1 each.

Directorate: S. B. Joel, J.P. (*Chairman*), J. H. Crosby (*Vice-Chairman*), Sir Reginald A. Blankenberg, K.B.E., J. G. Lawn, C.B.E., G. J. Joel, M.C., F. L. Marx, and Sir Willem van Hulsteyn.

Extracted from the Annual Report to December 31, 1929.

Tons crushed, 968,500, yielding **313,105** fine ounces of gold.

			Per ton, based on tonnage crushed.
Total Working Revenue	£1,334,695 16 2	£1 7 7	
Total Working Costs	1,022,863 16 1	1 1 2	
Working Profit	£311,832 0 1	£0 6 5	
Rents, Interest and Sundry Revenue	22,303 8 7		
Balance at December 31, 1928, brought forward	61,879 11 0		
		£396,014 19 8	
This amount has been dealt with as follows :—			
Taxation, Union and Provincial	£37,250 18 6		
Government's share of profits (Bewaarplaatsen)	3,846 5 0		
Royalty on Ore	773 1 9		
Miners' Phthisis Sanatoria, Donations and Depreciation	1,753 18 6		
Provision on account of Outstanding Liabilities, Miners' Phthisis Compensation Fund	30,107 17 10		
Capital Expenditure	632 1 4		
Dividends Nos. 76 and **77** of 7½% each	227,974 19 0		
		302,339 1 11	
Leaving a balance carried forward of		£93,675 17 9	

The **Ore Reserves** at the end of the year were estimated to contain **1,596,000** tons, with a value of **7·4** dwt. over a stoping width of 42 inches.

The full Report and Accounts may be obtained from the London Agents, The Johannesburg Consolidated Investment Company, Ltd., 10–11, Austin Friars, London, E.C. 2.

TWEEFONTEIN COLLIERY, LTD.

Directors : W. L. Castleden (*Chairman*), W. E. Lawson Johnston, L. Kessler. *Secretaries :* Henderson's Transvaal Estates, Ltd. *Office :* 36–38, New Broad Street, London, E.C. 2. *Formed* 1907. *Capital issued :* £135,000.

Business : Holds shares in the Tweefontein United Collieries which operates collieries in the Transvaal.

The twenty-third ordinary general meeting of Tweefontein Colliery, Ltd., was held on March 28 at the offices of the company, 36–38, New Broad Street, E.C., Mr. L. Kessler presiding.

The Chairman, in moving the adoption of the report and accounts for the year ended September 30 last, said this was the first balance-sheet issued since the new Companies Act came into force. There were, therefore, one or two new features in the accounts, the most important of which was the statement in the balance-sheet with regard to the £90,000 Debenture stock which was redeemed out of the proceeds of the issue of Preference and Ordinary shares in July, 1914. While it was not the intention of their directors to reissue this Debenture stock, or any part of the further Debenture stock created, the fact that they had the power to do so must be stated in the balance-sheet. It was therefore proposed to cancel this power, and they would be asked at the meeting immediately following this to pass a special resolution definitely cancelling the Debenture stock.

The screening plant and equipment of the new mine on Waterpan was nearing completion, and they were advised that production was expected to commence in the course of April. The plant and general layout have been designed with a view to securing the greatest efficiency in working. Since the closing of the Oogies pits, the old Tweefontein mine has had to be worked by day and night shifts to maintain the required output. The management will now be able to revert to the single-day shift, and we anticipate that the concentration of operations made possible by the opening of the new mine and by the introduction of improved machinery will have a beneficial effect on the profit-earning capacity of the collieries.

They would be aware that the Tweefontein United Collieries, Ltd., was a member of the Transvaal Coal Owners' Association, which was a voluntary organization first formed 20 years ago with the main objective of regulating the output of coal in accordance with the demand, of fixing the production quota for each mine, and side by side with that, machinery was provided for regulating the selling price. The scheme had undoubtedly created economic stability in the coal industry of the Transvaal, and benefited consumers as well as producers.

Mr. W. E. Lawson Johnston seconded the motion, which was carried unanimously.

At an extra-ordinary general meeting subsequently held, the special resolution referred to by the Chairman in his speech with reference to the cancellation of Debenture stock was passed unanimously.

TEMENGOR TIN MINING COMPANY, LTD.

Directors : J. G. Hay (*Chairman*), S. T. Harman, L. N. Leefe, E. T. McCarthy. *Secretaries :* Guthrie and Co., Ltd. *Office :* 5, Whittington Avenue, London, E.C.3. *Formed* 1926. *Capital issued :* £180,000.

