The Mining Magazine

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EDITORIAL

SOME idea of the recent rate of increase in the tin output may be obtained from the figures for production in the Federated Malay States. During the year 1928 the output was 61,898 tons, as compared with 52,176 tons in 1927 and 45,946 tons in 1926.

MUCH has been heard recently of attempts to restrict oil production in the United States and establish an agreement among the world's leading producers with regard to the distribution of markets. Judging, however, by current figures, the production of crude oil in the United States is rising again, and during the last week of 1928 the rate of output was almost equal to that of eighteen months ago, when the market was much perturbed with the fear of the results of over-production. It is evident that the restriction scheme is not yet in working order.

THE geology of Northern Rhodesia and its ore deposits has hitherto been little understood, and in particular the difficulty in tracing the oxidized copper mineralization to its sulphide source has for long enough been deemed insuperable. The recent discoveries of sulphides in depth at Bwana M'Kubwa, N'Kana, Roan Antelope, Mufulira, and other properties have, however, put quite a different complexion on this problem, and there is now every expectaton that Northern Rhodesia will become the centre of a prosperous smelting industry treating immense bodies of disseminated copper ores substantially richer than those now worked in Utah and Arizona. In our next issue we hope to publish an authoritative article describing these new ore deposits and the mining problems of Northern Rhodesia generally.

THE building of railways is a feature of progress which attracts the attention of the mining engineer and it is well to draw attention in these columns to items of news relating to expansion in this direction. Following up our recent article on Central African railways, it can now be announced that the Kenya–Uganda railway is being extended from Jinga to Kampala, both on Lake Victoria, the ceremony of cutting the first sod having been performed on December 15. Farther south, the scheme for building a railway bridge across the Zambesi at Chindio appears to be making progress, for the plans have been submitted for the approval of the Portuguese Government and a commencement of construction is thus within sight. The ferry at Chindio is a difficult one, for the railway terminals on both sides of the river have continually to be shifted owing to the eccentricities of the Zambesi. The bridge will greatly facilitate transport from Beira to Nyasaland and Northern Rhodesia.

Acid Discharged into the Air from Power Houses

A lawsuit of an unusual character is at present engaging the attention of those associated with modern power houses. It was generally supposed that the benefits accruing from the use of chain-grate stokers and pulverized coal furnaces would be the absence of smoky effluent and that the troubles arising from the fouling of the atmosphere by factory chimneys had been overcome to the universal content of the community. That there are still snags in the path of those who are responsible for the erection of the modern gigantic electric distributing stations is evidenced by the action taken by Mr. Arthur Farnsworth against the Manchester Corporation for alleged damage to his crops in the neighbourhood of the Barton-on-Irwell electric power station. He states that in the burning of 600 tons of coal per day at this power-house 11 tons of sulphur is ejected into the air as acid, which is sufficient to ruin the vegetation in the district. Mr. Farnsworth is a farmer and, in earlier days before the great growth of Manchester as a manufacturing centre, the land around Barton was farmed to advantage, and the estates of the Earl of Ellesmere and Sir Humphrey de Trafford, as well as those of the smaller land owners, were profitable as well as pleasant. But the city has grown as far as Barton, where the old canal built by the Duke of Bridgewater crosses the newer Manchester Ship Canal, and Trafford Park is a park only in name. The Barton power station was built by the corporation, and it is gradually being extended. The original equipment consisted of three turbo-alternators each of 27,500 k.w. capacity, and the boilers were fitted with chain-grate stokers. Its success is indicated by the fact that it has, since its erection in 1923, been continuously in the forefront for low figures for coal consumption and high

figures for thermal efficiency. A few weeks ago the station was extended by the addition of a 40,000 h.p. turbo-generator, which brings the capacity to 122,500 h.p., and plans are already in hand for providing plant for an additional 40,000 h.p. As regards the boilers of the extension just opened, there are two with chain-grate stokers and one employing pulverized coal. From these details it will be seen that the Manchester city engineers are striving to give the best service for the lowest charge possible and that no coal is being thrown away as smoke. The acid problem, however, is now with them, and, as many of the cheaper local coals are high in pyrites, it may become necessary to reconsider the fuel question, if the eventual decision of the law courts is in favour of the farmer.

The litigation commenced in July of last year when Mr. Justice Talbot, at the Manchester Assizes, held that the Corporation must succeed because the nuisance had been authorized by Parliament, that is to say, electricity undertakings of this sort are sanctioned by law. Last month Mr. Farnsworth appeared in the Appeal Court, where Lord Justices Scrutton and Sankey were in his favour, while Lord Justice Lawrence agreed with Mr. Justice Talbot. Lord Justice Scrutton pointed out that the legal phraseology of the Parliamentary sanction of this class of generating station should be revised and made more precise with regard to damages of this character, which were fairly obviously not sufficiently anticipated by either the engineers or the public at large. He criticized the corporation authorities for contending that it was not possible to generate electricity or create power by burning coal without sending sulphur dioxide into the air and that the nuisance could not be mitigated. He argued that, when contemplating embarkation on a scheme so much greater than anything hitherto adopted, they should have considered the effect of burning so much coal at one point and the likelihood of generating large amounts of noxious gases. Since the station came into use the corporation had never consulted with outside chemical and electrical experts as to whether some method of mitigation could not be devised. In giving the majority judgment of the Appeal Court he ordered an assessment of damages and gave notice of a year's grace during which the nuisance may be mitigated. It seems imperative that the case should be taken to the House of Lords in order that further legal views may be obtained. In the meantime it should be stated that this is not a case of "smoke-farming" as known in the United States, but is a genuine lawsuit intended to settle an entirely new question in engineering circles. Incidentally, it may provide a decisive factor in the controversy between the direct burning of coal and its carbonization before the delivery of combustible products to the boilers.

The Forthcoming Congresses in South Africa and Future Congresses

As has already been mentioned on several occasions in these columns, two Congresses of interest to mining men are to be held in South Africa in the near future. The first is the Fifteenth International Geological Congress, which will be held in August, 1929, and the other is the Third Empire Mining and Metallurgical Congress, which will commence its sittings at Cape Town towards the end of March, 1930. According to notices hitherto circulated, the sittings and excursions of both these Congresses are arranged to be held in the Union and Rhodesia only. It is of interest, therefore, to record that it has more recently been decided to include South-West Africa in the itinerary of the Geological Congress. Whether or not the Empire Congress will be extended in a similar way remains to be seen, but in all probability there will be no great difficulty in coming to an arrangement whereby the same organization could repeat the excursion half a year afterwards, with variations to suit the economic rather than the pure geologist. Possibly the leaders of the Empire Congress may hesitate to add a fortnight to the forty-seven days already charted, but the Canadian scheme of alternative excursions may be applicable in South Africa and the return journey from Rhodesia could be made either via South-West or by Natal and the Cape Province. There can hardly be any doubt that many mining engineers would appreciate the opportunity of visiting South-West, as it is a metalliferous region of more importance than Natal and the Cape and, moreover, it is less generally known.

An idea of the ground to be covered in South-West Africa can be obtained from a study of the time-table arranged for the Geological Congress. The tour will start from De Aar Junction and the railway journey will extend across the Orange River at

Upington, whence the route will pass through the southern limit of the Kalahari Desert towards the Zwastrand Plateau, and returning by train by Aus to Luderitzbucht. After visiting the diamond region, the railway journey will be resumed and the Karroo beds and the Tertiary volcano of Geitsi Gubib will be inspected on the way to Rehoboth and Windhoek. Train will then be taken to Karibib, whence a motor trip will be made to the Erongo granite tors, tin-bearing pegmatites, and the Ameib tin mine. The railway journey will be resumed and Tsumeb will be the next centre, the copper-lead mine being visited and also the Abenab vanadium property. Motor journeys will also be made northward, when the Etosha saltpan will, among other things, be inspected. The return journey will be direct from Tsumeb and Karibib to Windhoek and Keetmanshoop to De Aar. This region presents other features of interest in addition to those associated with mining and geology and, though much of it is barren, in the north there is a notable game preserve while in the south the Aughrabies Falls are among the greatest in the world.

While writing of forthcoming Congresses the opportunity presents itself to refer to the future policy in connection with the Empire Mining and Metallurgical Congress. Visits to various mining centres within the Empire are important features of the policy and in due course the Australasian societies will issue their invitation. It is also desirable that India and Malaya should join in acting as hosts at a more distant date. In order that such tours shall be successful it is essential for technical societies to be sufficiently powerful and local governments duly appreciative of the importance of mining operations. As regards Australasia there can be no doubt on this subject, but the position in India and Malaya is not quite the same. The Governments of India and Malaya necessarily view the miner and his financial supporters from a different angle, and their attitude towards a visiting Congress would not be quite the same as in the purely British countries. The technical societies in India, also, are not on the same footing as those in England, Canada, South Africa, and Australia, in that their membership and their publications are not of wide distribution. In spite of these restrictions it is probable that India would be able to respond to the requirements of a visit of the Congress. On the other hand Malaya is entirely lacking in cohesion among mining men. There is certainly an excellent Geological Survey, the members of which combine to enrich geological literature, but there is no society devoted to mining and there is no mining literature published locally. Our point is that steps ought to be taken to found a Malayan mining society and that the local mining engineers should be helped or encouraged to take such a step by the powers behind the Empire Mining Congress.

The December Institution Meeting

As a rule the meeting of the Institution of Mining and Metallurgy held just before Christmas is rather a dull occasion. Knowing that the attendance will be poor the Council is inclined to present papers of minor importance. This year, however, all three papers were of considerable interest, and each could well have occupied a whole evening to advantage. The papers were : " The Importance of Recovered or Secondary Tin," by Mr. J. B. Richardson ; " Prospecting and the Discovery of Mines in South Africa," by Major Tudor G. Trevor ; and " The Inefficient Use of Compressed Air in Mining," by Mr. Russell B. Woakes.

The paper by Mr. Richardson is of considerable current importance owing to the prevailing opinion that the supplies of tin will be running short in a few years' time. It is clear that under such circumstances the prevention of waste is essential and the recovery of old metal should be systematically organized. Tin, being a semi-precious metal, now brings a good price at the junk dealers ; that this is so is evidenced by the fact that glass has been substituted for pewter at the public-houses owing to widespread theft. In America, where there is no domestic output, the tin squeeze is most acutely felt and in consequence the best metallurgical brains are devoted to preventing old metal and alloys from going to the scrap heaps. Since the war Mr. Richardson has been occupied in similar work in this country and his paper is therefore written with considerable authority. He covers the ground in a manner similar to Dr. R. J. Anderson in his article on the recovery of aluminium from scrap published in the MAGAZINE for September, 1926, and the two papers may well be read in conjunction. Mr. Richardson shows that the dealers in this country are fully aware of the profit arising from the recovery of tin and have various useful and

interesting processes at work, but he is of opinion that much more can be done by better scientific direction. The great difficulty to be contended with by producers of secondary tin arises from the indiscriminate mixing of scrap alloys, a practice which adds immensely to the metallurgist's difficulties. There does not seem to be much chance of establishing an educated selective ability among the buyers of junk, who at present do not go much further than the separating of brass from white metals. As regards the greater recovery of tin from tinplate, this is already done to some extent in connection with clean scrap from the canneries, but its recovery from used cans has not got very far, owing, primarily, to the difficulty and cost of collection. In fact in the latter case it is only when there is a market for the iron after sweating and burning that it pays to recover the tin, and for a similar reason the proposal to employ the dust-collector's labour (paid for out of the rates) in sorting out valuable raw material for the secondary tin producer does not seem to be practical economics. However, some of Mr. Richardson's suggestions may bear fruit eventually.

In particular, his plea for the disclosure of statistical information relating to the relative amounts of tin consumed in individual uses deserves attention, for it is obvious that any reliable calculations relating to maximum expectations of recovery must be based on approximately accurate details of this character. For instance, the economist has only the vaguest idea of the amount of tin tetra-chloride employed in dyeing and weighting silk, how much is produced from virgin tin, and how much from recovered tin. Mr. Richardson's paper may be taken as a standard authority on the subject treated, and it is to be hoped that he and others will continue the collection and dissemination of further information on the subject.

Major Trevor's paper on prospecting and the discovery of mines in South Africa is naturally of great value, as he has been engaged for most of his life in that country, partly as an independent worker, and partly as a Government Inspector of Mines. His experience tells him that the day of the old-fashioned prospector is not over in spite of the growth of the field geologist and the educated mining engineer, for the finding of a payable deposit is still largely in the hands of the uneducated roamer. But the days are over when the prospector can blossom into the "mining expert," for the prospector, after discovering the existence of promising outcrops, hands further duties to the proved mining engineer. Another important point which Major Trevor presses home is that the stages in the history of mines or workings should be clearly defined: (1) The preliminary prospecting stage, (2) the exploration prospecting stage, (3) the development stage, and (4) the producing stage. By conforming to this classification both the engineers, directors, and the public will be able to grasp with a tolerable degree of exactness the nature of the work done and doing and the general outlook. He discusses the average expectation of operations passing from one stage to another and gives figures from his experience indicating the chances of such expectations being borne out in practice. The discussion included useful remarks by Professor Truscott, Dr. Wm. Cullen, Dr. J. A. L. Henderson, and Professor J. G. Lawn, and it is hoped that all mining men will read the paper and the report of the discussion.

Mr. Russell Woakes's paper on compressed air is intended to stir up the mine manager and mine staff to an appreciation of the great waste of compressed air, and he goes categorically through the various causes and opportunities for such waste. Undoubtedly one of the most difficult sections of the subject is centred round the advantage to ventilation of the discharge of rock-drills and other machines using compressed air underground, for the illegitimate discharge accounts for a great deal of waste. But both legitimate and illegitimate discharge should not enter into a discussion of ventilation, and both should be severely restricted if efficiency in air practice is to be followed up logically. The paper deserves far more discussion than was possible at the meeting. Only Professors Truscott and Holman had an opportunity of making any comment and their contributions to the discussion were necessarily restricted. One point made by Professor Holman that deserves special notice was his recommendation that the literature of the subject should be collected and classified. This literature is very extensive, and a collection of classified references would be helpful. May we be allowed here to recommend the inclusion in this list of Mr. B. Beringer's new book on Underground Practice in Mining, which contains several incisive and critical chapters on this subject ?

REVIEW OF MINING

Introduction.—The copper market has shown great activity lately, owing to the increased demand for American copper, and the prices for electrolytic in America and for standard here have advanced. On the other hand tin still shows signs of weakness, through over-production, and the efforts of bulls to raise the prices are only temporarily successful. Unemployment in the coalfields is sufficient to demand public relief this winter, but otherwise the state of trade in this country is fairly hopeful.

Transvaal.—The output of gold on the Rand during December was 821,582 oz. and in outside districts 38,179 oz., making a total of 859,761 oz. The output for the year 1928 was thus 9,908,188 oz. on the Rand, 451,408 oz. in outside districts, and the total 10,359,596 oz.

The accompanying table gives details of the dividends of Transvaal gold mining companies for the second half of 1928. There is no notable variation in these figures as compared with those of the preceding two half years.

DIVIDENDS PAID BY RAND GOLD MINES.

	1st half, 1927.	2nd half, 1927.	1st half, 1928.	2nd half, 1928.
	s. d.	s. d.	s. d.	s. d.
Brakpan	5 0	5 0	4 9	5 0
City Deep	1 0	—	—	—
Consolidated Main Reef	1 3	1 0	1 3	1 0
Crown Mines (10s.)	3 3	3 6	2 6	3 0
Geduld	3 6	4 0	3 3	3 6
Geldenhuis Deep	—	6	—	6
Government Areas	8 0	2 3‡	2 3‡	2 3‡
Langlaagte Estate	1 6	1 0	1 6	1 6
Meyer & Charlton	2 0	1 0	—	—
Modderfontein, New (10s.)	6 6	6 6	7 0	7 0
Modderfontein B (5s.)	2 0	2 0	2 0	2 0
Modderfontein Deep (5s.)	3 3	3 6	3 3	3 6
Modderfontein East	—	1 0	2 0	2 0
New State Areas	1 6	1 0	1 0	1 6
Nourse Mines	—	6	6	6
Robinson Deep (A, 1s.)	—	1 6	1 6	1 6
Robinson Deep (B)	—	—	—	—
Rose Deep	6	6	6	—
Simmer & Jack (2s. 6d.)	—	4½	—	—
Springs Mines	3 3	3 6	3 3	3 6
Sub Nigel (10s.)	2 6	3 6	3 0	3 0
Van Ryn	6*	6*	6*	6*
Van Ryn Deep	4 0	4 0	4 0	4 0
Village Deep	—	—	—	6
West Springs	1 3	9	9	1 0
Witwatersrand Gold	9	9	6	—

* Tax paid. ‡ 5s. shares.

Southern Rhodesia.—The output of gold during November was officially reported at 47,705 oz., as compared with 43,056 oz. in October and 47,435 oz. in November, 1927. The number of producers was 136. Other outputs during November were: Silver, 6,800 oz.; coal, 94,429 tons; chrome ore, 15,134 tons; asbestos, 3,616 tons; mica, 14 tons.

Northern Rhodesia.—Events have been moving fast in connection with the development of Northern Rhodesian copper resources. The Rhodesian Anglo American, Ltd., has been formed for the purpose of controlling the interests of the Anglo American Corporation of South Africa, Ltd., in Rhodesia. The fact is that this new branch of the Anglo American business is big enough to warrant its segregation from the Rand and diamond interests of the company. In addition to directors associated with the Rand and diamonds, the board includes representatives of the British South Africa Co. in the persons of Sir Henry Birchenough and Sir Edmund Davis.

Another company to which attention is now publicly directed is the Rhodesian Selection Trust, which was formed last May by Mr. A. Chester Beatty and associates to acquire from the Bwana M'Kubwa Copper Mining Co. the benefit of the N'Kana Concesson and to finance the prospecting and development of this region, excepting the N'Kana copper mine itself. On this Concession several deposits are known of a similar nature to that of the Roan Antelope, which is also controlled by Mr. Chester Beatty and particulars of which were given in the last issue. The most important of these deposits so far investigated are the Mufulira and the Chambishi, and their development points to the existence of equally large and important deposits.

Perhaps, however, the most interesting news, anyway from a sentimental standpoint, is to the effect that both at the Bwana M'Kubwa and the N'Kana mines diamond drilling has revealed the presence of sulphides at depth. There is reason to believe from the evidence so far available that the company which has struggled unsuccessfully for many years with the oxidized ores will come into its own by means of the sulphide ores at these two mines. At the Bwana property the existence of sulphide ore has so far been demonstrated by only one bore-hole, the record of which is: From 250 ft. to 290 ft., 5·2% copper over a true width of 17 ft.; 405 ft. to 483 ft., 3·58% over 33 ft.; 518 ft. to 529 ft., 4·5% over 5 ft.; and 549 ft. to 569 ft., 2·56% over 8 ft. At the N'Kana more drilling has been done, and it has been possible to estimate the ore so far disclosed at nearly 24,000,000 tons averaging 4·2% over an average width of 31·5 ft. Another

favourable feature at Bwana is the improvement in the reduction-ammonia process introduced by Mr. C. W. Dowsett, the new manager, whereby the process of solution is hastened by the preliminary separation of the sand and slime.

Gold Coast.—Readers are aware that the old Prestea Block A gold mine, on the dissolution of the company of that name, was purchased by another group who formed the Ariston Gold Mines, Ltd., to operate it and provide the finance. Under the management of Mr. E. J. Way, late of the Rand, the mine and plant have been reorganized. This work has now been concluded and 40 stamps started work towards the end of 1928, on ore averaging 10·7 dwt. gold per ton. The shaft is now down below the 16th level, and the average assay-value of the ore reserve is estimated by Mr. Way at around 12 dwt. per ton.

A company called the Gold Coast Selection Trust has been formed to acquire and reopen certain mines and workings in the same neighbourhood as the Ariston mine with Mr. H. G. Latilla as chairman.

Australia.—The Mount Isa Mines, Ltd., in which the Russo-Asiatic Corporation has such a large interest, is about to increase its capital from £1,500,000 to £2,000,000 by the creation of additional shares of £1 each. Debentures are to be issued to provide funds for building the first unit of the concentration plant with a capacity of 1,500 to 2,000 tons per day, and these debentures will carry the right of conversion into shares at the rate of £2 10s. per share.