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

The third annual general meeting of the members of Temengor Tin Mining Company, Ltd., was held on March 21 at Winchester House, Old Broad Street, E.C., Mr. J. G. Hay (Chairman of the company) presiding.

The Chairman, in moving the adoption of the report and accounts for the year ended September 30 last, made sympathetic reference to the death of the former Chairman, Major F. B. Lawson. Continuing, he said that the two essentials to the full exploitation of the mine were transport and water. The road to the mine was completed in May, 1928, and it had since served them well. They hoped that by gradually metalling the softer portions they would be able to utilize a faster motor service and thus cheapen and facilitate transport to and from the mine. The first portion of the ditch line was in fact completed by July 31 and, had they had a normal rainfall, hydraulicking operations would have been possible on a much larger scale.

Although it might be a disappointment that outputs have been deferred, work on the ditch line had been pushed forward with great rapidity. Spillways and dams had been constructed at various points. The pipeline had been laid complete with pressure boxes and subsidiary lines to the paddocks. The temporary tailings dam had been carried to a stage which should serve the company for another two years, and plans had been prepared and the necessary preliminary steps taken for the construction of the permanent dam.

In view of the limited water available, such hydraulicking operations as had been conducted were directed to further testing the mine. Up to the end of September the output was 1,064·93 piculs, and the output from hydraulicking was equivalent to 1·90 kattys per cubic yard. In opening the paddocks, it had been disclosed that the proportion of undecomposed rock was greater than had been anticipated. The prospecting stamp battery had been worked during the year for the main purpose of proving the value of this stone or rock from the different parts of the mine, and it was now evident that there was ample material of high payable values for working a crushing plant on an economic basis.

The full development scheme was completed on February 18 and the completion of such a scheme reflected the greatest credit on those who had planned it and those who had been responsible for its execution.

Mr. L. N. Leefe seconded the resolution, which was carried unanimously.

At an extra-ordinary general meeting which was subsequently held, a resolution was passed increasing the capital of the company to £300,000 by the creation of 100,000 additional shares of £1 each, and the proceedings terminated.

ANGLO-CONTINENTAL MINES CO., LTD.

Directors : W. F. Turner (*Chairman*), E. W. Janson, Sir Edmund Davis, Alfred W. Berry. *Secretary :* Alfred W. Berry. *Office :* 3, London Wall Buildings, E.C. 2. *Formed* 1909. *Capital issued :* £155,000 in 10s. shares.

Business : Finance of and investment in mining and other ventures.

The twentieth ordinary general meeting of the Anglo-Continental Mines Company, Ltd., was held on March 27, at Winchester House, Old Broad Street, E.C., Mr. W. F. Turner (Chairman of the company) presiding.

The Chairman, in moving the adoption of the report and accounts for the year ended December 31 last, said that the directors' report for the year, together with the profit and loss account for the year and the balance-sheet at that date, were satisfactory enough, but not so satisfactory as regards the question of dividend. They proposed to pay a dividend of 10% less income-tax, which was a reduction of 2½% compared with the preceding year. The profit and loss account showed gross profits £63,517, compared with £36,968 for the preceding year, an increase which spoke for itself. Interest amounted to £886, against £1,124, and the transfer fees were about the same; the total of these credits was £64,460. On the other side of the account they would find that they had dealt with the expenses of running the business in a different manner from previous years. The total expenses for the year amounted to £3,519. On the other hand, they earned in secretarial fees £2,437, and, deducting this, there remained the net figure of £1,082 shown in the profit and loss account. The reason for treating the expenses in this way was that during the year, owing to changed circumstances, they ceased to undertake secretarial work for other companies. New office arrangements had had to be made, and he was pleased to say that they were quite satisfactory to us, inasmuch as their expenses for secretarial work and office accommodation were reduced to the sum of £250 a year, plus, of course, their own necessary disbursements. The audit fees and directors' remuneration, together £1,548, were as usual. The next item was losses on investments written off, £2,504. This consisted of several amounts arising not out of current business, but out of business entered into years ago.