New Guinea.—Last month it was recorded that the Ellyou Goldfields Development Corporation had been formed by Mr. Leslie Urquhart for the purpose of acquiring gold mining properties in the Bulolo River goldfield in the Mandated Territory of New Guinea. Since then a statement has been published giving an outline of the proposals. The properties consist of alluvial, eluvial, and lode deposits. Mr. Arthur Dickinson has been in charge of prospecting and development, and Mr. W. E. Thorne is now on the spot making an examination. Mr. Dickinson sends a report on the results of his examination of seven different locations on lode occurrences. The assay-values obtained average around 1 oz. gold and 7 oz. of silver per ton of ore over 3 ft. 6 in. to 6 ft. As recorded in these columns on several occasions during the last two years, these deposits have already yielded large amounts of gold, and the results of further developments and examinations will therefore be awaited with keen interest.

India.—The mining operations of North Anantapur Gold Mines, Ltd., ceased some time ago and the remaining asset of the company consisted of shares in the Indian Copper Corporation. It has been resolved to wind up the company and distribute the latter shares among shareholders.

Malaya.—Operations at the Kay Yew tin mines in Kinta Valley have been suspended owing to unsatisfactory results obtained, and the directors have placed the matter in the hands of solicitors with a view of ascertaining what redress can be obtained from the vendors. The formation of this company by the Scottish Finance Co., Ltd., was recorded in our issue of October, 1927, when it was stated that the property consists of an alluvial deposit at the foot of limestone cliffs under a capping of decomposed granite, situated between Menglembu and Lahat, and that it was intended to erect a mechanical digger for the purpose of removing the overburden. As things did not go well, the board asked Mr. L. G. Attenborough to examine the property and, as his report was extremely unfavourable, he was asked further to comment on the reports embodied in the prospectus. Further news of the position will be awaited with interest.

In October record was made of the formation by the Anglo-Oriental group of the London Malayan Tin Trust to control the finance and management of a number of alluvial tin companies previously belonging to the Pratten and Yuba groups. Among these companies was the Rawang Tin, Serendah Tin, and Serendah South Tin. It is now announced that these three companies are to be amalgamated by the absorption of the latter two by the first named, the issued capital being increased to £876,000 in 10s. shares. The properties adjoin each other and are served with the same power station. It is also announced that the dredge of the Kramat Tin Dredging Co., which belongs to the same group, is now under construction. This dredge has 14 cu. ft. buckets, and its capacity is calculated at 200,000 cu. ft. per month. It is of interest to note that electric power will be supplied by the Perak River Hydro-Electric Power Co., Ltd. The dredge of Kampar Malaya Tin Dredging, Ltd., belonging also to the same group, is now under construction, and is expected to

be in operation in the spring. It has a monthly capacity of 215,000 cu. yd., and 20,000,000 cu. yd. of ground is estimated to average 1 lb. per yard.

Canada.—The terms of consolidation of the interests of the Mond Nickel Co. and the International Nickel Co. were published last month. The ownership of the International Nickel properties has been transferred from a New York to a Canadian company and holders of Mond Nickel shares are given the option to exchange into shares in the Canadian company. The object of this consolidation is to enable the Frood ore-body to be worked as one unit instead of as two independent organizations with separate shafts, milling plant and smelters. The Canadian company owns a considerably greater proportion of the Frood area than Mond Nickel and altogether the exploitation of the new ore-body can be managed more suitably by the Canadian company. The Frood ore-body is much richer in copper than any of the nickel ore-bodies at Sudbury, and indeed it is one of the most remarkable deposits ever discovered.

Mexico.—The Fresnillo silver property of the Mexican Corporation is now making large profits from its sulphide ore as will be seen from the abstract of its yearly report and from the Chairman's speech at the meeting of shareholders quoted elsewhere in this issue. The directors have now a plan in hand for amalgamating the interests of the company with the American-owned company from which the property is leased on a profit-sharing basis. Details of this scheme are expected to be settled during the Chairman's visit to New York this month.

During the twenty-one years of its existence the Santa Gertrudis Company has never had to suspend operations owing to causes arising from Mexican political troubles.

Colombia.—The Frontino and Bolivia company, which has successfully worked the Silencio gold mine for many years, recently embarked on an enterprise jointly with a Belgian company for providing hydro-electric power from the Dona Teresa falls. The cost of such an installation is comparatively great, but the company will reap a substantial advantage, for at present steam raising by means of wood forms a large item in the working costs. Much of the cost of the installation has been provided out of revenue, but in the near future shareholders will be invited to subscribe capital to liquidate the remainder of the expenditure.

Venezuela.—In the issue of August, 1927, particulars were given of the Bolivar Venezuela Gold Mines, Ltd., which was formed to work the Hansa and Union groups of gold mines near the old Callao property. The office is with the National Mining Corporation and Messrs. Frank Merricks, David Wilkinson, and Noel G. Hackney are on the board, with Mr. Cyril E. Parsons as manager at the mines. Development and road building have been carried on with success since the formation of the company, and, in particular, the discovery of a new lode has substantially added to its resources. This ore-body is unusually wide, and the assays vary from 6·9 dwt. over 90 ft. to 16·4 dwt. over 87 ft. Clearly the discovery of this ore-body will have an important bearing on the future policy of the company.

Spain.—The Dome Mining Corporation, which has of late years been associated with a gold-dredging property on the Orbigo River, northern Spain, is to be reconstructed with the object of providing funds for the purpose of reconditioning and improving the dredge. This dredge, it will be remembered, failed to obtain a profitable yield and in 1925 a company called the Dredging Development Co., Ltd., was formed for the purpose of building a bigger dredge capable of working to greater depths. That company, however, failed to provide the funds, and did not succeed in operating the old dredge. According to the new proposal the Dome company is to reduce its capital from £100,000 to £40,000 by writing off 3s. per 5s. share, and then create a further £60,000 share capital in 600,000 additional 2s. shares. The intention now is, as recorded above, to improve the dredge, and for the corporation to resume control. In previous years the comment has been made that a further examination of the property as a gold-bearer should be made by an independent alluvial engineer; this criticism still holds good.

Morocco.—In July, 1927, mention was made of the formation of the European and North African Mines, Ltd, to acquire iron and lead deposits in Spanish Morocco. Since then the Madrid organization has been discontinued and operations are now controlled from London, the National Mining Corporation being in charge of the administration of the company's business, with Messrs. Pellew-Harvey and Co. as consulting engineers, and Mr. L. C. Stuckey as manager. This change has caused some delay, but development and provision of plant are now being energetically conducted.

GREECE: ITS GEOLOGY AND MINERAL RESOURCES

By D. A. WRAY, Ph.D., M.Sc., F.G.S., F.R.G.S.

INTRODUCTORY.—One of the most interesting of the many kaleidoscopic changes produced by the Balkan and European Wars and subsequent events has been the growth and expansion of the modern State of Greece. At the present time, the total area of the Greek republican State is approximately fifty thousand square miles or practically double that of "Old Greece" in 1912. Epirus, Crete, numerous islands in the Ægean, and Southern Macedonia were incorporated within its frontiers in 1913 as a result of the Balkan Wars, while subsequent to the Great War, Western Thrace also became an integral part of modern Greece.

VIEW ON THE EAST COAST OF CORFU.
The island of Corfu consists of a highly folded series of Mesozoic and Tertiary rocks. The smaller island off the coast is traditionally regarded as the ship which brought Ulysses to Ithaka and was afterwards turned into stone by Poseidon.

These changes have been accompanied by various extensive racial migrations, both voluntary and compulsory, and large numbers of Greek emigrants from Asia Minor have replaced the former Turkish and Bulgarian residents in Western Thrace and Eastern Macedonia. The transference of nearly three million Bulgarians, Greeks, and Turks has materially helped to produce an approach to a homogenous Greek State, a feature that is to be particularly welcomed, for it augurs well for the greater stability of the new republic, and removes one of the main causes of political unrest in the Near East. The present population of Greece is approximately five and a half millions.

GEOLOGY.—In the complexity of its contour and the variety of its physical features, Greece stands unrivalled, and this is clearly reflected in its complicated geological structure. In probably no other country can there be seen such a succession of striking contrasts; fertile tracts with vineyards, olive-groves, and thick forests alternating with barren and precipitous mountains of massive limestone largely devoid of any surface soil or water. The broken character of its coast-line is unique, while the great mountain ranges which cover so large an area in peninsular Greece project abruptly into the sea, ending either in rugged peninsulas or in chains or strings of rocky islands. The combination of so varied a landscape with a remarkable clearness of the air produces scenes of unending charm and variety, scenes which, though little dwelt upon in ancient literature, must have exercised a very profound

influence on the artistic and poetic development of the ancient Greeks.

The geological structure of Greece has been mainly investigated by Austrian, German, and French geologists. Some fifty years ago, extensive researches were conducted by Neumayr, Bittner, Teller, Hoernes, and other Austrian geologists, who sketched in the broad outlines, though these have been profoundly modified by the later investigations of Lepsius, Renz, Philippson, and De Launay. Within recent years a State Geological Department has been instituted and Professor Ktenas and Dr. Georgalas, of the University of Athens, have respectively investigated in greater detail the geology and mineral resources.

In a general way Greece may be readily divided into two regions, an eastern and a western, the geological structure of the two areas being in sharp contrast. Western Greece consists of the southern portion of the Dinarides, the folded mountain system trending south-south-easterly along the eastern shores of the Adriatic Sea; while Eastern Greece is a complex of older and more complicated folded systems together with two fractured crystalline horsts or massifs.

Western Greece.—According to Philippson, the folded area of Western Greece may be further subdivided into two distinct belts; an outer zone termed the Ionian, and an inner and broader one trending from the Pindus Mountains across Ætolia and the Gulf of Corinth into the Western Peloponnesus, and referred to as the zone of Pindus.

The Ionian Zone.—This system trends in a north-north-west and south-south-easterly direction across Epirus, Acarnania, the Ionian Isles, and the extreme western promontories of the Peloponnesus; and attains its greatest width of about fifty miles in the vicinity of Yanina. Cretaceous limestones, characterized by the oyster-like shell *Rudistes*, predominate in Corfu and on the promontory of Acrocerania, while Liassic limestones and shales are also represented on Corfu. Further south in Acarnania, Zante, and the Western Peloponnesus, wide belts of highly folded Rudistid and Nummulitic limestones occur. The numerous bands of limestones in the Ionian Zone give rise to long mountainous rampants, while in the intervening narrow furrows occur strips of sandstones and shales of Lower Tertiary age, known throughout South-Eastern Europe as the Flysch.

The Zone of Pindus.—In a general manner, the zone of Pindus consists of three parallel belts or sub-zones: an eastern and a western band, each consisting mainly of arenaceous strata referred to the Flysch formation, and a broad central area of massive limestone.

The Flysch sandstones and shales which constitute the eastern sub-zone form a narrow belt of very highly folded strata, and show evidences of intense movement along the western margin of the more rigid and older massif of Eastern Greece. The central zone of Pindus consists mainly of Orbitoidal and Nummulitic limestones of Lower Tertiary age, the Rudistid limestone which characterizes the Ionian zone being absent. The belt of limestone gives rise to an almost uninterrupted and barren mountain barrier forming the Pindus Range in Northern Greece, the Ætolian Alps, and the high massif of Olonos to the south of the Gulf of Corinth. To the north of Greece it continues as a high mountain range across Albania and Western Yugoslavia. The western sub-zone of Pindus consists largely of soft arenaceous strata which give rise to long narrow areas of comparatively low relief. The axes of folding in the zone of Pindus maintain on the whole a very uniform north and south trend.

Eastern Greece and the Ægean Islands.—Eastern Greece may be conveniently subdivided into five main tectonic zones or structural areas: These include the crystalline massif of Thrace and Macedonia; the crystalline massif of the Cyclades; the folded zone of Central Greece; and the Southern Ægean, and Anatolian (or Eastern Ægean) folded areas.

The Crystalline Massif of the Northern Ægean.—Thrace, Macedonia, and Southern Yugoslavia together form a large and rigid continental mass between the Dinaric and Balkan folded ranges of the Western Balkans and Central Bulgaria respectively. The southern portion of this crystalline region includes Eastern Thessaly, the peninsula of Khalkidike, Western Thrace, and the islands of Thasos and Samothrace; all within the confines of modern Greece. The dominant rocks of this area consist of micaceous schists, phyllites, and crystalline limestones.

Gneissose rocks occur in Northern Thessaly and on the Khalkidike peninsula; and

massive granite on Samothrace. In Thessaly and the Khalkidike the general strike or trend varies from north and north-west to east, while in Thasos, Samothrace, and Western Thrace, the predominant strike in the older rocks is north-easterly. The southern part of the Northern Ægean crystalline core or massif has been profoundly modified by late Tertiary and Quaternary faulting, and the abruptness of its outline are the isolated fragments of a former crystalline massif, profoundly modified by the Quaternary fractures which gave rise to the Ægean Sea. The explanation of the great diversity in the arrangement of the axes of folding both on the mainland and in the islands is doubtless to be sought in the very varying earth-stresses and movements which would be produced by block-faulting on so extensive a scale.

is strikingly illustrated by great contrasts in relief. Thus Mounts Olympus and Athos, over nine and six thousand feet high respectively, lie practically alongside the shores of the Ægean Sea, while in their proximity depths of over 3,000 ft. have been recorded.

The Crystalline Massif of the Cyclades.—Southern Eubœa, Eastern Attica, and the archipelago of the Cyclades, with the exception of its south-eastern extremity, The islands of Andros, Keos, and Kythnos, together with Southern Eubœa and Eastern Attica, consist in the main of mica schists, phyllites, and marbles; while in the remaining islands amphibolite schists, gneisses, and gneissose granites, with beds of marble predominate.

Folded Zone of Central Greece.—Central Greece, including Attica, North and Central Eubœa, and Southern Thessaly, consists in the main of a series of sedimentary rocks

of Cretaceous age. These beds are strongly folded and constitute a broad lens-shaped area, the regularity of which is somewhat interrupted by the later fractures bordering Bœotia and the Gulf of Corinth. The orientation of the folds follows an arcuate course closely approximating to the external form of the area. The folding is most intense along the outer rim of the zone, and evidences of torsional movements are very pronounced along its north-western margin. Large intrusive masses of serpentine characterize the more northern portions of this area.

The Folded System of the Southern Ægean.—Mica-schists, phyllites, and marbles occur in the Eastern Peloponnesus and are overlain by thick and massive Cretaceous limestones characterized by Rudistid shells. Arcadia and Laconia are largely barren and arid upland regions in which the two principal mountain ranges are those of Taygetus and Parnon. The central part of Taygetus, culminating in Hagios Elias (7,904 ft.), consists of a long-drawn-out jagged ridge of massive Rudistid limestone falling away on either side to a more plateau-like type of country. The strata are highly folded and the axes of folding which trend north-north-westerly terminate en echelon against the eastern margin of the folded zone of Western Greece. The rugged peninsulas of Maina and Malea constitute the southern continuation of this system, while the mountainous island of Crete, culminating in Mount Ida or Psiloritis (8,065 ft.) represents an easterly deflection of these folds, now isolated by the sea. Still further east in the picturesque island of Rhodes the same succession occurs, and the orientation of the folding here becomes north-easterly.

The Folded System of the Eastern Ægean.—This area embraces the western flank of Asia Minor extending from the Dardanelles and the Troad in the north to the island of Cos in the south, together with the adjoining archipelago including the islands of Lesbos or Mitylene, Chios, and Samos. The predominant rocks consist of a crystalline series overlain by a thick succession of sedimentary rocks, including representatives of Palæozoic, Mesozoic, and Tertiary formations. The axes of folding here run mainly north and south, or transverse to the coast, in some places, however, ranging from north-east to north-west. The important development of Palæozoic rocks in the Eastern Ægean area constitutes its most distinctive feature.

Geological History in the Tertiary and Quaternary Periods.—Detailed studies on the relationships of the Tertiary rocks to those of older date have clearly shown that the whole of the Southern Balkan area, with the exception of the crystalline massifs of the Cyclades and the Northern Ægean, has been strongly affected by earth-folding movements in early Tertiary times. In each of the several zones or areas outlined above, however, there are several different systems of folding, and it would appear therefore that there were several distinct periods at which these tangential earth movements took place. Western Greece differs from the remaining areas only in being affected by the later movements, which it is generally conceded took place in Miocene times. The Ionian zone and the zone of Pindus represent in fact the southerly continuation of the Dinarides and are intimately related to the main Alpine earth-folding movements.

At the close of the Miocene period, these tangential earth-stresses were succeeded by a series of vertical movements and fractures which, attaining their maximum intensity in Quaternary times, have been operating more or less continuously to the present day. The basin of the Ægean, which is a complex foundered area, originated from the intersection of a series of these intense earth-fractures, some of which run more or less parallel to the main axes of folding, while others, which have independent directions, intersect the peninsula of Greece and give rise to its highly dissected nature. The gulfs of Corinth, Atalanti, Euripus, and Volo represent sunk-lands now drowned by the sea, while others such as the Trikkala and Larissa basins in Thessaly are floored with Quaternary clays and sands of lacustrine origin. The Tertiary and Quaternary lignites and brown coals of Greece were formed on the floors of many of these sunken areas, while the famous Pliocene lacustrine clays and gravels of Pikermi in Attica, which have yielded so prolific a mammalian fauna, originated in a similar manner. According to Philippson, thick Pliocene sediments which are extensively developed along the Bœotian coast and the Gulf of Corinth yield clear evidences of a succession of step-like downward movements of at least 4,000 ft., all of which took place in the Quaternary period.

These profound earth-movements were accompanied by a thick succession of volcanic and intrusive igneous rocks, and the mineral deposits of Attica, Eubœa, the Ægean Isles, and the Khalkidike are intimately related to them. Volcanic rocks cover large areas in the Troad, in Western Thrace, and occur on the majority of the islands of the Ægean Archipelago. Some of these volcanic islands such as Santorin place along the fractures which border the Ionian Isles, the island of Eubœa, and the Gulf of Corinth. Such movements in the past have profoundly modified the outline of the peninsula and its numerous islands, and the incomparable natural beauty of the land of Hellas is a direct result of such agencies.

THE MINERAL RESOURCES.—The more important minerals worked in Greece at

have been in active operation within historic times.

Movements along the main fracture lines still take place, for Greece is one of the most seismically active countries in the world. In comparison for its area the Grecian peninsula experiences four times as many earthquake shocks of the highest intensity as Italy, while there are nearly seven times as many in comparison with a similar area in Japan. The main movements within historic times have taken

the present day include magnesite, emery, and the ores of lead, zinc, chromium, iron, and manganese. The working of emery constitutes a State monopoly, but the remainder are worked by private companies. The earliest records of any mining refer to the Phœnicians who originally worked the rich ore deposits of Laurion in Attica, of Thrace and Thasos, and of many of the Ægean islands. There is also every indication that for many centuries afterwards the mining industry continued to be of

considerable importance and that it only finally ceased with the Turkish conquest.

Modern Greek mining dates from the middle of the last century, when the rich slags of the ancient Laurion workings were purchased and resmelted by a French mining concession. The present Greek Mining Law dates from 1861, and within the following twenty years several hundred concessions were granted for working a variety of mineral products.

Unsettled political conditions have for the past forty years proved a deterrent to extensive developments, except in isolated instances. Several English and French mining companies have, however, been in active operation for many years, in some cases with marked success. The large areas incorporated within the Greek republic in recent years are believed to contain considerable mineral wealth, and an attempt has been made in this article to give a somewhat comprehensive account of the mineral resources of present-day Greece.

Coal and Lignite.—The fuel resources of Greece are comparatively small, and the absence of a good native coal supply has hitherto prevented any extensive industrial developments. The Greek coals all consist of low-grade lignites belonging to the Tertiary or Quaternary formations; they have a relatively low heating power and, owing to their tendency to crumble, can stand neither transport nor storage. Being in a southerly latitude there is not a great demand for coal for domestic consumption, and the few industries working in Greece usually employ an admixture of British coal with the home product. In this respect Greece compares unfavourably with the neighbouring states of Bulgaria and Yugoslavia. The annual production of lignite in Greece is under 200,000 tons or about one-fifth that of Bulgaria and less than one-twelfth that of Yugoslavia. Prior to the European War only about 20,000 tons of brown coal were obtained annually in Greece. At that time, however, a great effort was made to increase the output of the local product, but the hope that this might relieve somewhat the large amounts of coal imported has not yet materialized. The import of coal from abroad is annually increasing in amount and within recent years this has amounted to over 600,000 tons annually. Of this total about 90% comes from Great Britain, and the remainder from the United States, Germany, and Turkey. The quantity imported from Great Britain during the first six months of 1928 amounted to 323,652 tons.

At the present time there are about twenty lignite mines in Greece, but they are all comparatively small undertakings. The principal mines are in Central Eubœa and Western Attica. This area produces a much greater amount of brown coal than anywhere else.