Coming to East Africa expenditure written off, £9,408, he referred to this subject at some length at the last general meeting. They had told them in the directors' report for the year 1928 that the prospecting expedition which had been sent out to East Africa under the direction of a mining engineer, Mr. A. Basil Reece, had examined a number of areas in Uganda, Tanganyika and Kenya without any satisfactory result. They held a three-fourths interest in the business, and their share of the expenditure up to December 31, 1928, was £6,554, which was carried forward to the next year for the reason that it was hoped that the expedition might be so far successful as to enable them to recover the cost. The two areas of 418 sq. miles and 103 sq. miles in the Uganda Protectorate, which were then being prospected, did not produce anything of value, and the expedition was closed. At the present time they were interested, with others, in another investigation in East Africa, but the amount involved was quite small, and it was too early yet to form any idea as to the probabilities of success.

The balance remaining on the year was £49,917; adding the balance brought forward from the preceding year, £33,379, making together £83,296, and deducting income-tax, £5,182, there remained £78,114.

This brought them to the question of dividend, which turned on the question of depreciation. As to this, he said frankly that they had been disappointed, and the cause of it was to be found in the extraordinary events of the latter part of the year. He need not go over the ground, which was only too familiar to all of them. The sensational collapse of prices in the United States and Canada, together with the series of extraordinary happenings on this side, brought about a debacle of prices in all departments here, the effect of which was still being felt severely everywhere. The consequence was, in their case, that instead of being able to propose an increase of dividend, as he for one hoped and at one time expected, they were reducing it to 10%, less tax, in order to leave a sufficient balance to cover the depreciation at December 31 last. They stated in the report that it was expected that a substantial proportion of this depreciation would disappear when the depression which now existed in the stock and share markets had given way to normal conditions. How soon that might be or how it might come about it was not possible to say. A sign of better times was the coming of cheap money, which was in itself a powerful factor, and it was only reasonable to expect that gradually markets would shake themselves free from the effects of the adverse incidents and influences of the past six months: indeed, he thought the process had already begun.

They had received a letter from a shareholder, whose chief complaint was the reduction in the dividend. He had already expressed his own disappointment in that respect. He could not, however, for his own part, accept the view that a dividend of 10% in a company of this kind was an unsatisfactory one. A long experience had taught him that it was about as much as could be expected. As regards the company's share-holdings, they knew it was not their practice to give particulars of them for reasons which he had given on previous occasions. It was sufficient indication of their character to say that to the extent of about 60% they consisted of Mining shares, about 10% was in Oil shares, and the balance in Industrial and Miscellaneous interests.

Sir Edmund Davis seconded the motion, which was carried unanimously.

NUNDYDROOG MINES, LTD.

Directors : V. Herbert Smith (*Chairman*), P. C. C. Francis, Major-Gen. A. C. J. de Lotbinière, Edgar Taylor, Henry C. Taylor, W. L. Bayley. *Managers and Consulting Engineers :* Messrs. John Taylor and Sons. *Secretary :* C. H. D. Garland. *Office :* 5 and 6, Queen Street Place, London, E.C. 4.
Formed 1920. *Capital :* £283,000 in 10s. shares.
Business : Operates a gold mine in the Kolar district of Mysore, India.

The ninth ordinary general meeting of Nundydroog Mines, Ltd., was held on April 10, 1930, at Cannon Street Hotel, London, E.C., Mr. V. Herbert Smith (Chairman of the company) presiding.

The Chairman, in moving the adoption of the report and accounts for 1929, said : During the past year 129,857 tons of ore were treated, producing 66,541 oz. of gold, and 214,384 tons of accumulated tailings were re-treated, yielding 13,579 oz., the total production being 80,120 oz. of gold. This was an increase of 4,693 oz. and the realized value of the returns was £19,106 greater than that of the previous year. The average assay value of the ore milled was 15 grains per ton higher, which largely accounts for the improved return. The receipts from sales of bullion (less royalty), interest and rents, etc., amounted to £325,400, and the revenue costs totalled £217,319, leaving a profit of £108,081, which is £14,914 more than was obtained in 1928. Working costs were 1s. per ton higher, owing to an unavoidable increase in the cost of stoping and heavier expenditure on ventilation work ; on the other hand, development costs were 6d. per ton less. The underground development work during the period under review measured 10,334 ft., a little less than in 1928, and the superintendent's estimate of ore reserves at the end of 1929 was 265,595 tons, showing an increase of 19,131 tons.