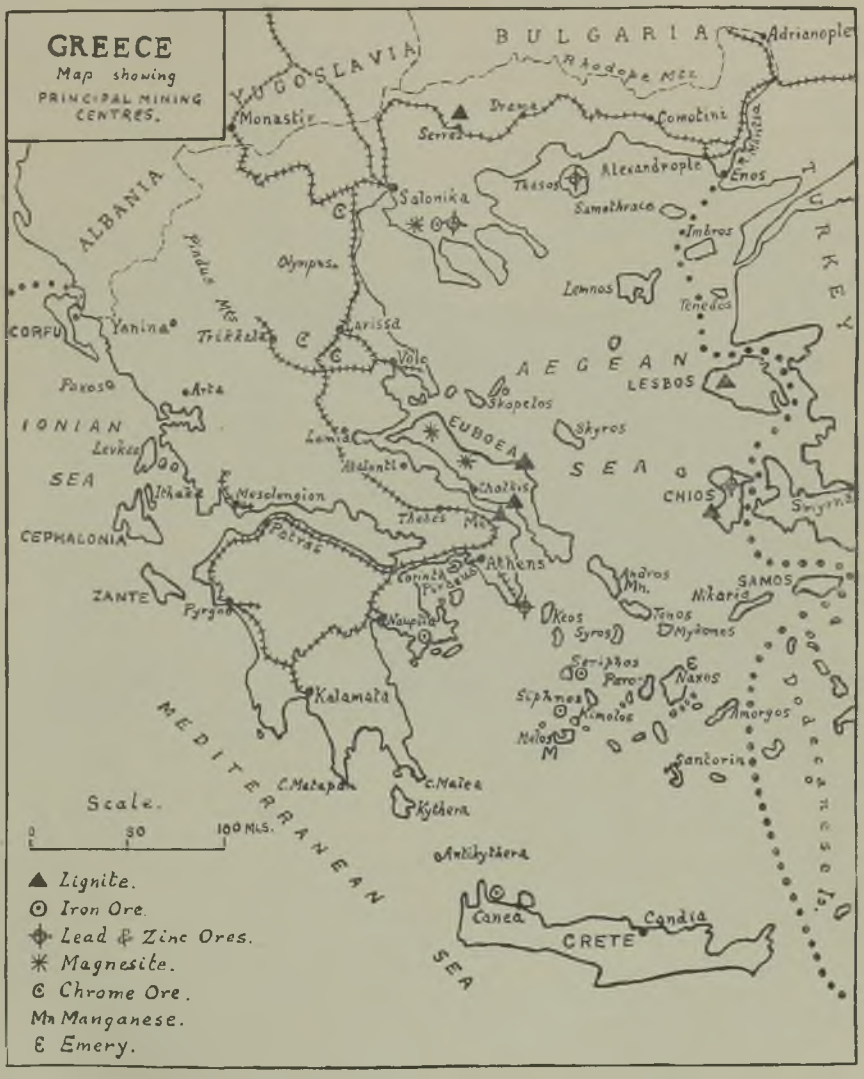
The village of Oropos on the west coast of the Gulf of Euripus and thirty miles north of Athens is the centre of the brown coal industry in Attica. About seven hundred miners in all are employed in this district. The largest mine at Oropos has an annual production of about 30,000 tons while a smaller mine adjoining it produces about 2,000 tons annually. Three miles south-east of Oropos is the Milessi mine with a yearly output of 15,000 tons, while two small shallow workings at Malakessa produce under 1,000 tons a year. Malakessa is a station on the Athens-Salonika railway; and a light railway, nine miles in length, has been built to connect the Oropos mines with the main railway at Malakessa. In addition there is also a small harbour at Oropos where the lignite can be transferred into lighters and transhipped.

On the island of Eubœa there are three centres of the lignite industry, and of these the most important is that of Aliveri on the west coast directly opposite to the extensive workings at Oropos in Attica. The Aliveri mines have an annual production of 22,000 tons. They are two miles inland, but a light railway connects them with the port of Skala Aliverion. On the east coast of Eubœa there are two lignite mines near Koumi, one of which is leased to a French company and the other to a Greek syndicate. Both workings are about five miles from the coast, and the French mine is connected with the shore by means of an aerial ropeway, while a light railroad serves the Greek concession. The total annual production at Koumi is about 18,000 tons. The other mine in Eubœa is at Psachna, to the north of Chalcis, and is quite small. All the brown coal workings in Eubœa are close to the sea, and the lignite is mainly forwarded by boat to the Piraeus and Athens districts.

The other localities in which brown coal is worked are widely scattered throughout Greece. Thus at Megara in Western Attica, 26 miles west of Athens, there is a small lignite

mine with an annual output of about 2,000 tons supplying local requirements. In a similar manner there are two small mines in the Western Peloponnesus. One of these is at Koroni, in the extreme south of Greece, producing in some years as much as 7,000 tons; while a smaller one is worked at Brouma, seven miles east of Pyrgos, in the centre of the currant industry. In the Plain of Thessaly in Northern Greece large areas of lignite-bearing formations occur and these are worked on a very small scale in two places. One of these is at Dranista, thirty-four miles north of Lamia, and the other at Pasha in the vicinity of Larissa.

The only area in Greek Macedonia where lignite is being mined is in the Serres district. Here there are three small mines supplying purely local requirements, and with a total annual output of 10,000 tons. Lignite is also being worked on some of the larger islands in the Ægean, the principal workings being on Lesbos (or Mytilene) and Chios.



IRON ORES.—Comparatively speaking, Greece is fairly rich in iron ores and in the estimates made for the International Geological Congress at Stockholm in 1910 the actual iron-ore reserves for "Old" Greece are stated to be 100 million tons, with an estimated iron content of 45 million tons. In the Cyclades, on the Khalkidike

peninsula, and in Attica there are extensive deposits, but the absence of a suitable native fuel for smelting has hitherto prevented the development of a local iron industry. The ore is exported principally to Great Britain, America, and Germany, and the prosperity of the iron-ore industry in Greece is consequently dependent on low freights and the relative prosperity of the iron industry in those countries. The amount mined annually varies considerably; in some recent years as much as half a million tons have been exported; while in less prosperous years, less than one tenth of that amount has been mined.

There are at the present time about fifteen iron-ore mines in active operation, and of these the more important are those on the island of Seriphos and at Izvoron on the Khalkidike peninsula.

The bulk of the red and brown iron ores of the numerous Ægean districts occur as large lens-shaped masses in massive limestone. Those of the island of Seriphos were worked by the ancients, and in 1869 were reopened by a Greek company who endeavoured unsuccessfully to smelt the ores with lignite from Koumi in Eubœa. In 1880 the majority of the mines were taken over by a French syndicate and greatly extended. Within the next twenty years upwards of two million tons of high-grade iron ore were exported, while in recent years the annual production has averaged 180,000 tons.

Among other islands in the Cyclades where iron ore has been worked in the past are Siphnos, Syra, Kythnos (or Thermia), Keos (or Zea), Melos, Andros, and Kimolos. The mines at Capsalo at the southern end of the island of Siphnos in pre-war years sometimes yielded as much as 14,000 tons of iron ore annually. On Syra there are five principal mines, formerly worked by an Austrian company, but these are now standing.

There are several small mines on the island of Kythnos which have not been worked for many years; two of the more important are close to the port of St. Stephanos, while near Port Irene is another iron-ore mine in disuse.

Iron ores are being worked on a small scale on the island of Nikaria, while on Crete there are important iron-ore deposits which are occasionally rich in manganese. At the extreme western end of the island and near Kissamo Bay these are being worked by two companies: the French Laurion Company and the Cretoise Mining Society. The island of Thasos is also stated to be rich in iron ores but none are at present being worked.

An important mining district covering an area of some two hundred square miles is that of Izvoron on the eastern slopes of the Cholomonda Mountains and on the peninsula of Khalkidike. This area lies some thirty to forty miles to the east of Salonika. Ancient disused workings, overgrown slag heaps, and abandoned shafts occur throughout the district, for in ancient times iron and silver-bearing lead ores appear to have been mined on a very extensive scale.

The Cassandra Mining Company, formed in 1893, and controlled principally by merchants of Salonika, has mined brown iron ore, iron pyrites, silver-bearing lead ore, chromite, antimony, and lignite in this district. In the first fifteen years, over a million tons of iron ore were exported. The main workings are close to Izvoron, and a light railway five miles long connects these with the port of Stratoniki on the Gulf of Erissos, where an iron pier has been built to facilitate transhipment. Less important iron-ore deposits occur at several places on the Cassandra peninsula. An aerial ropeway is projected to serve the numerous scattered workings.

There are several places to the north of Athens where iron ores are worked. The Grammatiko mines are on the slopes of Mount Hagios Elias and about four miles north of Marathon; a light railway ten miles long has been constructed to connect the workings with the small port of Limiona from whence the ore is exported. The annual production is about 10,000 tons.

In the province of Locris are two mines at Atalanti and one at Larimma which produce brown iron ore. Chrome iron ore in addition is produced at each of these mines.

At the extreme south-eastern end of the Greek peninsula, in the Vatika district, there is a small iron-ore mine with an annual production of one hundred tons.

Iron Pyrites.—The mines of Izvoron on the Khalkidike peninsula constitute the most important source of iron pyrites within the republic of Greece, the annual production of which averages 50,000 tons. Two of the more important mines are those of Polygyros and Molivoporgos at the head of the Gulf of Cassandra. At the southern

end of the Cassandra peninsula iron pyrites is also worked in the hills in the Paliouri district. The only other locality in which iron pyrites is being worked is at Hermione (or Kastri) at the southern end of the peninsula of Argolis in the Peloponnesus. Here the workings are being considerably extended, and an extensive washing and crushing plant is being installed.

Iron pyrites has been recorded from a large number of widely separated localities, and on the islands of Crete, Thasos, and Andros there appear to be deposits of some importance.

and a narrow-gauge railway connects the mines with a small pier where the ore is loaded. The dressed ore is mainly exported to England.

The Kokini mines on the island of Andros in recent years have produced upwards of 3,000 tons of ore annually.

At Grammatiko, near Marathon, and thirty miles north of Athens, there are iron mines (referred to above) which have produced considerable quantities of manganese ore in the past. In the extreme south-west of Greece, there are small disused manganese mines at Saratzas, four miles

THERA, THE PRINCIPAL TOWN IN THE ISLAND OF SANTORIN.
Built at the edge of precipitous cliffs composed of volcanic lava-flows and tuffs.

MANGANESE.—Manganese ores come principally from the islands of Melos and Andros, and also from the Grammatiko mines near Marathon. Thirty years ago the annual production in Greece was upwards of 15,000 tons, though within recent years it has fallen to less than one-tenth of that amount.

The Bani Milos mines on the island of Melos are close to Cape Vani. The manganese ore here occurs in Pliocene clays in the immediate vicinity of trachytic tuffs, from which presumably the ore solutions are derived. The main bed ranges from 2 ft. to 6 ft. in thickness, while the manganese content varies from 32 to 52%. The ore is exploited in large open-cast workings and washing is effected with sea-water. There is a small dressing plant, west of Koroni. Manganese ores have also been recorded from the islands of Paros, Siphnos, Seriphos, Kimolos, Keos, and Mykonos. The deposits on Mykonos have been investigated but are stated to be very siliceous. Small amounts of manganiferous iron ore are also produced at Laurion in Attica.

(*To be continued.*)

The Whitworth Society, which is composed of holders of Whitworth Scholarships and Exhibitions, held its sixth annual commemoration dinner at Holborn Restaurant on December 21, Mr. F. H. Livens, of Messrs. Ruston and Hornsby, Ltd., occupying the presidential chair. Mr. W. H. Fowler was elected president for the year 1929.

UNST AND ITS CHROMITE DEPOSITS

By C. STANSFIELD HITCHEN, A.R.C.Sc., B.Sc.

The author gives an account of the geology of the most northerly island of the Shetland group and of the occurrence of chromite and platinum metals.

Unst, the most northerly island of the Shetland group, is situated in the North Atlantic, some 200 miles west of the Norwegian coast, and is approximately on the same latitude as Bergen in Norway and Cape Farewell in Greenland. It remains, nevertheless, still well south of the Arctic Circle.

In fair weather, during the summer months, a visit to the island provides a short but enjoyable trip for the traveller who has a liking for the sea ; the coastal scenery of Shetland is magnificent and compensates in some measure for the bareness and uninteresting appearance of its interior where expanses of moorland and peat-bog, devoid of tree or shrub, meet the eye in every direction. Ronas Hill, on the island of Mainland, attains an altitude of 1,400 ft., and Saxavord in Unst, 938 ft. Most of the land forming the islands is, however, much below this level and rises from 200 to 600 ft. above the sea, which it frequently meets abruptly forming precipitous cliffs. In few places are the effects of marine denudation more readily seen than in Shetland, and especially is this true of its western coasts. In one place on Mainland, great boulders, weighing several hundredweight, have been hurled over a cliff 80 ft. in height, and wherever weak points in the strata or low-lying valleys have occurred, the sea has made a deep incision forming in the case of the latter " Voes " or Fjords, some of which are several miles in length and intersect the more elevated parts of the islands in such a way that few places are more than three miles from the sea.

The journey to Unst is not a direct one. Boats leave Aberdeen twice a week for Lerwick, the principal town of Shetland, and the traveller must then proceed by a small coasting vessel which plies between Lerwick and the more northerly islands. The direct passage from Aberdeen to Lerwick occupies only about 18 hours, if normal seas and weather prevail, but may take several days in the stormy seas which not infrequently occur during the winter months. Even in summer the sea is rarely calm, being incessantly agitated by tidal phenomena which are prone to affect this part of the ocean in particular. Unst lies about a day's journey from Lerwick, and it is to this latter island that we must henceforth more closely confine our attention.

GEOLOGY AND TOPOGRAPHY.—From the remarks made above it will be apparent that there is ample justification for discussing these two subjects conjointly, for where intense marine denudation, coupled with ordinary denudation, acts upon a land mass composed of many varying types of rocks, the scenery must, in the course of ages, be affected by such action and bear direct relation to the geological structure of the country.

Unst, in common with the remainder of Shetland, has not yet been officially mapped by the officers of the Geological Survey, but the late Professor Heddle, during his study of the mineralogy of the island,[1] prepared, both from his own observations and from the earlier work of others, a geological map which, although presenting no great detail, is usually considered to be fairly accurate. The map here reproduced in Fig. 1 is essentially that of Heddle, to which additions have been made for the purpose of this account. On the west, a ridge of gneiss traverses the island from north to south for a distance of about 11 miles, forming the core of a crumpled anticline, and acting as a barrier against the Atlantic. The coast is here much indented, and altogether void of habitation. It held little charm for Heddle, who wrote of it as follows : " The gneiss . . . forms a cliffy bulwark against the western ocean. This seems never to repose peacefully at its feet, but to be unceasingly scathing and grinding among the rocks of a shore, which, for ruggedness and absolute repulsiveness of appearance, can have few equals."

The gneiss composing this western ridge is highly micaceous and contains kyanite, garnet, and locally staurolite, although somewhat deficient in felspar, much of which has suffered conversion to muscovite mica.

[1] Publication of Prof. Heddle's work on the mineralogy of Shetland commenced in the *Mineralogical Magazine* for 1876; the field observations were, however, carried out as long ago as 1845.

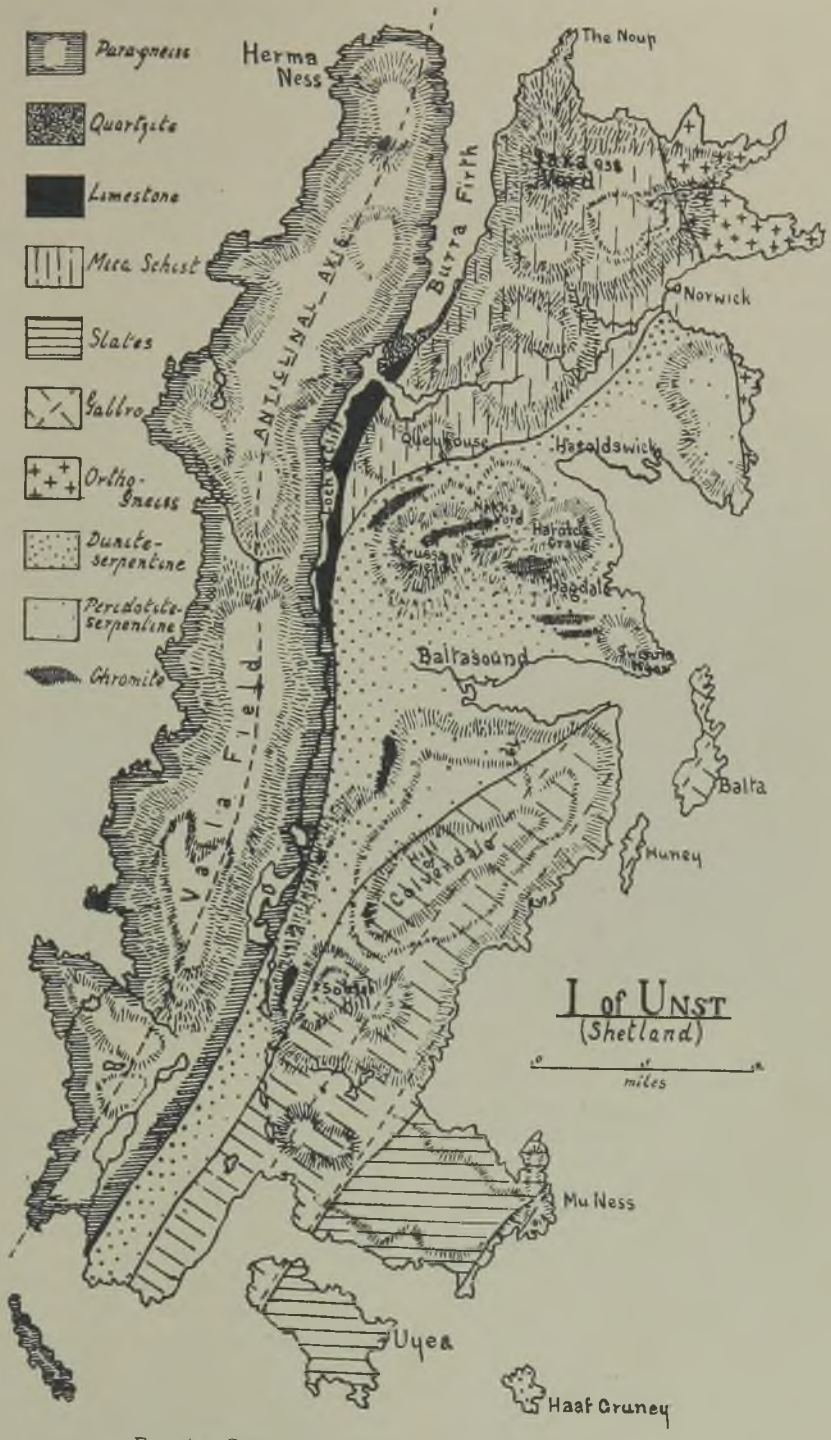


FIG. 1.—GEOLOGICAL MAP OF UNST, SHETLAND ISLES.

It is doubtless of pre-Caledonian age, as indeed are all the rocks of the island. The gneissose ridge slopes away fairly steeply on the east, and is here flanked by a bed of limestone which, having suffered considerable denudation, forms the floor of a valley in which are situated two freshwater lochs, the larger of the two being some three miles in length, but very narrow. At its northern extremity the limestone is underlain by a quartzose mica-schist, which appears to have stemmed the encroachment of the sea along the Voe of Burrafirth. Travelling still eastwards the land rises again, for the most part fairly steeply, from the central trough or depression as the outcrops of schist, gabbro, and serpentine are approached. The north-eastern portion of the island is characterized by comparatively lofty hills and bold headlands, one such hill (Saxavord) rising nearly 1,000 ft. above the surrounding ocean and presenting a magnificent spectacle. The rock outcropping here is a compact variety of mica-schist, extremely resistant to denudation.

The main body of serpentine, with which we shall be more closely concerned anon, lies to the south of this elevated outcrop of schist, and occupies the centre of the eastern side of the island; a narrow arm, however, continues southwards, flanking the gneiss, until the southern coastline is reached. The outcrop of serpentine, covering about 10 square miles, presents the usual characteristics of such rocks; a serrated appearance is observed here and there, but it has mostly been obliterated by the intense glaciation to which Unst, and Shetland generally, were subject at a comparatively recent period. The serpentine weathers to a rusty brown colour, and as it supports very little vegetation anywhere and frequently none in exposed places, the appearance of the land here presents an exceptionally bleak and dismal aspect. A range of low hills lie on the serpentine outcrop to the north of Baltasound, one of which is reputed to be the burial place of the once-mighty Harold Haarfagr, who subdued the islands during the ninth century; another bears the remains of three stone circles of still more remote origin.