Turning to the profit and loss account, you will see the credits amount to £123,212, and the debits, including the interim dividend paid in October last, to £62,500, leaving a disposable balance of £60,712. Out of this a final dividend for 1929 of 1s. 9d. per share was paid on April 3, absorbing £49,525, which allowed £11,187 to be carried forward to the current year's account. The directors were pleased to be able to make distributions by way of dividend amounting to 2s. 6d. per share, as against 2s. per share paid for the preceding year, and this distribution of 25% on the capital is the highest since the year 1917.

The company's interests in its subsidiary (Indian and General Mining Trust, Ltd.) have been written down to £27,500, which represents a fair valuation of the Trust's stock and share holdings at the present time. Its principal holdings, in addition to Government stock, are shares in Kolar Mines Power Station, Ltd., Kolar Brickmaking Company, Ltd., Indian Copper Corporation, Ltd., Anglo-Canadian Explorers (1917), Ltd., and Central Manitoba Mines, Ltd. The Kolar Mines Power Station and Kolar Brickmaking Company continue to pay satisfactory dividends ; the Indian Copper Corporation has been on a producing scale for some time, with, we understand, good prospects. As regards the Canadian interests, the last annual report of Central Manitoba Mines, Ltd., issued in November last, showed that continued development work had not located any fresh ore body of commercial value in the main section of the mine. However, a comprehensive programme of diamond drilling was decided upon, and future prospects depend upon the results of that programme. As the market value of the Central Manitoba Mines shares has declined, we made a corresponding reduction in the valuation of our holding in the Trust.

A reserve fund has been started by the allocation of the sum of £10,000, and I am sure you will endorse the directors' action in this regard. The Board have for some time looked forward to starting such a fund, and are glad the time has arrived when this can be done. The liquid assets of the company at December 31, 1929, were £146,138, from which we must deduct the liabilities, £31,692, leaving a balance of liquid assets of £114,446, in addition to materials and stores, and goods in transit valued at £66,881.

You will gather from the report and accounts and from what I have told you that the company has had a successful year, and it is additionally gratifying to know the outlook is so promising, particularly at a time when the Nundydroog Company is celebrating the jubilee of its inauguration. The undertaking came into being in 1880, and on November 6 next it will have completed 50 years of existence. It is interesting to recall that the first returns of gold were made in the year 1882, and the first dividend was paid in 1888 ; since the latter date shareholders have received an unbroken succession of dividends, the total cash distributed up to now amounting to nearly three million pounds sterling, and we have every reason to anticipate that the mine will continue to reward its proprietors for many years to come.

Your directors desire to make special reference to the valuable services of the mine superintendent, Mr. W. T. Hudson, and his efficient staff, who deserve our hearty thanks for their devotion to the best interests of the company. The general health of the camp has been excellent, and it is a pleasure to be able to congratulate the chief medical officer, Dr. L. P. Stokes, and his staff on their successful work throughout the year. In closing these remarks I have very much pleasure, on behalf of my colleagues and myself, in tendering to Messrs. John Taylor and Sons, our managers, our cordial thanks for their able services during the period under review.

Mr. P. C. C. Francis seconded the resolution.

Mr. Kenneth B. Taylor said he had to refer with regret to the strike which was at present taking place on the Kolar goldfield. The cabled information received that morning reported that all was quiet and that the position had not materially changed. Negotiations were proceeding for a settlement.

The result of last year's operations could, he thought, be considered satisfactory. Development work in the Oriental section had again been satisfactory, and had contributed largely to the new ore opened up in the mine, but perhaps the most interesting development last year occurred in Kennedy's section.

The report and accounts were unanimously adopted.

MINERALS SEPARATION, LTD.

Directors : Francis L. Gibbs (*Chairman*), Sir Ernest M. Clarke, Walter Broadbridge, E. T. Bartlett, Hon. R. M. Preston, J. N. Buchanan, A. C. Howard (*Managing Director*). *Secretary :* H. C. Hankins. *Office :* 62, London Wall, E.C. 2. *Formed* 1903. *Capital issued :* £200,000 in £1 shares.

Business : Owns patents for several flotation and metallurgical processes and has also large holdings in Rhodesian mining companies.

The twenty-fifth annual ordinary general meeting of Minerals Separation, Limited, was held on April 8, 1930 at Winchester House, Old Broad Street, London, E.C. Mr. Francis L. Gibbs (Chairman of the company) presiding.

The Secretary (Mr. H. C. Hankins) having read the notice convening the meeting and the report of the auditors,

The Chairman, in dealing with the accounts, said that the profit for the period under review amounted to £60,015, as against £58,599 in the previous year, an increase of £1,416. The directors recommended a dividend of 25%, equivalent to 5s. per share. That dividend was the same as last year. Continuing, he said, I will next deal with our existing shareholdings in the Rhodesian companies. To-day we hold, including new shares taken up upon which calls and premiums are outstanding, 76,724 shares in The Rhodesian Congo Border Concession, Limited, and 65,808 shares in N'Changa Copper Mines, Limited, also 26,533 shares in Southern Rhodesia Base Metals Corporation, Limited, and 508 Priority and 2,098 Ordinary shares in Luiri Gold Areas, Limited. These Rhodesian holdings have a market value to-day of over one and a quarter million pounds. In addition to this we have cash and Government and other marketable securities, after providing for calls, etc., unpaid, amounting to over £200,000.

As you were informed in the directors' report, there has been little extension in the operation of our coal-cleaning processes in this country during the year, but in Spain the cleaned coal produced by our methods was increased by over 84,000 tons.

On the metalliferous side of our business improvement was again shown. In Spain 79,141 tons of mineral concentrates were produced, as against 71,112 tons in 1928. In the Belgian Congo the Union Minière du Haut Katanga treated 870,635 tons of ore, as against 593,888 tons in the previous year ; and in Chile the Andes Copper Company treated 4,926,915 tons of ore, as against 3,849,339 tons in 1928.

Research and experimental work in connexion with the copper segregation process has been continued and many improvements made in connexion therewith. Demonstrations of the process in our London works, where we have a small working model installed, have been given to several of the prominent metallurgists of the world, all of whom have expressed great interest in the process and have confirmed our engineers' views as to its commercial value. We have installed recently in our London works a large size furnace, and the results of the tests carried out in this larger furnace have been even better than those in the smaller model. A plant capable of treating 50 tons of oxide and mixed oxide/sulphide ores per day is under construction for the Alaska Mine of Southern Rhodesia Base Metals Corporation, Limited, and I am sure the operations of that plant will be followed with great interest by all the mining companies operating in Rhodesia. While referring to Southern Rhodesia Base Metals Corporation, Limited, I might mention that that company in September last commenced operations in the first unit of a flotation plant for the treatment of the Alaska sulphide ores. To the end of March of this year approximately 1,100 tons of copper concentrates were produced with an average grade of 60% copper for the first three months' operations and 67% copper for the second three months' operations.

I will now turn to the work which is being done in Northern Rhodesia by the companies in which we are so largely interested. As you are aware, our company holds a substantial interest in The Rhodesian Congo Border Concession, Limited, and also in the N'Changa Copper Mines, Limited, which was formed by The Rhodesian Congo Border Concession, Limited, to develop and work an area within its concession.

N'Changa Copper Mines, Limited, already possesses within its area an estimated tonnage of approximately 59,000,000 tons of nearly 4% mixed oxide/sulphide ores, and there is a probability that much larger tonnages will be disclosed in the course of time. So far there has been discovered in the N'Changa Copper Mines area about 2,000,000 tons of sulphide copper ores, and further drilling, which is in progress, may quite possibly prove the existence of much larger tonnages of this class of ore.

In the Rhodesian Congo Border Concession, particularly within that part of its concession which lies immediately to the west of the N'Changa boundary, the drilling results during the past few months have been truly wonderful, indicating a tonnage of extremely high-grade sulphide copper ore amounting to many millions of tons, and there is every reason to believe that further extensions of these bodies of rich copper-bearing sulphide ores will be disclosed by the extensive drilling operations now in progress. In view of their nearness to the N'Changa Company's boundary these drilling results are of paramount importance, not only to the Rhodesian Congo Border Company, but also to the N'Changa Company, as there is every reason to hope that the sulphide ore body may extend into the latter company's area, and boreholes are being put down to determine if this is the case. Important indications have been shown by boreholes which have been put down by the Rhodesian Congo Border Company approximately two miles south-west of the N'Changa boundary. Three holes have disclosed ore of good grade, and, in view of their proximity to the surface indications at Chingola, they are considered to be important.