The accompanying photograph (Fig. 2) serves not only to give some idea of the inland scenery of the island, but also helps to illustrate some of the remarks made above in connection with the topography. It was taken from the summit of the ridge of gneiss, and one is looking in a northerly direction towards the hill of Saxavord, which is seen on the horizon. The central depression, carrying the Loch of Cliff, is to be seen immediately above the peat-stacks in the centre of the foreground, while the low hills on the right form part of the serpentine outcrop. The distinctly glaciated contours of the hills are also fairly well exhibited.

South of the outcrop of serpentine lies that of the gabbro which, in conjunction with a series of schists and slates of doubtful affinities, forms the south-eastern section. The gabbro is of the finer grained variety, extremely tough, and consists almost entirely of labradorite and diallage.

The island of Balta, composed chiefly of this latter rock, is seen upon the map lying east of the village of Baltasound, and although only one mile in length is so situated as to convert the Voe of Baltasound into a fine natural harbour, affording, as it does, protection from easterly gales. Balta, although small, contains much to interest both the mineralogist and antiquary. Its eastern cliffs have suffered considerably from the effect of the waves and are cut into deep clefts or "geos", in which are exposed veins of amphibole-asbestos of excellent quality, but this unfortunately does not occur in sufficient quantity to warrant commercial exploitation. In association with these veins of asbestos occur albite-zoisite veins containing large crystals of diallage. These two types of veins appear to represent later extrusions of the gabbro-magma and to bear the same relations to it as do pegmatites to a granite. Balta has apparently only recently (that is, geologically speaking) become an island, for the stone dykes, dividing the fields in Unst, can be traced across to Balta; and, again, it is unlikely that the ancient inhabitants would build a fortress, the ruins of which (Fig. 3) can still be seen upon its eastern cliff, upon an island so small that it could be easily surrounded by the craft of an invader. Be that as it may, however, the island is again threatening to split in two, for in one place it is only 30 yards wide!

Little remains to add to this brief topographical account of Unst before considering the chromite deposits. Mention might be made, however, of an intrusive rock which is in contact with the mica-schist in the north-east of the island, and which forms a long promontory running out to sea for about a mile. It consists of

large pink phenochrysts of felspar, set in a dark matrix. Heddle originally described this rock as a " porphyritic syenite," but it is now regarded as an ortho-gneiss, possibly derived from a syenite; the difference is, of course, merely one of the superimposed effect of dynamic metamorphism.

The Serpentine and Chromite Deposits. —The gneiss, as already mentioned, forms the core of an ancient anticline and, in conjunction with the schists, etc., forms a rock-series of pre-Caledonian age, although the mutual relation of the sedimentary members is not always apparent. Heddle, writing in 1876, states that the rocks of Unst were regarded as a metamorphic series assigned to the Lower Silurian epoch. More modern views, however, favour the opinion that the gneiss of the west is pre-Cambrian in age. Prior to Old Red Sandstone times, this rock series was intruded into by magmas ranging in composition from granitic to ultrabasic; that this was so is demonstrated by the fact that rolled pebbles of these igneous rocks, together with those of the metamorphic rocks, are found in the basal conglomerates of the Old Red series which occur in other parts of Shetland.

The serpentine, carrying the chromite, formed part of this early intrusive series and has recently formed the subject of a comprehensive paper by Dr. Coles Phillips.[1] In this he shows that the serpentine is not, as was formerly supposed, a metamorphosed form of the gabbro, but is a separate intrusion, exhibiting certain variations. Along its entire western border it presents the characters of an altered dunite (olivine rock), a certain amount of olivine still remaining unchanged. This variety, however, is not confined to the edges of the intrusion, for a large patch is seen upon the map lying north of Baltasound, forming the hill range already mentioned. With the exception of this patch of dunite, the serpentine of the east has more the character of peridotite-serpentine, for pseudomorphs of a rhombic pyroxene appear here, and on Swinnaness enstatite constitutes a large portion of the rock. Chromite is not found in any quantity in these latter types, and seems to be confined to the dunite-serpentine, which, besides containing large local segregations, also exhibits, almost everywhere, small chromite crystals set in its dark green matrix.

Fig. 2.—Saxavord from the Western Ridge.

The commercially workable deposits of chromite fall into two classes, namely large local segregations, or " pots ", and deposits of a vein-like character which wind tortuously through the serpentine, apparently without relation to anything as regards direction.

[1] *Quarterly Journal Geological Society*, Vol. 83, 1927, pp. 622 et seq.

Although occurring more particularly in association with the dark green dunite-serpentine, it should be mentioned that both types of chromite deposit are embedded in, or fringed by, a lighter variety of serpentine which is often of a yellow-green or greenish-white colour. The distribution of the larger ore-bodies will be readily seen from a glance at the map, on which they are represented by shaded areas, and it will be immediately noticed that they tend to form lenticular masses which, as regards position, bear little relation to the margin of the serpentine. According to theory, one would expect the crystals of earlier formation to migrate towards the borders of a consolidating magma. Dr. Harker demonstrated this as long ago as 1898 in connection with the gabbro of Carrock Fell in Cumberland, the outer portions of which are rich in the earlier products of crystallization. With chromite-bearing rocks, however, this rule apparently cannot be relied upon, for Unst is not the only locality which exibits this haphazard distribution of the larger ore-bodies. Regarding the size of these major segregations they are, or rather were, of considerable dimensions. Heddle states that the large "pot" in Hagdale was 86 ft. in depth and 60 ft. wide. A quarry near Queyhouse indicates, according to Phillips, a former mass 60 yards long and of unknown depth, and there are several more of similar dimensions.

The smaller vein-like occurrences, already alluded to, are frequently observed in the hillsides north of Baltasound, where trials have been made upon them. The ore exposed in these trials is of the banded variety and stringers of it wind through the serpentine and occasionally several of these fuse to form a small nucleus. This latter mode of occurrence is illustrated in Fig. 4, and doubtless represents the chromite in the act of segregating, a process, which was in this case cut short by the consolidation of the magma. As far as I could gather, it was found unprofitable to work such ore under the prevailing conditions.

Coming now to a consideration of the mineral itself rather than its situation and form in bulk, we find that it was one of the earlier substances to crystallize out from the magma and is consequently associated with other early accessory minerals, such as pentlandite, specks of which can be frequently seen in most specimens of the ore. Chromite, being a member of the spinel isomorphous group, is liable to vary considerably as regards its Cr_2O_3 content. Pure chromite, contains some 68% Cr_2O_3, mitchellite (magnochromite) 40%, while picotite yields only 8–10% and apparently the percentage of chromic oxide may vary between such limits in different samples, all of which can appear similar in hand specimens. Heddle remarks, regarding the Sobul Hill quarries, Unst: "The immense amount of working . . . the size of the water-filled quarries and the quantity of stacked and unsaleable ore prove that if chromite does not pass by insensible gradations into picotite, the average exploiter is at least unable to discriminate between the two minerals." Analyses which

Fig. 3.—Island of Balsa, with Castle Ruins on Right.

he made of the richer ore afforded the following figures :—

Analysis I

FeO	MgO	Al_2O_3	Cr_2O_3	SiO_2	CaO
%	%	%	%	%	%
17·52	—	23·74	44·56	11·09	1·29

Analysis II

18·08	16·61	16·55	48·03	0·83	—

The chromite of Unst, therefore, although comparable with that found in other localities, falls considerably short of pure chromite as regards its chromic oxide content.

cracks (Fig. 5). Dresser [1] has noticed the same phenomenon in chromite from Canada and has shown that the outer opaque portion is richer in ferric iron, but poorer in chromic oxide, than the inner translucent chromite. Phillips rather favours the view that this black material was grown upon the earlier formed chromite during crystallization. After a brief examination, however, I was inclined to regard it as due to alteration of some kind. It remains nevertheless a mystery ; one fact is at least certain, namely, that the greater

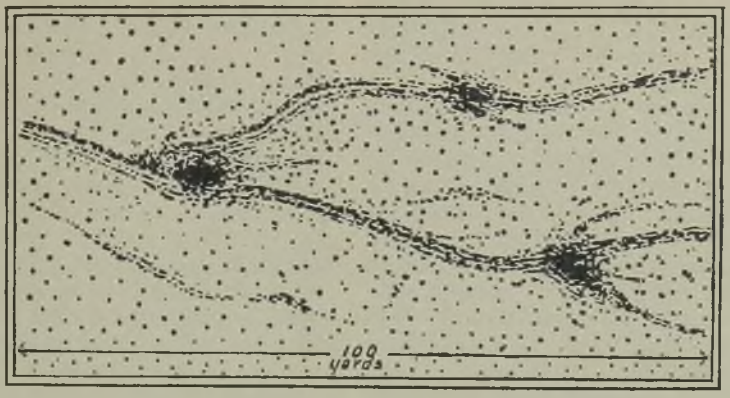


Fig. 4.—Stringers of Chromite in the Serpentine.

Fig. 5.—Chromite Crystals in Micro-Section.

Examined in thin sections under the microscope, the spinel is seen to be frequently idiomorphic as, indeed, would be expected from its early crystallization. The centre of each crystal appears a deep yellow-brown by transmitted light and is surrounded by a black opaque border which often penetrates to the centre along what seem to be incipient the development of black material the lower will the chromium content prove.

Associated with the chromite, especially at the Nikka Vord quarries, is the beautiful chrome-chlorite, kämmererite, which occurs along fissures in the ore-bodies. It is found in crystals of a rich purple-red colour which may attain as much as half-an-inch in length and greatly resemble mica in their form and perfect basal cleavage. Sometimes the mineral occurs in the massive condition in which form it can be cut and polished for ornamental purposes. The formation of kämmererite was doubtless due to the action of magmatic water escaping from the mass during the final stages of consolidation. Another mineral of great beauty is the chrome-garnet, uvarovite, which occurs very rarely in small dodecahedra of a bright emerald-green colour. Mr. Wm. Sandison, the discoverer of this mineral in Unst, has, I believe, only succeeded in obtaining about a dozen specimens.

On Swinnaness and also in the cliffs on the south of Haroldswick Bay are exposed veins of brucite of the finest quality I have

[1] Serpentine and Associated Rocks of Southern Quebec. Mem. Geological Survey of Canada, 22.

ever seen, and in the latter locality pieces of native copper have been occasionally found. Although unsuccessful in finding any copper myself, I frequently saw indications of its presence both here and in a geo on the south of Balta Island where the rocks were abundantly copper-stained.

Working of the Deposits.—The discovery of chromite in Unst was made about the year 1818 by Hibbert, who published an early work dealing with the topography and geology of Shetland. The discovery was certainly prior to 1820, for mention of "Considerable masses of chromite in the island of Unst" is made in Jameson's "Mineralogy" which was published in this latter year.

Working appears to have commenced almost immediately and thenceforth large quantities of ore were shipped and employed in the manufacture of pigments such as chrome-yellow, etc. In early days, the great bulk of the ore came from the large quarry in Hagdale, but on reaching a depth of 86 ft., the ore gave out and when Heddle visited the island about the year 1845 attention was being given to two smaller segregations nearby. According to Mr. Sandison, work progressed until about 1870 when, for some reason, it ceased rather abruptly. In former times, as at the present day, the method of working the ore was always by means of open quarries which were sunk on the ore-body and I never saw indication of any other method having been employed.

Some time prior to 1900 the old plant was sold, some being shipped and the remainder being purchased by Mr. Sandison who, for a number of years, worked several of the old quarries intermittently. The export of ore during this period was not very great and the ore itself was of low grade. In common with many other British mining concessions, the chromite industry experienced renewed activity as a result of the war. Exports increased yearly and were continued after the armistice, a maximum production being recorded in 1920 when 900 tons of concentrate were shipped.

During the last few years a new mill has been erected near the old quarry in Hagdale for the more immediate purpose of re-working the old dumps, but the market for chrome ore slumped soon after its erection and the output from it has consequently not been great, amounting only to 1,650 tons of concentrates. The mill has a capacity of 20 tons per 10 hour day, and milling follows fairly orthodox lines. The ore is crushed by a stonebreaker and two pairs of rolls, and separation is accomplished by jig and vanning tables; power is supplied by a Tangye gas engine working on producer-gas.

As there are no suitable streams running off the serpentine outcrop near the mill, the adequate supply of water has proved somewhat of a problem, but this has been overcome, at least for the present, by electrically pumping water from the quarry which is flooded to within 15 ft. of the brink.

The ore crushed during the last few years was mostly of low grade, containing some 10% Cr_2O_3, and concentration was not carried beyond 32–34%, as this quality found a ready sale for the manufacture of furnace linings and chrome bricks.

Platinum, etc.—The paragenesis displayed in Unst must naturally promote speculation as to the presence of platinum and its allied metals. Several years ago samples of concentrated ore from the vanning tables were taken and assayed for platinum, with the result that 1 dwt. of platinum and allied metals per ton was found, and the presence of some palladium, iridium, and osmiridium was also established. More recently, I have had an assay carried out on some chrome concentrates which I collected from the vanning tables during my visit in 1927, but the result for this material is much lower, amounting to only 4·8 grains of platinum and platinum metals per long ton. Although evidence is not complete one might, however, feel inclined to regard platinum as being generally present in the chrome concentrates from this area, but in proportions which vary very considerably.

Conclusion.—In concluding this short account of Unst and its chromite field, I desire to express my thanks to Mr. C. G. Sandison, of Baltasound, who has kindly forwarded me information and figures relative to the milling, etc.

The Centenary of the birth of Sir Joseph W. Swan, noted in the October Magazine, was celebrated by a lecture, at the Institution of Electrical Engineers on December 20, on his work as a pioneer of the electric incandescent lamp, delivered by Mr. James Swinburne, who was associated with him in his early experiments. The lecture was accompanied by an exhibition of Swan's early lamps and of an autograph account of the invention.

HYDROGEN ASSAY FOR TIN ORE
AS EMPLOYED AT PENPOLL

By WILLIAM H. R. ALLEN,
General Manager of the Penpoll Tin Smelting Co., Ltd.

The author gives an account of the assay methods employed at the Penpoll tin smelter

Standard Solution :—
700 grammes iodine
28 lb. potassium iodide
40 litres water.
(This concentration of iodide is used so as to inhibit the effect of titanium, which interferes when less iodide is used.)

Starch Indicator :—Mix 5 grammes of potato starch with a little cold water, add 70 c.c. boiling water, boil for a minute, and pour into a solution of zinc chloride in 20 c.c. water and 40 c.c. HCl.

Method for Clean Ores.—Weigh 0·5 gramme of agated ore into a porcelain crucible (platinum shape 30 m.m. diameter) containing 0·6 grm pure CaO. Mix intimately with a brass wire rod and brush the rod with a camel-hair brush. Reduce in hydrogen for 20 minutes at a red heat over a Meker or other suitable burner. The hydrogen is passed into the crucible through a Rose crucible leading tube with cover and sufficient gas should be used to allow of a small flame of burning hydrogen to be visible round the lid. Cool while the hydrogen is still passing and if the hydrogen flame persists, blow it out. After cooling place the crucible in a conical beaker (400 c.c.), add a few drops of water to slake the lime and then 30 c.c. of concentrated HCl. Heat the beaker gently till all metal has dissolved. Remove the crucible with a bent glass rod and wash with 5% HCl. Wash the contents of the beaker into a 1,000 c.c. flask. The solution should now have a bulk of about 100 c.c.

Now add 2·5 grammes of pure aluminium ribbon and lay the flask on its side in water until action has almost ceased (about ½ an hour). The sponge of reduced tin and remaining aluminium are then redissolved by adding 40 c.c. concentrated HCl and boiling on a hot plate.

During boiling, the neck of the flask is closed by a rubber bung carrying a short tube with a bulb blown in it above the bung and the lower end cut off obliquely. The upper end of the tube is slightly drawn out. On completion of solution the flask is connected to a CO_2 apparatus, by slipping the delivery tube from the latter over the drawn-out tube in the bung of the flask, at the same instant removing the flask from the hot plate. This ensures the flask being filled with CO_2. Cool in a water trough.

Standardize the iodine solution with 0·5 gramme of pure tin dissolved and treated with aluminium ribbon as above. Titrate the assay solution with the standard solution, using a few c.c. of the starch solution as indicator. If the standard solution is made according to the directions given about 61·5 c.c. = 0·5 gramme Sn.

Treatment of Ores containing Tungsten and/or Antimony, Bismuth, Copper, and Arsenic.—These elements interfere with the assay and must be removed before titration. The ore is treated as before up to the stage where the metal is dissolved after the hydrogen reduction.

The crucible is removed as before, but is washed with 50% HCl instead of 5% HCl. A little $KClO_3$ is added to the solution to oxidize and dissolve the antimony. The solution is cooled, and 30 c.c. of cold water added. This gives an acid strength of 50%. 1 grm of reduced iron is added, and the solution allowed to stand 20–30 minutes. This removes W, Sb, Bi, As, and Cu from solution.

The iron must be free from sulphur, and the ordinary ferrum reductum is not satisfactory. Merck's iron reduced by hydrogen is guaranteed free from sulphur and is the only satisfactory brand for this purpose.

The solution is then filtered into the flask through a 9 cm. (C. S. and S. No. 597) paper. The beaker is washed twice, and the paper three times with 5% HCl. In cases where much antimony is present, the precipitate is washed only once on the paper, and is then washed back into the beaker, dissolved in HCl and a little $KClO_3$ and reprecipitated. The solution is then treated with aluminium as before.

ORGANISMS AS GUIDES TO COPPER ORE

By CHARLES HENRY WHITE,
formerly Professor of Mining and Metallurgy at Harvard University

Copper is apparently a normal constituent of the tissues of both plants and animals. It is found in straw, hay, flour, meat, cheese, and eggs as well as in many marine forms.[1] It has been determined quantitatively in a large number of vegetables, fruits, and seeds, the content varying from one to seventeen milligrams per kilo.[2] Human blood serum contains from one to two milligrams per litre.[3] Slight additions of copper to that normally contained in the soil, experiment shows, promotes the growth of peas, wheat,[4] and Kentucky blue grass.[5] These and other researches indicate that it is not only a normal, but an essential, constituent of organic tissue. It is evident that the mere presence of copper in an organism does not indicate that the organism grew in proximity to copper ore, but only that soil everywhere, and the sea, contain copper, at least in traces.

While evidence tends to prove that copper is essential to the growth of organic tissue, it is well known that in more than minute doses the metal is a poison to both plants and animals. Appreciable amounts of copper in mineralized outcrops, therefore, inhibit plant growth and make conspicuous the copper-bearing areas in forested regions.[6] In the Belgian Congo such bare spots are reliable indicators of mineralized areas and have been " valuable aids in prospecting."[7]

Plants vary in their tolerance to this poison. Bateman and Wells [8] in the study of the flora of a copper-tailing region found most of the flora destroyed. Among the larger shrubs, only the wild rose appeared to flourish. In Africa, Guillemain found an azure blue flower to be confined to the places in which copper occurs, growing only on outcrops, slag dumps, and ore piles.[1]

Plants having roots that spread out near the surface might survive while others that send their roots deeper to less leached soil would perish. Possibly this explains the persistence of *polycarpea* on copper outcrops in Australia. This small herb, called " copper grass " by the prospectors, is regarded by them as a reliable guide to ore, and the plant is mentioned in this connexion, and with apparent approval, by Government geologists in official reports.[2]

The owner of a claim on one occasion called my attention to the vigorous growth of wattle (acacia) on his prospect, which, he said, was a sure sign of copper. His opinion, however, was probably a unique and sudden inspiration, since there was little else on the ground to which he could appeal.

Insects and quadrupeds that burrow in the ground, like ants and badgers, have been of great assistance in ore discovery, by bringing samples to the surface. Singular as it may seem, there was hope at one time that a bird might assist in leading man to outcrops of copper ore, as bees in the forest lead him to stores of wild honey. The plantain eaters of Africa, *Musophagidae* (Tuoracoes), have notable amounts of copper in the colouring matter of the large wing feathers. These birds are related to the cuckoos ; but their general colouring, which is usually from grey-green to blue-green, and their conspicuous crest, suggest the blue jay. Most species of Tuoracoes, however, are much larger than the blue jay. Eighteen of the twenty-five species of plantain eaters have a considerable part of the pen feathers coloured deep crimson. This organic colouring matter *turacin*, because of its considerable content of copper and its solubility in water, has excited much interest.

Professor Church,[3] of Oxford, through the

[1] Rose, William C., and Meyer Bodansky, *J. Biol. Chem.*, 44, 99–112, 1920.

[2] Guerithault, B., *Compt. Rend.*, 171, 196–198, 1920.

[3] Warburg, Otto, *Klein. Wochschr.*, 6, 1094–5, 1927.

[4] Maquenne, L., and E. Demoussy. *Compt. Rend.*, 170, 1542–45, 1920.

[5] McHargue, J. S. *Ind. Eng. Chem.*, 19, 274–6, 1927.

[6] Outcrops of nickel ore also produce a similar effect.

[7] Ball, Sydney H., and Millard K. Shaler. *Economic Geology*, 9, 619, 1914.

[8] Bateman, W. G., and Lansing S. Wells, *Jour. Am. Chem. Soc.*, 39, 811–819, 1917.

[1] *Economic Geology*, 9, 620, 1914.

[2] Ball, Lionel C. Queensland Geol. Survey Pub. No. 215, pp. 71, 221, 228, 1908.

[3] Church, A. H. Student and Intellectual Observer. Vol. 1, pp. 161–168, 1868 ; Phil. Trans. 1869, pp. 627–636 ; 1892. A. pp. 511–530.

aid of a grant from the Royal Society, studied this peculiar colouring matter for a period covering more than twenty years. Perhaps his discovery of greatest interest concerning it was that it contains 7% copper. Specimens of *turacin* are on exhibition, with the Tuoracoes, in the British Museum of Natural History. It seems a logical inference that the source of the copper contained in *turacin* is the ore outcrops where the plantain eaters most conveniently find their gravel supply. If this inference be correct, the search for outcrops would best begin by observing the flight of these crimson-winged birds. Professor Church expressed the opinion that the source of the copper is not the gravel of the outcrops but the plantains on which the birds feed, since he found in this fruit small quantities of copper. Apparently he did not test the gravel from the crops of the birds for copper ; but even if malachite were present in the crops, prospectors would hardly find it practicable to use these birds as guides, since their habitat covers the whole of Africa south of the Sahara.

The remaining organism to be mentioned in this connexion, and the one to which I would particularly direct attention, has no relation whatever to copper deposits except that the green colouration it gives to the rock on which it grows is sometimes mistaken for an ore mineral. It is an alga of the genus *Pleurococcus*.[1] I have found it in widely separated arid regions, even in the tropics where the ground temperature is often above 140° F. I have not found it on the exposed surface of the rock, but it comes almost to the surface in narrow seams and joints, and when the rock is broken it is exposed as a green coating somewhat resembling malachite " stain " on the walls of the small cracks. With a good lens its true nature should be evident to the trained eye, and it would seem incredible that this innocent " mimicry " could be a party in victimizing the directors of a mining company.

On several occasions recently, and by different persons, I have had my attention directed to this alga as a " surface indication " of copper, and found in one instance that a drilling outfit had been sent nearly half way around the world to test a large area, where this organism was appealed to as one of the " evidences " of mineralization, and on a considerable part, the only evidence. While no one recognizing green alga in rock fractures would regard it as evidence of copper below, it should be stated that malachite " stain " in a similar environment, that is, on rock otherwise unaltered, is no better evidence of ore in the rock below than a vegetable growth.

Copper in solution in descending surface waters is often carried laterally far from its source and precipitated in small quantities in wholly unmineralized country rock. In such a position copper " stain "—as I have said elsewhere ,—[1] instead of being a guide to ore in the immediate vicinity, should be a danger signal to the prospector. In rare cases, such transported copper is precipitated in sufficient quantity to make an ore-body as the Black Warrior in Arizona ; but in these cases the rock has been intensely altered by long-continued action of the invading sulphate solutions.

[1] Determined for the writer by J. Ramsbottom of the British Museum of Natural History.

BOOK REVIEWS

Assimilation and Petrogenesis : Separation of Ores from Magmas. By JOHN STANSFIELD. Cloth, octavo, 197 pages, illustrated. Price 17s. 6d. Urbana, Illinois : Valley Publishing Co.

It is a great pleasure and honour to review a book that contains, as this volume does, a great deal of new and valuable information on such controversial subjects as the processes involved in the origin of rocks and on the separation of ores from magmas. This new information is based on the results of a long series of costly laboratory experiments carried out at the University of Illinois and at the School of Mines, Butte, Montana.

British geologists, handicapped by the fact that there is no geophysical laboratory in this country where costly experimental work could be undertaken in these subjects to which Teall and Harker contributed such valuable and inspiring information, will feel grateful to the author and to his financial supporters for placing at their disposal, within the compass of 197 pages, new data of first-rate scientific importance which throw considerable light on petrogenesis and the origin of some of the world's most important ore-bodies.

[1] *Eng. and Min. Jour.*, April 5, 1924.

Over a century ago experimental work was undertaken to produce minerals from pure chemicals, and the notable results that have been attained, especially during recent years at the Carnegie Institution of Washington, have enriched greatly our knowledge of mineralogy and have given most valuable information of the physico-chemical relations of minerals and melts. Experimental work with more complex solutions like rock magmas is a longer and more costly undertaking and hence has not, until recent years, received much attention, although so far back as 1798 James Hall, after melting basalt in a graphite crucible, obtained, by slow cooling, the crystalline minerals olivine and labradorite; and Vogt's notable work on industrial slag in 1882, and Fouqué and Levy's classic account in the same year of the synthesis of minerals and rocks, laid the foundation of important principles in the study of igneous rocks.

Part I of this volume gives the results obtained by melting powdered igneous rocks at temperatures of over 1,400° C. alone, and also when mixed with calcite, kaolin, quartz, magnetite, hematite, siderite, dolomite, magnesite, tremolite schists, bauxite, chromite, graphite, chalcocite, bornite, chalcopyrite, and the sulphides of iron, lead, and zinc.

The scope of these experiments will be appreciated from the fact that no fewer than 57 powdered igneous rocks, ranging from acid to ultrabasic, were separately mixed with calcite, melted at temperatures ranging from 1,400° to 1,500° C., and the resulting slow-cooled product examined microscopically; that 40 similar experiments were carried out with bauxite; and that seven different igneous rocks were mixed separately with the sulphide ores of copper, iron, lead, and zinc.

The assimilation hypotheses of rock magmas, as put forward by Teall, Harker, Bowen, Daly, and others, are discussed by the author in the light furnished by these experiments, and while he agrees with the possibility of assimilation of sedimentary and other materials by igneous magmas, he comes to the conclusion that in the important case of limestone it is doubtful if such a large proportion as the equivalent of 25% of the magma, as advocated by some geologists, has taken place in nature.

Part II consists of a detailed examination of the results of the individual experiments with rock and ore minerals, particular attention being devoted to the materials which separated from the melts and to the position they occupied in the solidified mass. An example will illustrate the interesting results obtained by the author when powdered basalt and chalcopyrite, in the ratio of 3 to 1, were heated to 1,410° C. and cooled slowly. "Bornite with a little chalcocite and native copper and a mass of iron inside it is at the centre of the base (of the cooled mass); a little chalcocite as small globules is on the sides."

From the consideration of the results of experimental melts of rock materials containing certain proportions of metals of oxide, or of sulphide, ores (evenly distributed before being subjected to heat), the author arrives at conclusions of the greatest interest as, for example, that the separation of metals, oxides, or sulphides from magma may take place rapidly if the conditions are favourable, and hence that ore-bodies may have formed in comparatively short periods of time; that sinking under the action of gravity is an important factor in the separation of certain minerals; and that ores may accumulate at the upper contact of an igneous intrusion by the action of gas bubbles, a process which W. H. Goodchild, in his classic articles in the MAGAZINE for 1918, described as "flotation of ores in magmas." It is gratifying to an admirer of Goodchild to find also that the results of these valuable experiments give undoubted support to his hypothesis that an important cause of the formation of vein-fractures is the differences of coefficient of expansion of separated minerals and silicates of the solidified magma, resulting in unequal contraction of ore and rocks, thus providing passages for the movement of the still liquid parts of ores and magmas.

The effect of temperature in controlling the products of magmatic consolidation is brought out very convincingly by the results of the experiments with mixtures of different kinds of igneous rocks and the sulphides of iron and copper. It was found, for example, that chalcopyrite gave way to bornite and bornite to chalcocite at high temperatures, and that chalcocite was stable at these temperatures and hence is to be regarded, except where it is of secondary origin, as a mineral of high temperature formation. In its relation to the theory of "flotation of ores in magma" it is particularly interesting to note that, in spite of its high density, lead sulphide was found, in these experiments,

to have a dominant tendency to upward rather than downward movement.

The book is well annotated and is illustrated by sixty clearly reproduced micro-photographs. The publishers have maintained the high standard that one has learnt to associate with scientific and technical books printed in the United States.

The author is to be heartily congratulated on producing a volume that is unique in many respects, not the least being that it contains more new experimental data on petrogenesis and the separation of ore minerals from magmas than anything that has hitherto been published.

WILLIAM R. JONES.

Nitroglycerine and Nitroglycerine Explosives. By PHOKION NAOUM, Ph.D.; translated by E. M. SYMMES, of the Hercules Powder Co. Cloth, octavo, 470 pages, illustrated. Price 31s. 6d. London: Bailliere, Tindall, and Cox.

This book is No. 1 of "The World-Wide Chemical Translation Series," edited by E. Emmet Reid, Professor of Organic Chemistry in the Johns Hopkins University. In an introductory note, which is dated October, 1923, the author states that plans had been made by several experts to issue a large comprehensive handbook of the entire technique of explosives, but, on difficulties being encountered, the author, to whom the section with which this volume deals had been entrusted, decided to issue his work as a special volume. He dares to hope, in the closing paragraph of the introduction, "that he has made a welcome contribution to the knowledge of an important branch of art, which may be of use to all who manufacture, test, or use explosives."

Let me assure him straight away that he has accomplished all that he set out to do. He is also extremely fortunate in his translator, Mr. E. M. Symmes, whose occasional footnotes are most illuminating and much to the point. Authors sometimes suffer very much at the hands of translators, but it is the reverse in this case. The diction is smooth, the right word is always found, and, unless one were told, it would be difficult to realize that a translation, and not an original, was being read.

There is a great dearth of books on explosives in English, and the present volume will indeed fill a want. With the index it runs to 469 pages and there are many most useful tables and woodcuts, so that it will form an excellent work of reference to those interested. But the number of such cannot possibly be great, for in Great Britain there are only four nitroglycerine plants, and other seven or eight in the Empire. Of course, on the Continent and in America there are many more, for both military and industrial explosives, but the whole world's annual output cannot be more than 100,000 tons. This, of course, means much more in the way of explosives.

The book is divided into three parts. Part I deals with nitroglycerine in a most comprehensive manner. Part II, probably the most important in the light of recent discoveries, is concerned with "homologues and related nitro esters," and Part III with "nitroglycerine explosives", which are legion. Generally speaking the omissions are few and comparatively unimportant, and considering the great secrecy with which explosive companies carried out their operations in the past one marvels at the completeness of the information. The reviewer recognizes, however, that the author was, and no doubt still is, in a most favourable position for obtaining information, as is also his translator. Nevertheless, one omission is very noticeable. In the chapter dealing with plant lay-out there is not one word about protection from lightning. In his young days, when the reviewer was very much worried about this subject, he went to Schlebusch for the latest ideas and thought he got them. The author is the director of the scientific laboratories of the Nobel Co. there. Later on the same subject took him to Wilmington, Delaware, where the translator has his headquarters, and again he came away with the same idea. But all these ideas were of no avail as events subsequently proved, so perhaps the author after all was wise in leaving this very difficult subject alone.

Only in one instance, the middle paragraph of page 6, has the translator failed. The reviewer, at any rate, cannot follow the idea meant to be conveyed. On page 19 the author states that di-nitro glycerine was still being used in Germany, notwithstanding the troublesome nature of its manufacture and its solubility in water. It never even caught on in British possessions. Then on page 60 he mentions that 150–250 kilos of glycerine is still the normal charge in Germany. One would have thought that, with the known

advantages gained by working larger charges, the Germans would have adopted them long ago. Chapter 5 is devoted to the problems connected with separation of the nitroglycerine from the refuse acids which are indeed an admixture of nitric and sulphuric acid, and in it the author brings out the fact that he invented a process which the reviewer adopted as soon as he heard of it, to the very great advantage of his company. Chapter 6 deals with purification, but the author says too little about the chemistry of this process.

In Chapter 11 the author mentions that in Germany it is customary to have the nitrator and separator under the one roof, and the reviewer himself favours this if the separator is of a particular type of which the author is apparently unaware. The particular apparatus which the reviewer has in view has now been in use with most satisfactory results for twenty years. With regard to piping and gutters, all that need be said is that the British practice is quite different from the German, but this has always been so. Chapter 17, on "the homologous nitric esters," will be considered by many to be the most interesting in the whole book, and there the author is very nearly, if not quite, up to date. The translator remarks in a footnote on page 250 that nitro sugar, notwithstanding its great drawbacks, is still in use in the United States. In Great Britain its manufacture, in the light of our knowledge, would not be tolerated.

Altogether there is little to criticize but much to praise in the book, and the author's remarks on "stabilizers" (incomplete if anything) and "insensitiveness" are very good indeed. Plenty of Englishmen could write such a book, but the reviewer knows none who would take the trouble to do so.

WM. CULLEN.

☛ 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.

LETTER TO THE EDITOR

Cubic Magnetite and Hematite

THE EDITOR:

SIR,—In the *Mineralogical Magazine* for 1903, vol. xiii, No. 62, pp. 351–352, I described minute cubes of magnetite from Upper Bunter Sands at Hinksford, near Stourbridge, and suggested that they were pseudomorphs after pyrite. Owing to the loss of the original specimen and failure on the part of other geologists to obtain more cubes of magnetite from this locality my description has been looked on, I believe, with a certain amount of suspicion, about which I do not complain. I have seen, for instance, a photograph of my old microscope preparation in Mr. Milner's "Introduction to Sedimentary Petrography" (Plate 16), obtained from Dr. H. H. Thomas, F.R.S., but no mention is made of the magnetite being present as cubes. I even began to doubt myself if I had seen cubes and not octahedra; but recently I have obtained a specimen in Malaya, in which black cubes occur, measuring on an average about one-third of a millimetre in diameter, and associated with pyrite crystals after which they are certainly pseudomorphs, showing in many cases the same striation of the faces. These cubes were found in a concentrate from bores put down near Serendah, Selangor, by Alluvial Tin (Malaya), Ltd., to whom I am indebted for information concerning the locality and a further supply of the mineral. The following is the mineral composition of the concentrate:—

Magnetic: Ilmenite, tourmaline, pyrrhotite, and magnetic pseudomorphs after pyrite.

Non-Magnetic: Quartz, topaz, andalusite, zircon, cassiterite, pyrite (abundant), and non-magnetic pseudomorphs after pyrite.

It was found that the magnetic cubes were mostly less attracted by a horse-shoe magnet than the pyrrhotite; therefore by this means, and hand-picking, cubes could be isolated for examination. They are readily attacked by hydrochloric acid; but their streak is red-brown, which will not do for magnetite. Unfortunately the amount of material available is not sufficient for chemical analysis, but the red-brown streak, and the fact that they are less easily attracted by a magnet than the pyrrhotite, point to the cubes being formed of magnetic hematite, not magnetite, hematite being known sometimes to have polarity.

The evidence points to these cubes from Serendah being magnetic hematite pseudomorphs after pyrite. The mineral found at Hinksford certainly ocurred as cubes, but in the light of this new occurrence in Malaya, it is not certain that they were magnetite. They also may have been magnetic hematite pseudomorphs after pyrite.

J. B. SCRIVENOR.

Batu Gajah, F.M.S.
November 6.

NEWS LETTERS

BRISBANE

November 13.

THE COPPER OUTLOOK.—In last month's notes it was stated, on what was apparently dependable authority, that the Port Kembla ore treatment works, in New South Wales, had practically ceased operations. This, if true, would have had a very serious effect on the production of copper in the Queensland Cloncurry district. Fortunately, however, this report, at least as far as the treatment of copper ore is concerned, is not correct. On the contrary, the general manager at Port Kembla is endeavouring to increase the supplies of ore, and, with a view to attaining this object, has been to Cloncurry to make arrangements which will be more satisfactory to the "gougers" and decrease the cost of production and transport. One advantage of the new proposals is that the Port Kembla Company will buy ore of a lower grade than previously. The price of standard copper is now over £68 a ton, and the increase, which has been steady for some time, should give a further spurt to copper production in this district, which is the principal producer of the metal in the State. The "gougers"—or miners working individually or as small parties of tributers in the mines of the Mount Elliott and Hampden Cloncurry companies—have also the advantage of a substantial rebate allowed to them by the Government on railage rates.

The improvement in the copper market should also help the Mount Elliott company in the scheme for the reorganization of its capital lately decided on, and, it is hoped, hasten the time when it will resume operations at Cloncurry.

STATE MINING LOSSES.—The Queensland Auditor-General (Mr. G. L. Beal), an official of Parliament who has the supervision of the public funds, in his last annual report, lately issued, makes disclosures respecting the State mining enterprises that emphasize the disastrous results of these socialistic undertakings. Of the Chillagoe smelters, which closed down in February last, it is stated that the indebtedness to the public Treasury at June 30, 1928, was £926,728. The balance-sheet value of capital assets is put down at £540,283, but the Auditor-General is of opinion, now that the works are closed, that many of these assets have a very much reduced (if any) value. Connected with the Chillagoe State enterprise are several mining leases and the Mount Mulligan coal mine. The amounts given as assets of these leases are regarded as mythical, and the opinion is given that, if the works were permanently closed (as they are considered certain to be) and the assets disposed of on present day conditions, the amount realized would be approximately from £400,000 to £500,000 less than the total balance-sheet values. Mr. Beal sums up the position by stating that if the whole of the assets are disposed of and realize £100,000, which he thinks doubtful, the net cost to the Treasury of this undertaking will be over £1,000,000.

Of the six State coal mines, started at different periods in the past several years, all except one (Bowen) have incurred losses. On the whole of the State coal-mining activities the net losses to June 30 last total £232,000, without taking into account that for two years on one of the mines no interest has been charged. Of this total the Baralaba mine, which was destroyed by flood in April, 1928, and one smaller colliery are responsible for £128,600. Besides deficits on some lesser undertakings, the total losses on the State treatment works and tramway at Irvinebank have amounted to £48,237. Among other State enterprises not connected with mining, there has been a net loss of £1,299,756 in pastoral stations.

MOUNT ISA OPERATIONS.—In the four weeks ended September 15, 198 ft. of drilling was done at Mount Isa on the Rio Grande lode, 12,231 ft. on the Black Star, and 224 ft. on the Mount Isa deep levels. Five gangs of carpenters and concreters were engaged in the erection of the first block of 25 workmen's cottages; while at the dam on Rifle Creek all preparatory work had been finished, and the concreting of the main wall across the creek was in progress. The rails on the Duchess-Mount Isa line, 54 miles in length, have been laid to 40 miles, which is about six miles beyond Rifle Creek, where the dam is being constructed.

FLUOR-SPAR.—Fluor-spar, which is common in the tin and wolfram lodes of North Queensland, has not, owing to unfavourable market conditions, hitherto been produced to any extent in this State. During the past few months, however, over twenty men have been employed obtaining this mineral in the Chillagoe and Mungana districts. The lodes here are in granite country. From the principal Chillagoe mine (the Harlequin) a total of 300 tons of about 85% ore has been mined in about fourteen

weeks. The Fluric, a mine at Mungana, which has been worked for some considerable time, has a large body of ore, a considerable proportion of which goes 90%. During the present year it has produced 500 tons, of an average grade of 40%. So far, the market price—under 30s. a ton—has not given a very satisfactory return, but negotiations are in progress with various works in the Southern States using the mineral that are expected to result in a better price being obtained.

Mount Lyell Success.—The Mount Lyell Company, operating in Tasmania and the only company producing copper in Australia, has declared a dividend of 1s. and a bonus of 6d. per share. This distribution will absorb £96,690, and will raise the total sum paid to shareholders to £3,751,972. In the last two years the dividend has been at the rate of 11¼%, and this year it has been unexpectedly increased to 12½%. The company has extended its activities in the chemical industries, and the recent advance in the price of copper will increase profits from mining and treatment operations.

JOHANNESBURG

December 6.