It has been proved beyond doubt by the work already accomplished that within that small portion of the Rhodesian Congo Border Concession which has been systematically drilled there exists one of the richest and most extensive copper-bearing formations ever known, containing masses of sulphide copper ore, which present no difficulty of treatment to the mind of anyone conversant with common metallurgical methods. Many people, however,

who have not had the opportunity for special metallurgical research which our own company has enjoyed, and which indeed is its business, have persistently thrown doubt upon the possibility of equally successful treatment of the mixed oxide/sulphide ores which exist, as I have said, in large quantities at N'Changa, and also exist in the Rhodesian Congo Border Concession areas and in those belonging to other owners in Northern Rhodesia. In all matters relating to the treatment of ores, we as a company are dealing with a business in which I venture to say we have proved ourselves to be experts. I again repeat to-day what I have said on other occasions, that our company foresees no difficulty in the treatment of the mixed oxide/sulphide ores in Northern Rhodesia by the processes which we own and upon which we have expended and shall continue to expend both time and money.

Our shareholders must surely feel gratified that the formation of The Rhodesian Congo Border Concession, Limited, was entirely due to the foresight of this company and its associates, and that through all these years your board have never wavered in their confidence of the ultimate success of the enterprise.

You will have seen in the directors' report that Mr. J. C. Moulden has retired from the board and that Mr. J. N. Buchanan has been appointed to fill the vacancy thus created. I should like to express the board's regret in losing the services of Mr. Moulden, who has been associated with the directorate since 1918 and whose technical knowledge has been of much assistance to our company. The presence of Mr. J. N. Buchanan on this board will be of great advantage to our company, and I shall ask you to-day to confirm his appointment.

The report and accounts were unanimously adopted and the dividend as recommended was approved.

BALAGHÂT GOLD MINES, LTD.

Directors : Lieut.-Col. Sir Donald Robertson (*Chairman*), Major-Gen. A. C. J. de Lotbinière, Henry C. Taylor, Arthur E. Taylor, E. R. Woakes, W. L. Bayley. *Managers and Consulting Engineers :* Messrs. John Taylor and Sons. *Secretary :* G. H. D. Garland. *Office :* 5 and 6, Queen Street Place, London, E.C. 4. *Formed* 1919. *Capital issued :* £153,965 in 10s. shares.
Business : Operates a gold mine in the Kolar district of Mysore, India.

The tenth ordinary general meeting of the Balaghât Gold Mines, Ltd., was held on April 9, 1930, at 6, Queen Street Place, E.C. Mr. E. R. Woakes presided in the absence, through indisposition, of Lieut.-Col. Sir Donald Robertson, the chairman of the company.

The Chairman in moving the adoption of the report and accounts for the year 1929, said they would have seen from the report that during the twelve months ended December 31, 1929, there was an increase of 2,150 tons crushed at the mill and an increase of 2,490 oz. in the total return, the figures being 50,100 tons of ore, yielding 32,468 oz. of gold. The amount realized by the sale of this gold was £10,143 greater than that obtained in the preceding year. The revenue account showed that the receipts from sales of bullion (less royalty), bank interest' rents, etc., amounted to £132,025, and the costs totalled £105,983, leaving a profit of £26,042, as compared with £24,153 in 1928. He might here remark that the working costs for the year, excluding development, showed a satisfactory decrease per ton, but, owing to extra development carried out, the total costs per ton milled were 1s. 3d. higher. The profit and loss account showed credits amounting to £36,377, and debits leaving a disposable balance of £14,776, out of which a final dividend for the year of 6d. per share on the Preference and Ordinary shares was paid on March 27, which absorbed £7,698. The distributions by way of dividend were similar to those of 1928, and the balance carried forward—namely, £7,077—was very much the same.

From a perusal of the balance-sheet they would notice a new item—namely "Development suspense"—which had been credited with £5,500. The directors had considered it expedient to set aside this amount out of the year's profits, and it would be available to meet any extra expenditure on underground development work, which must be pursued this year with the utmost vigour.

On the credit side of the balance-sheet they would observe a portion of the capital expenditure had been charged to profit and loss account, as usual. The sum of £4,500 had thus been written off buildings, machinery and plant, etc., the outlay on which during the year amounted to £10,541. The "Purchase of mining rights account" was reduced by £2,479. With regard to the company's investments, their liquid assets at December 31, 1929, were £74,621 and materials, stores and goods in transit were valued at £28,662.

The underground development work of the year measured 5,254 ft., an increase over the previous year, but the reserves showed a decrease of 18,123 tons, being estimated at the end of the year at 56,008 tons.

Mr. Arthur E. Taylor, in seconding the motion, referred to the strike which had broken out on the mines of the Kolar Gold Field, including the Balaghât Mines, but the latest information went to show that the situation was in hand and improving.

The report and accounts were unanimously adopted.