Sub Nigel Outlook.—According to the latest official statements, encouraging, and in several cases, high values continue to be exposed in the eastern and western sections of the Rand's most talked-of gold mine, the Sub Nigel. It is definitely stated that the development position has shown a distinct improvement during the last few months. At the company's annual meeting the Chairman again emphasized the fact that variations in development results, both as regards values and percentage of payability, must occur from time to time on a mine like the Sub Nigel, where payable values are found in well defined shoots, where a large proportion of development footage is between these shoots, and where a good deal of exploratory work is being carried out. "Therefore," he added, "if for any particular quarter poorer values or lower percentages of payability are met with, shareholders should not attach undue importance to them." Although not depreciating the importance of what current development may open up during the year in other sections of the mine, perhaps it is of special interest for the more distant future of the mine as to what will be met with on the 28th level east and west of the Betty shaft. If good values are met with here, and the directors see no reason why this should not be the case, it will give an early and valuable assurance of the continuation of pay-shoots to much greater depths.

It is expected that the Betty shaft will reach the final depth well within the time limit allowed, namely September next. Meanwhile, development has been carried to the position of this shaft. The reef horizon has been met with, and so satisfactory is the ventilation position that it is not necessary to wait for the shaft to connect with the workings before proceeding with an extensive development programme in this area. The 28 cross-cut, which is the main connection to the Betty shaft, intersected the reef at the beginning of November, after being advanced a distance of 1,700 ft. from the large upthrow fault. Driving east has been started and unpayable values have been exposed for the 65 ft. sampled. This confirms the bore-hole results and is satisfactory, because the shaft was located with the object of having the shaft pillar outside the pay-shoot, otherwise the shaft pillar would have to be left standing until the end of the life of the mine. A cross-cut rise has been put in from the main cross-cut at about 800 ft. from the point of the intersection of the reef, and here again the reef has been cut. From this point 15 ft. of driving showed an average value of 385 in.-dwt. It is interesting to note that this is the only other point where the reef has been exposed on the farther side of the fault, and it is hoped that further work will show that this drive is just entering what will prove to be the continuation of the pay-shoot adjacent to the main haulage.

Namaqualand Diamond Discoveries.—The removal of the ban on prospecting for diamonds so far affects twelve non-coastal farms, seven in the Van Rhynsdorp district and five in Namaqualand. All these farms have gravel but whether they carry diamonds remains to be proved. The issue of prospecting licences will be confined to residents of Namaqualand, many of whom are destitute. If diamonds are found in large quantities the Government will limit the output, but so far no restrictions have been placed on the farms thrown open. The discovery by the Consolidated Diamonds Company of a marine terrace on the north bank of the Orange River at Alexander Bay increases the value of the company's property enormously. It is stated that the prospects there are

quite as good as those on the south side of the bay where the State diggings are. The output from this new area will fall under the regulation governing the diamond output of the Union.

PROSPECTING IN SOUTH-WEST AFRICA.—Advices from South-West Africa state that the Karibib marble deposits are to be worked on a small scale, and there is every reason to expect that the results will be satisfactory. A remarkable range of decorative marbles is available.

The asbestos prospects in the Keetmanshoop district are some 50 miles south-east of the town of Keetmanshoop on the farms Kochena, Garis, and Wittenhorst. A considerable amount of pegging has been done, and the indications have encouraged the taking of options, for example by Mr. Roland Starkey, on behalf of Messrs. Turner Bros. and Newall, but so far little work has been done, and it is therefore too soon to attempt to assess the value of the field.

Labour shortage is at present a serious handicap in the tin fields. The three tin plants along the Omaruru River look like being compelled to close down unless boys are forthcoming soon. The Whitworth Finance and Mining Corporation, Ltd., a new British company, has started development on a considerable scale at Paukwab. The local representatives of the Whitworth Corporation are Messrs. G. Gordon Thomas and W. H. Beak.

The Elbof Company has one of its teams doing geophysical work at Bobas, near Tsumeb, for the South-West Africa Co. They are going to do some work on an oil area near Marienthal before the end of the year.

The extensive occurrence of graphite east of and close to the railway near Otjiwarongo is to be tested by the owners, on the advice of Professor R. B. Young.

DIAMOND FIELDS OF TANGANYIKA.—Dr. A. L. du Toit, formerly of the Union Geological Survey and now Geological Adviser to De Beers Consolidated Mines, has paid a visit to Tanganyika Territory with a view to investigating the diamondiferous occurrences of that country. Dr. du Toit has prepared two separate reports, one dealing with the Tanganyika Diamond Mine and the other with the Shinyanga property of the Central Diamond Mines (Tanganyika), Ltd. Dr. du Toit's views on the geology of the occurrences, it is understood, agree closely with those expressed by Mr. H. S. Harger mentioned in the MAGAZINE for December.

SCOTT MEDAL FOR DR. A. W. ROGERS.—At a meeting of the South African Biological Society held in Pretoria, Dr. A. W. Rogers, Director of the Geological Survey, was presented with the Captain Scott Medal in recognition of his services in connection with scientific survey within the Union. The medal has an interesting history. When Captain Scott lost his life in his Polar expedition, a fund was opened to erect a memorial in his memory. Pretoria subscribed £100, which was forwarded to England. Sufficient money had been subscribed for the purpose, however, so it was decided to return the £100 to Pretoria, where it was banked. From the interest accruing annually a medal is stamped which is presented to the scientist who has rendered his country signal service during the year.

Born in 1872 and educated at Clifton College and Christ's College, Cambridge, Dr. Rogers arrived in South Africa in February, 1896, to assume the position of Assistant Geologist to the Geological Commission of the Cape of Good Hope, and subsequently became its Director. A few years later the University of Cambridge conferred on him the degree of Doctor of Science. When, as a result of Union, the Geological Commission was amalgamated with the Geological Survey of the Transvaal, Dr. Rogers became Director of the Union Survey. Ever since his arrival in South Africa Dr. Rogers has taken a keen interest in the geology of the country, and is now rightly acknowledged as the foremost authority on that subject. He has to his credit a long list of contributions to South African geology, the great value of which has been recognized by the Royal Society, of which Dr. Rogers became a Fellow in 1918.

TORONTO

December 18.

PORCUPINE.—The output of the eight producing companies in this field during October amounted to $1,698,122, as compared with $1,530,605 for the preceding month. The Hollinger Consolidated is treating about 5,000 tons of ore a day with an average recovery of approximately $6 per ton. Active efforts are being directed towards establishing the continuity of the ore deposits at greater depth. Some delay has been occasioned by the work involved in back-filling the old stopes in compliance with the new regulations for the prevention of accidents. Production at the Dome Mines is

well maintained, the output of gold during November amounting to $418,540, as compared with $332,519 in October, and $375,474 for November, 1927. The output this year will reach approximately $3,800,000, and development during the year has added about as much new ore to the reserves as has been taken out. The Vipond Consolidated has latterly materially improved its position and production is being maintained at $2,000 per day, with a recovery of nearly $8 per ton. An important ore-shoot has been encountered at the 7th level, and work is being undertaken to follow its upward and downward continuation. Consideration of the payment of a dividend has been deferred until the extent and value of the new ore zone has been determined. Since the McIntyre Porcupine started operations in 1912 the total production has reached approximately $36,000,000. Dividends have been paid to the amount of $7,600,000, and a surplus of $4,000,000 has been accumulated. The value of the ore reserves is estimated at $17,000,000, which is greater than at any previous time in the company's history. There will be a large further increase should the work now being carried on prove the continuity of mineralization of ore deposits at lower horizons. The Premier-Paymaster has abandoned the effort to treat large bodies of low-grade porphyry, finding it unprofitable, and is now engaged in the search for ore of a higher grade. At the Coniaurum production has fallen much below expectations owing to low gold values and narrow veins. The question of deepening the shaft at present now down 2,000 ft. is under consideration. The West Dome Lake is developing good ore at the 1,200 ft. level and large additions are being made to ore reserves. It is planned to resume milling operations in the spring. The Canusa is calling on active development work and will deepen the shaft to the 300 ft. level.

Kirkland Lake.—During October the gold mines of this area yielded bullion to the amount of $1,100,305, as against $972,060 in September. The Sylvanite is obtaining good ore from a vein coming in from the Wright-Hargreaves property adjoining at the 1,000 ft. level. A new hoist is being installed which will enable work to be carried on ultimately to a depth of 2,000 ft. The mill is treating about 200 tons daily with mill heads close to $11. The Wright-Hargreaves is treating ore of a better grade than during the earlier months of the year. The average recovery for the first nine months of the year was around $7·27 per ton, but during the third quarter the average was $7·81, and so far the final quarter shows a still further betterment of the grade. Production from the Lake Shore, although reaching a new high record this year, is pretty well assured of another 30% in production during 1929. Basing estimates on output for the first eleven months, production at the Lake Shore for the whole of 1928 will reach at least $4,000,000. The company will enter the new year on an output basis of $5,500,000 annually. Operations which were commenced about a year ago on the Murphy property have been attended with highly successful results. Diamong-drilling has proved the occurrence of important high-grade ore-bodies, and development is being actively carried on. An electrically driven hoist is being installed. The shaft of the Kirkland Lake mine has reached a depth of 3,200 ft. When it is completed to the 3,250 ft. level, lateral work will be done at that horizon to open up a deposit which is believed to come in from the Teck-Hughes. The mill is handling 150 tons daily with an average recovery of $8 per ton.

Rouyn.—The Noranda smelter is handling upwards of 900 tons of ore per day, the production being valued at $650,000 a month. It had been planned to attain a rate of 1,500 tons daily by the end of the year, but this plan was changed in order to maintain development on a large scale pending completion of a new shaft to 1,000 ft. The increase in capacity will come within the next ten months. Development results on the 500 ft. and 600 ft. levels have shown an improvement over those obtained on the 400 ft. level, which were not so good as on the 300 ft. level. When the new shaft reaches its objective lateral work will be done to open up the " H " ore-body at that horizon. The 100 ton mill of the Siscoe gold mine is practically completed and is expected to be in operation by the end of the year. It is the first gold mine in Canada to use oil-burning engines as motive power, and the result will be watched with much interest by mining men. High-grade ore encountered on the 500 ft. level yielded assays varying from $40 to $20 per ton. A mining plant is being installed at the Gilbec where an important discovery has been made by electrical prospecting, which indicates a wide mineralized zone. A test pit was put down 20 ft. and assays of the ore showed 6% copper.

A shaft will be put down 100 ft. and lateral work will be done to open up the deposit at that level. A controversy has arisen as to the extent of the ore reserves of the Abana, widely different estimates having appeared. Charles Spearman, consulting engineer of the company, states that a conservative estimate of the indicated or possible ore tonnage is 1,000,000 tons. He goes on to say that Abana has no geological problems to solve and that the major engineering problems have been overcome for the present. The Granada Rouyn has completed work to 625 ft. in depth, and extensive lateral operations are to be proceeded with. This will carry drifts out to sections where high-grade values were encountered by diamond-drilling.

PATRICIA DISTRICT.—The extension of the known gold-bearing area of this district has been folllwed by great activity in the new camp. A rush of prospectors to Gold River has set in, and many claims are being staked. The name of the camp has been officially changed to Shoniah Lake, as there are other Gold Lakes in Canada, which might result in confusion. Several additional discoveries of importance are reported. The Northern Aerial Mining Exploration, which owns the original discovery, has sent in a crew of men to make a thorough exploration of the property preparatory to development on a large scale in the spring. The regular aeroplane service now in operation to the other fields of the district will include Shoniah Lake during the winter. At Crow River and Pickle Lake 50 miles east of Shoniah Lake two impressive discoveries have been made, one held by the N.A.M.E. and the other by the Connell interests, which have yielded high assays. The Howey at Red Lake is preparing for production on an extensive scale, and the first unit of the mill to be erected will have a capacity of 500 tons. Development has already disclosed an average width of 26 ft. over a length of 200 ft. on the 500 ft. level, the ore carrying over $9 per ton. The average value throughout the mine is about $7 per ton. At a point 1,500 ft. to the east of the shaft diamond-drilling has indicated $10 values across the width of 10 ft. On the Red Lake Centre immediately adjoining the Howey two veins, 9 ft. and 15 ft. wide respectively, coming in from that property and carrying good values are being opened up.

MANITOBA.—The coming winter will witness great activity in the Flin Flon copper area. Exploration is being actively carried on by means of aeroplanes, and new discoveries are frequently reported. At the Flin Flon property work is being carried on by a crew of 300 men, and an equal number are engaged on the power development at Island Falls. Large quantities of materials and supplies will be brought in over the winter roads. The route of the railway from the Flin Flon branch line to the Sherritt-Gordon property at Cold Lake is being surveyed, and the construction will be pushed as rapidly as possible. The shaft at the Mandy copper mine is being put down to 1,000 ft. So far the results of development have been uncertain, and the future of the enterprise depends on what may be found at the lower horizon. A new base metal camp has been established at Bird River, 75 miles from Winnipeg, where the Lindsley interests have acquired several properties under option, giving them six miles along the main break. The Consolidated Mining and Smelting Co. is also largely interested in this locality, which promises to become an important mining centre.

SUDBURY.—The nickel companies have latterly largely increased their outputs and are making steady progress with their programme of expansion. The output of the Coniston smelter of the Mond Nickel Company has been increased by 250 tons a day, and it is now handling 1,750 tons daily. The International Nickel Company has begun the enlargement of its smelter in preparation for the increased tonnage anticipated from the development of the Frood.

VANCOUVER

December 10.

REVIEW OF YEAR 1928.—With only three weeks remaining in 1928, it is possible to make a fairly accurate estimate of the mineral production for the year, and it is satisfactory to note that, despite the sharp decreases in the market prices of lead and zinc, the two metals that British Columbia produces most of, the value of the production is likely to exceed that of 1927 by about one and a half million dollars. With the exception of silver, the outputs of all metals will show increases ; those of lead and copper will be substantial. Zinc, too, would have shown a substantial increase but for the shortage of electric energy at the Tadanac smelter throughout the year, which was made more acute during two or three months by a collapse of some of the plant at one of the Bonnington Falls stations. This condition now has been relieved, and the third station

on the Kootenay River, at Slocan Pool, has just been put into operation, but will require some adjustment before it reaches capacity, 70,000 h.p. The increase in the price of copper has caused an impetus in copper production, which will be about 10 million pounds more than in 1927. The iron pyrites production, a by-product in the production of copper concentrate at the Britannia mine, will be about double that of last year. The cadmium output, which appears for the first time among British Columbia products and which is obtained as a by-product in the manufacture of zinc at Tadanac, will be rather less than half a million pounds. The coal production is expected to run about 150,000 tons ahead of the 1927 production, the increase coming from the Crow's Nest Pass and Princeton fields. The Vancouver Island field will show a decrease.

An appalling number of new mining companies have been formed during the year, some of which have already gone to the wall, and a large amount has been spent on exploration and development, much of which, unfortunately, has been misdirected effort. This, of course, is to be expected at a time when money is as readily accessible as it was last year. There have been several important new discoveries, which give promise of being developed into important mines, notable among which are the shoot on the Deadman vein in the Noble Five, at Sandon, rich silver ore at the Mountain Boy, near Stewart, the discovery of ore beyond the fault at the Henderson, on Hudson Bay Mountain, and the large silver-lead-zinc deposits in Pre-Cambrian formation, at the Kootenay King, near Fort Steele. Of the older prospects and mines that have shown marked improvement under development, special mention should be made of the Ferguson, at Ingineka River, in the Peace River region, and the Reeves-McDonald at the junction of the Salmon and Pend d'Oreille Rivers, near the British Columbia–Washington boundary. The total dividends for the year are expected to amount to about one million dollars more than in 1927.

The most noticeable, though not the most satisfactory, event of the year, is the evident prosperity of the brokers. Handsome new buildings in Vancouver and Victoria have replaced and are replacing dingy offices in obscure buildings, and limousines, resplendent with enamel and nickel, the homely Ford. One does not begrudge the broker a fair commission, but have they always been fair? The answer to this is that in the majority of instances the quotations for the stocks of new mining companies on the local exchanges are lower to-day than the prices at which they were issued. It would appear, therefore, that the advice of the broker to "get in on the ground floor" may be bettered by wait and get in at the basement.

Snowflake Report.—The report issued by the Provincial Department of Mines to correct false statements which had been given out by officials of the Snowflake and Waverley-Tangier companies has provoked vituperations from certain Vancouver papers, calling for the retirement of the Provincial Mineralogist and the reorganization of the whole department. It is easy to see that the veiled hands behind these railings are those of dishonest brokers and company promoters who see in the stand taken by the Minister of Mines an end to their nefarious occupations. Genuine mining men, I feel confident in stating, agree that the Mines Department is one of the best-run departments of the local Government, and the fact that Mr. Galloway was elected as Chairman of the British Columbia branch of the Canadian Institute of Mining and Metallurgy last year is sufficient proof, if proof were needed, of the confidence that mining men have in him.

That some of the mining laws need amending is no fault of the present administration. They are likely to receive attention at the next session of the Provincial Legislature. The Honourable W. A. McKenzie already has expressed his intention of conferring with the mine operators of the Province through their several associations before any new mining legislation is enacted.

The Kootenays.—The further development of the new shoot of ore on the Deadman vein from the bottom level of the Noble Five mine at Sandon is opening up one of the most important bodies of ore that have been found in the West Kootenay district for many years. A level about 12 ft. wide, has been driven in ore for 150 ft. on the hanging-wall side. At the end of the drift a cross-cut has been driven for 40 ft. without reaching the foot-wall. A level has now been started from the end of the cross-cut, to parallel the hanging wall. The main level, the face of which is in ore, will be continued as soon as the mill is started, but all available storage space has been filled with ore won in develop-

ment, and, pending the starting of the mill, both shipping and milling ore is being sent to Tadanac. What this swelling of ore is has not yet been ascertained. Whether the whole vein has swelled and the enlargement is likely to persist to the surface, or whether it is a lens remains to be determined, but in either event an immense body of ore has been found. The drift has been run from the bottom tunnel, with 1,000 ft. of virgin ground above it. It is believed that the full width can be profitably milled after the bands of clean ore, ranging from a few inches to four feet, have been removed for direct shipment. The new mill will be ready as soon as a box of parts for the flotation cells, which has been lost in transit, has either been found or duplicated.

The Consolidated Mining and Smelting Co. of Canada evidently intends to go ahead with the manufacturing of superphosphate fertilizer. It has made a survey from the Crow's Nest Pass branch of the Canadian Pacific Railway to its deposits of phosphate of lime, at Cedar Valley, and has purchased 40 acres of land as a site for a plant there. The company is making a spur to its St. Eugene mine concentrator, to facilitate the movement of ore from the Sullivan mine to the concentrator. The coarse crushing plant has a capacity of 500 tons and the fine crushing and flotation section 800 tons per day. During the winter, while the lake containing the old tailing is frozen, the plant will be used only for Sullivan ore, but after the spring thaw for both Sullivan ore and St. Eugene tailing. The company is reported to be developing a promising vein of copper-silver-gold ore on the Duchess group, 30 miles south of Telkwa station, on the Canadian National Railway, but no official statement has been made other than that development will be continued during the winter.

CAMBORNE

January 1.

Wheal Buller.—Since the completion of the unwatering preparations have been made for the sinking of Kistle's shaft which is now in progress, the rock from the sinking being stored in the old stopes. At the same time the 660 ft. level is being connected from Hocking's shaft to the former in order to facilitate access to the eastern section of the mine. The unwatering of this mine was carried out through Hocking's shaft and occupied about 23 weeks, the total amount of water pumped being in the neighbourhood of 38,000,000 gallons. Considering that Hocking's shaft (which is typical of many of the old shafts in Cornwall) is first vertical, then inclined, and finally vertical, and that a bad choke was encountered in the shaft, extending from a depth of 153 ft. to 277 ft., which had to be cleared, it speaks well for the efficiency of the management and of the two electrically-driven centrifugal pumps which were used in the unwatering. Some of the local " die-hards " who view with disfavour all pumps other than those of the Cornish type will, possibly, now be inclined to modify their views.

Wheal Vlow.—This mine has now been unwatered to the 44 fathom level, which is at the bottom of the mine, but progress at this depth has been somewhat hindered by the encountering of a quantity of ochrey mud in the bottom of the shaft. It is noted that most of the ground opened up by the old miners has been largely stoped out, thus proving it to have been productive and consequently the results of further development and sinking are being looked forward to with great interest.

Lambriggan.—In the hope of locating other lodes of lead and zinc, geophysical prospecting is at present being carried out on the ground in the immediate vicinity of the Lambriggan sett. It is understood that the company owning the Lambriggan mine has acquired the Wheal Hermon tin mine near St. Just in West Cornwall, and that a programme of vigorous development has been arranged for the new year.

North Parbola.—At this mine, which is situated near the village of Wall in the parish of Gwinear, the cassiterite occurs in an elvan dyke which traverses the killas country in a south-westerly and north-easterly direction, and dips to the north-west. Recent prospecting has disclosed rich ore at a depth of 30 ft. averaging 66 lb. of black tin per ton over a sampled width of 3½ ft. on the foot-wall side of the elvan. The elvan course is presumed to be about 30 ft. wide and along its outcrop for a distance of over 300 ft. there is an almost continuous line of old workings which augurs well for the continuity of the tin values.

South Terras.—The unwatering of this " Radium " mine has now been completed to the lowest level, namely, 40 fathoms below adit. A considerable amount of old stope-filling has been cleared out and taken to surface, where it is being " worked up " to form a radium bromide concentrate of which

some 100 milligrams per month, it is understood, are being produced. The company is interested in the surrounding properties and is carrying out prospecting operations with the view of determining the most favourable direction for future development.

Bideford Black.—The mining of " Bideford Black " is one of the oldest commercial undertakings of the town of Bideford, Devonshire. In this county there is a very large series of rocks of Carboniferous age, and near Bideford these are coal-bearing, and the coal is a true anthracite. One of the seams carries what is known as " mother-of-coal " and has been worked almost continually for 140 years. The material from this seam is dried and ground, and sold for the manufacture of paint under the name of " Bideford Black ". Despite the competition of lamp-black and American carbon black, it has continued to find a regular market. A company called Bideford Black, Ltd., with a capital of £100,000, has been formed to exploit this so-called " paint " seam which persists through a distance of over 12 miles and has an average thickness of 2 ft. 6 in.

Amalgamation of Cornish Mines.—At a meeting of the Cornish Institute of Engineers held at Camborne on December 15 some remarkable opinions were expressed by Mr. William Hosking (a Past-President) concerning possible amalgamation and consolidation of Cornish mining interests. He hoped that the Seton mines would be included in the scheme of reconstruction for Dolcoath and suggested that the Roskears and Setons would be " in full swing as a combined scheme before a considerable number of years had elapsed." Mr. Hosking went on to say: " You will probably see another scheme in which Tolgus and East Pool mines will become a joint concern. I will not go so far as to say with South Crofty thrown in, but it is quite possible that the three may work together. Cornwall had held its own through the annals of history, and it would continue to do so. If Cornwall had only been South Wales and from a political point of view could turn the scales and win an election for any party, we should have had Government assistance for our mines. By being compelled to help ourselves we have brought out the pluck and grit of Cornishmen. I believe we shall see other mines opening up and a consolidation of interests all the way round which, if it can be brought about, will result in a restoration of confidence and prove a boon to the Duchy."

Beach Tin Deposits, Ltd.—This company was originally formed last spring to take over the business of the Ore Dressing Co., Ltd., at Gwythian. The board consists of Mr. Philip W. Smith, as Chairman, Professor B. W. Holman, and Mr. R. B. Hirsch. Since the creation of the company a new mill has been installed on the site of the old one. Formerly the Ore Dressing Co. treated some 10 tons of tin-bearing sands daily, conveying it to the mill in horse-drawn carts. It is the intention of the present company to treat 300 tons daily, transport being effected with a system of specially designed Ford tractors, trailers, drag-line bucket excavator, and aerial ropeways. The plant consists of two circular ferro-concrete bins with a capacity of, roughly, 3,000 tons (there is an additional storage space which will be used in connection with a specially designed scraper having a capacity of 20,000 or 30,000 tons of ore), a Hardinge ball-mill of 300 tons capacity per 24 hours, two tube-mills, Dorr classifier, various centrifugal pumps, and some 48 James sand tables. At present it is not contemplated installing a slime plant, as the grade of concentrate which will be sold will not exceed 25% tin, and therefore practically no slime will be made as there is none in the original ore. It is interesting to note that if it were attempted to make a high-grade concentrate, such difficulty would be encountered as to render the scheme uncommerical since a very large loss in recovery would occur. As it is only within the last three years or so that smelters, generally speaking, have been able to treat low-grade concentrates at an economic returning charge, the commercial possibilities of the proposition are comparatively recent. Production is expected to be some 120 tons of concentrates monthly and will start almost immediately. The services of Mr. H. C. Horner, manager of the Ore Dressing Co., have been retained.

St. Ives Bay Concession.—An article appeared in the Magazine for July on this subject. It seems that during the summer, systematic boring—which did not reach bed-rock—was carried out in the bay, as a result of which it would appear that there is a large deposit of tin-bearing sand under the sea, probably owing its origin to the accumulation of tailings which have been washed down the Hayle and Red rivers ever since the tin industry of Cornwall came into existence. Although the nature of the deposit prohibits the simple treatment usually per-

missible in Eastern and Nigerian alluvial tinfields, the average grade of the ore is expected to off-set such additonal expense as may arise. Sufficient tonnage was dredged from the bay in order to conduct experimental tests, which are at present being undergone both in this country and on the Continent. Definite conclusions are expected to be reached within the next few weeks. The consultant engineer to the enterprise (which is entirely in private and British hands) is Mr. H. G. Scott, of the Siamese Tin Syndicate, Ltd., who has as his assistant Mr. A. B. Rowe; Professor Holman is collaborating.

ST. ERTH VALLEY.—A statement was made in the December issue of the MAGAZINE to the effect that if investigations warranted it, the owners of the concession contemplated spending £1,000,000 in the development of the property. The interested parties, however, wish to repudiate any such statement. At present systematic boring of the valley is being carried out under the direction of accepted authorities, and future development will, of course, depend entirely on the results obtained. This enterprise is in the hands of the same group as the St. Ives Bay concession.

PERSONAL

A. E. BLACKWOOD has been elected president of the Sullivan Machinery.

Sir CECIL L. BUDD has resigned as chairman of the board of the London Metal Exchange, a position he has held continuously since 1902.

J. M. CALLOW is here from the United States.

C. H. J. CLAYTON is here from Australia.

PHILIP L. FOSTER is here from New York.

CHARLES HABBERJAM has been appointed a mining engineer to the Imperial Chemical Industries, Ltd., Nobel section.

G. A. HARRISON has resigned as director and general manager of the West African Diamond Syndicate.

Dr. J. A. L. HENDERSON has returned from Canada.

EDWARD HOOPER has left for South Africa.

S. D. KIRKPATRICK has been appointed editor of *Chemical and Metallurgical Engineering* in succession to H. C. Parmelee.

T. G. MADGWICK is here from Canada.

A. LIVINGSTONE OKE is home on leave from Spain.

DUNCAN SMITH has returned to Brussels.

A. HOWELL WILLIAMS has returned from Peru.

SIR CHARLES METCALFE, the friend of Cecil Rhodes and pioneer of railway construction in Rhodesia, died last month.

T. C. CHAMBERLIN, for many years professor of geology at Chicago University, died on November 15 at the age of 85. He was the co-author of the standard American book on general geology and the originator of the planitesimal theory.

SIR PIETER STEWART-BAM died suddenly last month at the age of 60. He was born in South Africa of Dutch descent and was a great advocate of reconciliation between the two white races. He travelled in Canada for the purpose of studying the friendliness of English and French in the Dominion and took every opportunity of retailing his experience for the benefit of the Dutch in South Africa. Of recent years he had borne the expense of the exchange visits of British and South African farmers.

W. R. H. CHAPPEL, lately a partner in the firm of Osborne and Chappel, died at Exeter last month in his 59th year. He was a son of Canon Chappel, of Camborne, and was educated at the Camborne School of Mines. In conjunction with the late Douglas Osborne he obtained Cornish capital for the development of Malayan alluvial tin deposits, and the excellent record of the various companies formed for this purpose is a matter of history. At the time of his death he was chairman of the Gopeng and other companies of the group.

TRADE PARAGRAPHS

Werf Conrad have changed the address of their London office to Moorgate Hall, 153, Moorgate, E.C. 2, and their new telephone number is London Wall 0425.

The Consolidated Pneumatic Tool Co., Ltd., 170, Piccadilly, London, W. 1, send us a leaflet devoted to their new type Little Giant pneumatic coal pick.

Hadfields, Ltd., of East Hecla Works, Sheffield, have issued a leaflet devoted to hollow and solid mining drill steel of all shapes and lengths to fit any make of rock-drill.

The Bureau of Information on Nickel, Ltd., 2, Metal Exchange Buildings, London, E.C. 3, send us a paper on the Properties and Applications of Invar and Related Alloys.

Samuel Osborn and Co., Ltd., of Clyde Steel Works, Sheffield, send us a leaflet about their newly introduced S.O.B.V. cutting alloy, to which reference has already been made in these columns.

Nordac, Ltd., of Reno Works, Wealdstone, Middlesex, at a recent Rubber Fair held in London, made a feature of rubber linings for tanks, pipes, valves, and fittings, as also for ball and tube mills and separators.

The Broadley Engineering Co., of Broad Street House, London, E.C. 2, is the title and address under which J. R. Broadley, who was until recently with the Wilfley Co., Ltd., has commenced business for the supply of patent ball-mills, centrifugal pumps, and concentrating tables.

Crosby Lockwood and Son, of Stationers' Hall Court, Ludgate Hill, London, E.C. 4, send us their 1929 catalogue of industrial textbooks containing sections devoted *inter alia* to metallurgy, mining (mineralogy and prospecting), chemistry, various branches of engineering, and mathematical and other tables.

The Eagle Engineering Export Co., of 45, Pall Mall, London, S.W. 1, inform us that they have recently received the following orders: 80 pneumatic tyred, 4-wheel trailers for the Indian Government; 26 solid rubber tyred, 2-wheel, 5-ton trailers for a contractor; and 18 solid rubber tyred, 4-wheel, 10 ton trailers for use in Egypt.

Metropolitan-Vickers Electrical Co., Ltd., of Trafford Park, Manchester, publish in the November issue of their *Gazette* an illustrated article describing the high voltage equipments at Witbank and Brakpan power stations which belong to a chain maintained by the Victoria Falls and Transvaal Power Co. supplying the gold mines of the Rand.

The British Industries Fair will be held as previously simultaneously in London at the White City and in Birmingham at Castle Bromwich, the latter section covering the heavy industries, including engineering, mining, electrical power plant, and metals. On this occasion still further extensions to the available space have become necessary in order to accommodate additional exhibitors.

Edgar Allen and Co., Ltd., of Imperial Steel Works, Sheffield, send us a copy of their Mine and Quarry Book (a new publication) containing notes on crushing and grinding machinery: Stag ore crushers, gyratories, granulators, rolls, ball and tube mills, air separators, feeders and conveyors, forged steel balls, and stone dryers, shoes and dies for stamps, and dredge buckets. Notes on drill steels include heat treatment instructions. The whole is well prepared and illustrated.

Ruston No. 25 Quarry-Type Steam Shovel.

Richard Klinger, Ltd., of 120, Southwark Street, London, S.E. 1, inform us that in a description given in these columns last month one of their boiler water-gauges was incorrectly described as designed for working pressures up to 250 lb. Actually, we learn, these gauges are specially intended for high pressure work on modern steam boilers and are made of gunmetal for pressures up to 350 lb. and of steel for pressures up to 2,000 lb.

Underfeed Stoker Co., Ltd., of Africa House, Kingsway, London, W.C. 2, send us a copy of a splendidly prepared booklet giving details of the "L" type or Louvre stoker which is of the travelling-grate type and of entirely modern design. Since its first introduction late in 1927, no less than 110 orders for it have been executed in this country and arrangements have now been made for the American and French associated companies to sell it in their respective territories.

Detrick Arch Co., Ltd., of Sentinel House, Southampton Row, London, W.C. 1, inform us that they have taken over from the Underfeed Stoker Co., Ltd., all the rights for the design, manufacture, and sale of all flat suspended arches and roofs and furnace walls constructed under the patent rights of the M.H. Detrick Co. in Great Britain and the Colonies (except Canada). Sales during the past year increased by 300%. Similar rights for the Beco boiler baffles have been secured.

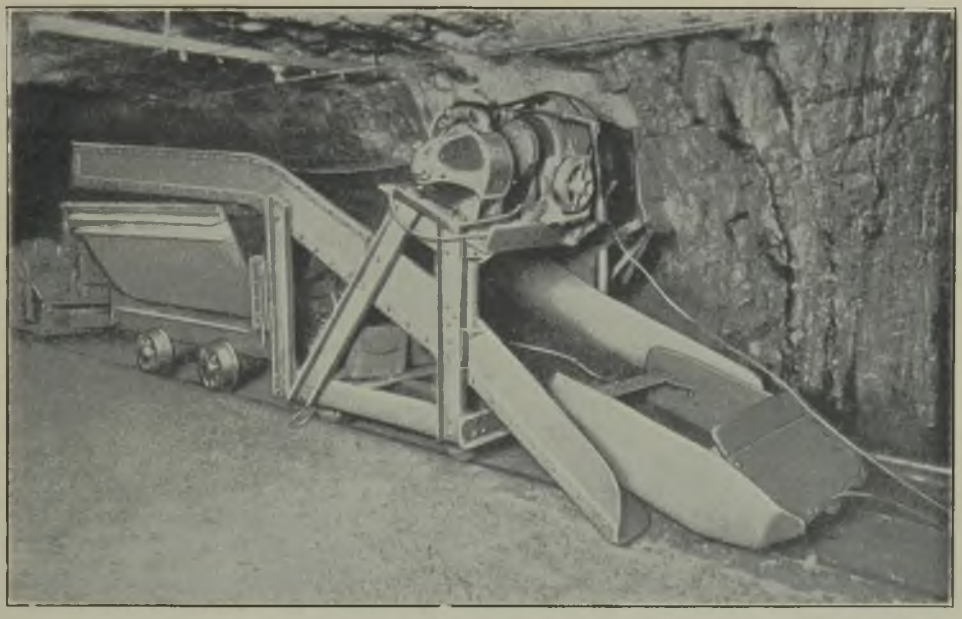
Ruston and Hornsby, Ltd., of Lincoln, have introduced a new type of quarry or open-cast mine shovel which they call the No. 25. This is 3½ cu. yd. machine steam driven, and is illustrated in the accompanying photograph. Special features to which attention is drawn include: An unusually high ground clearance of 16 in., totally enclosed gears, all-gear drive without chains, driving sprockets with internal gears, 10 ft. diameter roller path having a live ring of 36 slewing rollers, each 8 in. diameter, and a semi-automatic tripping gear controlling the bucket door. It is interesting to note also that the bucket arms (on either side of the jib) are built up of oak and mild steel plates.

International Combustion, Ltd., of Africa House, Kingsway, London, W.C. 2, inform us that their French associate company has obtained an order for Lopulco equipment for two boilers, each of 3,750 sq. ft., comprising two 4-ton Raymond mills, raw coal handling plant, combustion chambers lined with Murray fin tubes, water screens, and air heaters. Their American associates have obtained the following: One Lopulco storage system with air heater, fin-tube furnace, and one boilder

of 46,000 lb. evaporation; four Raymond 15 ton 6-roller mills; three Lopulco storage systems, each boiler of 27,500 lb. evaporation; two steam generators of 1,800 lb. per sq. in. working pressure, the highest yet known in the United States.

International Combustion, Ltd., Grinding and Pulverizing Offices, of 11, Southampton Row, London, W.C. 1, report the following orders recently received: For England: One 3 ft. by 5 ft., 2-surface, type 37, Hum-mer screen for slag; one 3 ft. by 2½ ft., 1-surface, type 39, Hum-mer screen for lime; one 3 ft. by 5 ft., 1-surface, type 33, Hum-mer screen for iron and mixed iron and zinc shavings, and one 3 ft. by 18 in. Hardinge mill with classifier for glass grit. For Australia: Three 8 ft., 1-surface, type 39, Hum-mer screens and two 4 ft. by 5 ft., 1-surface, type 39, for lead-zinc ore. For France: One 4½ ft. by 22 in. Hardinge mill for lead compound; one 4½ ft. by 36 in. mill for calcined flint; one 3 ft. by 24 in. mill for unknown duty; one 5-roller and two 4-roller Raymond mills for coal; one No. 0000 Raymond pulverizer for copper hydrate; one No. 00 for carbonate of magnesia; and two 3 ft. Raymond separators for unknown duty.

The Sullivan Machinery Co., of Salisbury House, London Wall, London, E.C. 2, send us particulars of their scraper loaders, a particular type of which is shown in the accompanying photograph. They point out that scraper loading or "slushing," as it is sometimes called, has entirely passed the experimental stage and has been successfully applied both in coal and ore mining. They are made in sizes having electric motors with outputs of 10, 15, 25 and 35 h.p. The method of operation is not dissimilar from that of a dragline excavator, the little scraper bucket being hauled by steel wire hawser by means of a drum, to which the motor is geared, and a system of pulleys. Cases are quoted of remarkable performances by these machines in different parts of the world, of which the following may be taken as typical. In the Montreal mine a Sullivan 6½ h.p. hoist with slide and 40 in. hoe type scraper was used in a 9 by 8 rock drift. A round of 16 to 23 holes produced about 18 cu. yd. of broken rock, which took two men hand shovelling 16 hours to clear away. With the scraper and slide two men cleaned up the breast in 4 to 5 hours. A typical cycle would be:—Rigging up, 45 min.; drilling and tearing down, 5 hr. 45 min.; loading and shooting, 30 min.; blowing away smoke, 30 min.; shovelling, 4 hr. 30 min.



Sullivan Electric Hoist and Scraper at Eureka Mine, Michigan.

HARDINGE AND RAYMOND MILLS AS COAL PULVERIZERS

On the occasion of a recent visit to the newly enlarged works of International Combustion, Ltd., at Derby, to which the manufactures formerly carried on at Barrow have now been transferred, we were afforded opportunities of observing the progress that has been made in the design of plant for coal crushing as well as many other incidentals to the firing of boilers (such as Usco-Murray fin tubes and chain-grate stokers). After passing through the large machine shop, the plate shop, and the foundry, we came to the test house which was the prime object of our visit. Here are means for carrying out crushing and sizing tests in a variety of mills with air classification and a Hum-mer screen.

Our attention was particularly directed, however, to the use which is now being made of the Hardinge conical ball-mill as a coal-pulverizing unit in association with the new system of air classification, the layout of the plant being shown in Fig. 1 overleaf. This is intended for the unit system of powdered fuel firing, namely that which makes no provision for intermediate storage of the pulverized

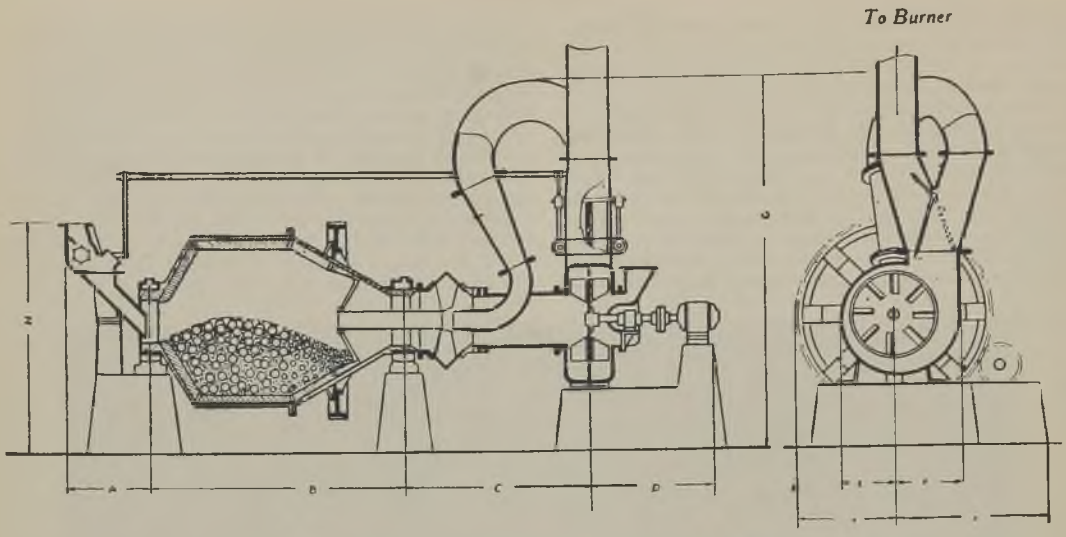


FIG. 1.—ARRANGEMENT OF HARDINGE BALL-MILL AS COAL PULVERIZER ON THE UNIT SYSTEM.

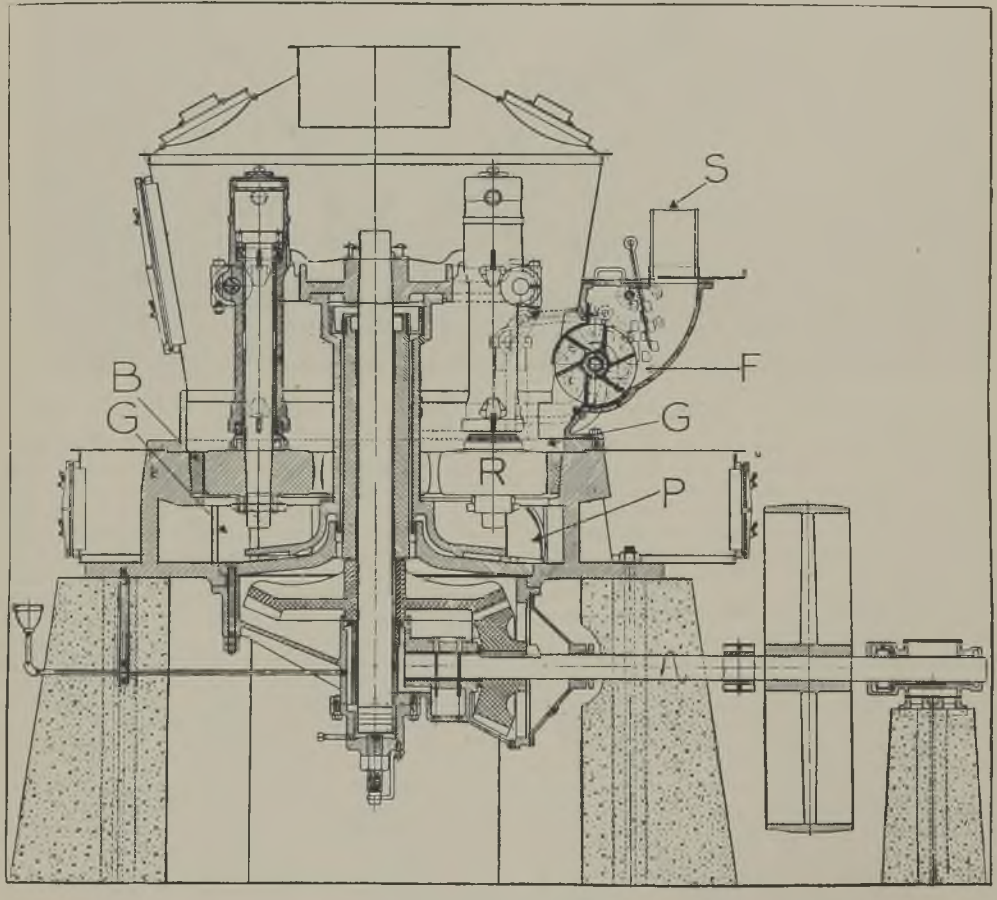


FIG. 2.—RAYMOND MILL.
B, Bull-ring. F, Automatic Feeding Mechanism. G, Grinding Chamber. P, Manganese Steel Ploughs. R Rollers. S, Feed Spout.

fuel. There seems to be a general trend of preference for this system on account of its simplicity and low installation cost both for the firing of boilers and for kilns and other furnaces. It is unnecessary to enter into a description of the Hardinge mill, with which mining men are already familiar. The paramount feature of this plant is the system of control which permits the rate of the feed of coal to the furnace to be varied instantaneously and whereby oversize particles are returned to the mill for regrinding. This mechanism also controls the feed of raw coal to the mill. Similarly the secondary air control may also be arranged to operate from this same motion. In this way the rate and all other conditions of firing can be controlled in one operation, which is achieved by means of a system of circulating air currents and moveable vanes. Thus the fan serves the double purpose of drawing in secondary air and keeping that already in the system in constant circulation. On the air currents the powdered coal is borne to the burner in an amount depending on the degree to which vanes in the burner feed are opened, the extent to which they are open in turn controlling directly the amount of raw coal entering the mill. So, if the vanes are quite closed, no coal enters the mill and no powdered coal the burner, the air stream keeping it in constant circulation within the mill.

We reproduce here, also, sectional drawings in Figs. 2 and 3 representing respectively the Raymond mill and the Raymond Lopulco mill, the latter (formerly known as the Loesche mill) being an important modification of the former developed in Germany and now adopted by International Combustion, Ltd., but not in complete replacement of the Raymond mill which is still unsurpassed for the grinding of sticky and ultra fine materials. Earlier reference to the Raymond mill will be found in an article describing the Lopulco system of boiler firing in the MAGAZINE for April, 1927.

It will be noted that the crushing element, instead of being a number of pendulums with roller bases that swing by centrifugal force against a fixed " bull-ring," consists of a ring which revolves horizontally and against which are a number of spring-supported rollers rotating on pivotally supported shafts. This arrangement has the important advantage that whereas the pendulums in the Raymond mill cannot be lubricated while in operation the present roller system permits such lubication with a grease gun by way of the channel shown down the centre of the shaft (inclined) in Fig. 2, thus affording continuity of operation.

In conclusion, it may be well to comment on the remarkable expansion which has been evidenced by this organization in the course of but two or

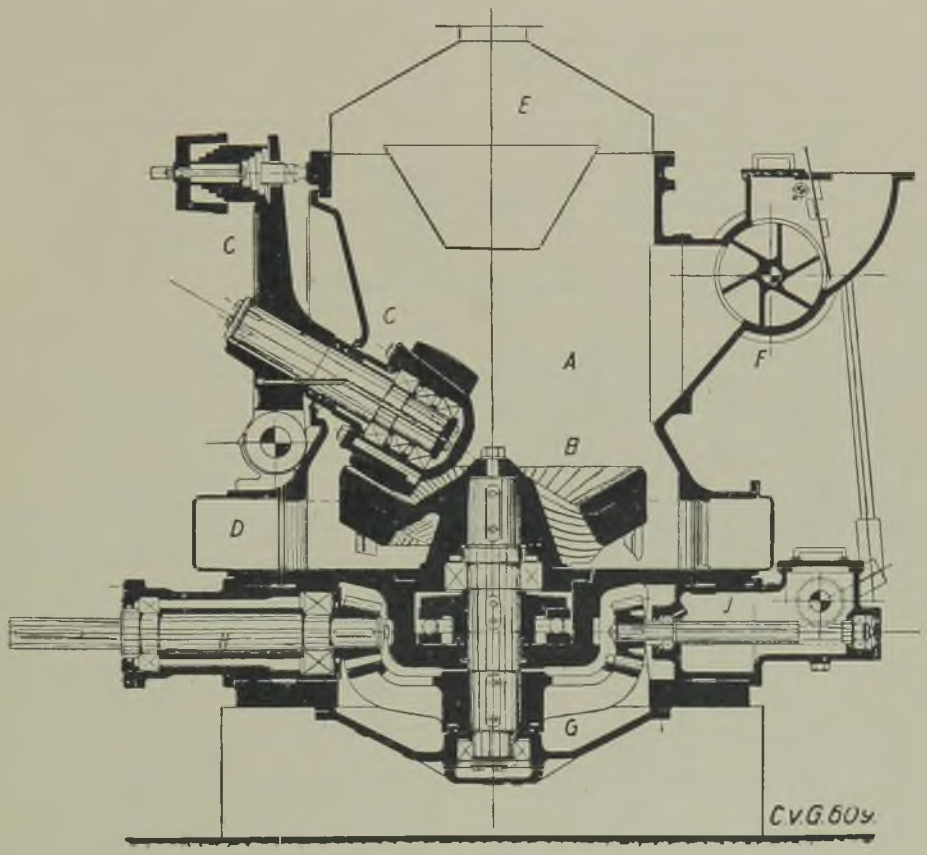


FIG. 3.—RAYMOND LOPULCO MILL (FORMERLY LOESCHE MILL).

three years. The group, if the subsidiary companies are included, has departments devoted to pulverized coal burning, mechanical stoking, furnace design, low temperature carbonization, and crushing grinding, screening, or other classification of all kinds whether for metalliferous ores or other industrial products.

METAL MARKETS

COPPER.—After being fairly steady throughout the larger part of December, copper values towards the close began to harden further, owing to a fresh inrush of buying. That both the Continent and America should have displayed such eagerness to buy at the turn of the year, when industrial interest is usually restricted, came as a surprise, but it appears to have been not unconnected with the recent earthquake in Chile, which will probably result in a curtailment of shipments from that country. Standard values went up with a rush in the closing days of the month, while during December the export quotation for electrolytic in New York was advanced from 16·00 to 16·60 cents per lb.

Average price of cash standard copper: December, 1928, £69 7s. 7d.; November, 1928, £68 2s. 3d.; December, 1927, £60 2s. 3d.; November, 1927, £58 17s. 3d.

TIN.—The bulls suffered some reverses during December, and, despite occasional minor rallies prices at the close of the month reflected a substantial decline from the opening levels. The downward movement was perfectly justified by the statistical position of the metal, as nobody can really believe that prices should go up at a time when world consumption, although undoubtedly good and increasing, is definitely below the rate of output, and stocks, both visible and invisible, are expanding dangerously. However, the bull element have not yet had their last word and the possibility of further advances in the quotation—if only temporary—cannot be ignored.

Average price of cash standard tin: December, 1928, £227 13s. 11d.; November, 1928, £232 19s. 5d.; December, 1927, £267 4s. 10d.; November, 1927, £262 13s. 9d.

LEAD.—After receding quite appreciably, London lead values suddenly underwent a spurt at the close of December and actually showed a slight gain over the month as a whole. Arrivals in this country were heavier than previously, but there was a fair amount of buying by the Continent, despite the approach of the stock-taking period. The past year has, of course, not been a very propitious one for the lead market and naturally enough everybody is therefore inclined to take a hopeful view of prospects for 1929. This feeling has been accentuated by the announcement that producers propose to hold a further meeting next March, when steps may be taken to tighten their present very loose control over the situation.

Average mean price of soft foreign lead: December, 1928, £21 10s. 8d.; November, 1928, £21 7s.; December, 1927, £22 6s.; November, 1927, £21 2s.

SPELTER.—This market was rather firmer during the past month. There was a tendency for sentiment to become tinged with optimism in view of the definite steps which producers throughout the world have decided to take in the direction of market control. It is apparently proposed to curtail European production in the early part of 1929 by some 7%, and exports from America are to be simultaneously restricted if not altogether suspended. If this can be carried out, we may see values higher during the course of the coming year. Meanwhile, the very threat of control has already lifted prices from about £24 in October to nearly £27 by the end of December. The extent of the control measures of producers will be regulated by the size of world stocks and the price in London.

Average mean price of spelter; December, 1928, £26 12s. 2d.; November, 1928, £24 16s. 3d.; December, 1927, £26 4s. 8d.; November, 1927, £26 2s. 10d.

IRON AND STEEL.—Generally speaking, the Cleveland pig iron market was a fairly good one during December. Surplus stocks have been heavily reduced during recent months, and although export sales are restricted, home demand is sufficiently brisk for makers to propose to increase their output further in the near future. Prices were unaltered during the month, Cleveland No. 3 foundry G.M.B. remaining at 66s. Hematite was a moderately good spot with East Coast Mixed Nos. quoted at 71s., though sellers appeared willing if necessary to shade this figure; here also, production is being increased. As regards finished iron and steel, the situation has been considerably improved by the recent placing of numerous shipbuilding orders in this country, which will result in due course in a heavier demand for ship steel at the rolling mills. Export sales are still slow, however, and it is difficult to foresee much immediate improvement in this regard. Following the settlement of the lock-out in the German Ruhr iron and steel industry, the market for Continental iron and steel has begun to show signs of easiness.

IRON ORE.—The closing weeks of the year witnessed very little fresh buying, but both producers and consumers seem pretty well covered for the time being and prices remain steady at 22s. 6d. per ton c.i.f. for best Bilbao rubio.

ANTIMONY.—At the close of December, English regulus was quoted at about £54 to £55 per ton. Business was quiet. Chinese material was also dull, with spot priced about £38 15s. to £39 ex warehouse and metal for shipment from China at £35 15s. to £36 c.i.f.

ARSENIC.—A quiet business is passing at about £16 5s. per ton f.o.r. mines for 99% Cornish white.

BISMUTH.—There is no change to report, a fair demand continuing at the official price of 7s. 6d. per lb.

CADMIUM.—Rather quieter conditions prevailed during December, and although the undertone is still firm, spot is now offered at around 4s. 6d. to 4s. 8d. per lb., while forward shipment might be obtained at 4s. 1d.

COBALT METAL.—There is no alteration in the position, the official price remaining at 10s. per lb.

COBALT OXIDES.—A fair turnover is reported at 8s. per lb. for black and 8s. 10d. for grey.

PLATINUM.—Continued dullness in demand has led to a further reduction in the official price of refined metal to £15 5s. per oz. However, for merchant quantities this figure is still being shaded.

PALLADIUM.—About £9 10s. to £10 10s. is the current range of prices, the latter being the official rate.

IRIDIUM.—This market is quietly steady, with sponge and powder held for about £57 to £60 per oz.

LONDON DAILY METAL PRICES

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

	COPPER.						TIN.		ZINC (Spelter).	
	Standard.		Electrolytic.		Wire Bars	Best Selected.				
	Cash.	3 Months.	Near.	Forward.		Near.	Forward.	Cash.	3 Months.	Near.	Forward.
Dec.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
11	68 2 6	68 8 9	74 15 0	75 5 0	75 5 0	72 15 0	74 0 0	227 15 0	225 2 6	26 12 6	26 15 0
12	68 7 6	68 12 6	74 15 0	75 5 0	75 5 0	—	—	225 5 0	222 7 6	26 15 0	26 15 0
13	68 5 0	68 7 6	74 15 0	75 5 0	75 5 0	—	—	226 10 0	223 17 6	26 17 6	26 17 6
14	68 5 0	68 8 9	74 15 0	75 5 0	75 5 0	72 15 0	74 0 0	224 5 0	222 5 0	26 18 9	26 13 9
17	68 10 0	68 10 0	74 15 0	75 5 0	75 5 0	—	—	224 10 0	223 10 0	26 17 6	26 12 6
18	68 17 6	68 12 6	74 15 0	75 5 0	75 5 0	72 15 0	74 0 0	225 0 0	224 0 0	26 16 3	26 12 6
19	68 17 6	68 12 6	74 15 0	75 5 0	75 5 0	—	—	224 10 0	223 15 0	26 15 0	26 11 3
20	69 12 6	69 1 3	74 15 0	75 5 0	75 5 0	—	—	223 15 0	223 2 6	26 13 9	26 10 0
21	70 7 6	69 11 3	74 15 0	75 5 0	75 5 0	73 10 0	74 15 0	223 0 0	223 5 0	26 15 0	26 11 3
24	70 12 6	69 11 3	74 15 0	75 5 0	75 5 0	—	—	224 0 0	223 15 0	26 13 9	26 10 0
27	71 0 0	70 2 6	76 0 0	76 5 0	76 5 0	—	—	226 5 0	225 10 0	26 15 0	26 11 3
28	72 10 0	71 10 0	76 0 0	76 10 0	76 10 0	74 15 0	76 0 0	227 15 0	227 7 6	26 18 9	26 15 0
31	74 12 6	73 5 0	77 0 0	77 10 0	77 10 0	—	—	225 15 0	225 10 0	26 17 6	26 15 0
Jan.											
2	75 0 0	73 15 0	77 5 0	77 15 0	77 15 0	76 0 0	77 5 0	225 15 0	226 0 0	26 15 0	26 15 0
3	74 7 6	73 5 0	78 5 0	78 15 0	78 15 0	—	—	222 0 0	222 10 0	26 8 9	26 8 9
4	74 15 0	73 8 9	78 5 0	78 15 0	78 15 0	76 10 0	77 15 0	220 15 0	220 15 0	26 1 3	26 1 3
7	74 10 0	73 2 6	78 5 0	78 15 0	78 15 0	—	—	223 0 0	222 15 0	26 2 6	26 6 3
8	74 5 0	73 0 0	78 5 0	78 15 0	78 15 0	76 10 0	77 15 0	226 0 0	225 10 0	26 7 6	26 11 3
9	75 0 0	73 7 6	78 5 0	78 15 0	78 15 0	—	—	226 5 0	225 5 0	26 12 6	26 13 9

Selenium.—A very fair turnover is moving with black powder unchanged at 7s. 8d. to 7s. 9d. per lb. ex warehouse.

Tellurium.—Hardly any interest is shown in this commodity and prices are nominal at about 12s. 6d. to 15s. per lb.

Manganese Ore.—The market has ruled quiet, very little fresh buying having been seen. Consequently prices are rather nominal, but best Indian seems to be about 1s. 4d. per unit c.i.f., and ordinary grades 1s. 2d. to 1s. 2½d., while ordinary grades of Russian ore might be obtainable at slightly lower figures.

Aluminium.—No change has occurred in the price, which remains at £95 per ton, less the usual discounts.

Sulphate of Copper.—The price of this commodity has naturally been increased following the advance in copper prices, and English material now stands at about £27 to £27 10s. per ton, less 5%.

Nickel.—A steady business continues at the unaltered price of £170 to £175 per ton for both home and export business. Of considerable interest, however, is the merging of the International Nickel Co. and the Mond Nickel Co., Ltd., and the possibility of this affecting prices should not be ignored.

Chrome Ore.—There is nothing fresh to report, business remaining on a fair scale with quotations unaltered at £4 5s. to £4 7s. 6d. for Rhodesian and £4 10s. to £4 15s. c.i.f. for good quality Indian ore.

Quicksilver.—A moderate business is passing with consumers, but the current market quotation of £22 5s. to £22 10s. is still rather below the parity asked by the selling agency of the Spanish-Italian cartel.

Tungsten Ore.—December showed a further accession of strength in this market, and with nearby shipment from China practically unobtainable and spot material very scarce, prices advanced to about 20s. 6d. to 21s. per unit for forward shipment and 21s. to 21s. 3d. for prompt material.

LEAD.						SILVER.		GOLD.	
Soft Foreign.				English.					
Near.		Forward.				Forward.	Cash.		
£ s. d.		£ s. d.		£ s. d.		d.	d.	s. d.	Dec.
21 2 6		21 12 6		22 10 0		26 5/16	26 7/16	84 11½	11
21 6 3		21 13 9		22 10 0		26 5/16	26 7/16	84 11½	12
21 5 0		21 13 9		22 10 0		26 3/16	26⅜	84 11⅛	13
21 3 9		21 11 3		22 10 0		26¼	26⅜	84 11⅛	14
21 3 9		21 12 6		22 10 0		26 5/16	26 7/16	84 11⅛	17
21 5 0		21 13 9		22 10 0		26¼	26⅜	84 11⅛	18
21 6 3		21 15 0		22 10 0		26 5/16	26¼	84 11½	19
21 6 3		21 13 9		22 10 0		26 5/16	26 7/16	84 11½	20
21 2 6		21 11 3		22 10 0		26⅜	26 7/16	84 11¼	21
21 3 9		21 11 3		22 10 0		26 7/16	26¼	84 11⅛	24
21 5 0		21 11 3		22 10 0		26 7/16	26¼	84 11⅛	27
21 10 0		21 17 6		22 15 0		26 7/16	26¼	84 11½	28
22 0 0		22 6 3		23 5 0		26⅜	26 7/16	84 11½	31
									Jan.
22 5 0		22 13 9		23 10 0		26 5/16	26⅜	84 11½	2
22 6 3		22 13 9		23 10 0		26 5/16	26⅜	84 11¼	3
22 1 3		22 10 0		23 10 0		26 3/16	26⅜	84 11¼	4
22 3 9		23 12 6		23 10 0		26 7/16	26⅜	84 11⅛	7
22 3 9		23 11 3		23 10 0		26⅜	26 7/16	84 11½	8
22 1 3		22 10 0		23 10 0		26⅜	26 7/16	84 11½	9

Molybdenum Ore.—Rather easier conditions have developed here owing to the small demand, and Australian 85% concentrates are now offering at about 34s. 6d. to 35s. per unit c.i.f. and American at rather less.

Graphite.—The market continues quietly steady with 85 to 90% raw Madagascar flake about £25 to £27 per ton c.i.f. and high-grade Ceylon lumps about £22 to £24 c.i.f.

Silver.—On December 1 spot bars were 26 5/16d., the market at that time being very quiet. Subsequently India came forward as a buyer but China entered the ranks as a seller and on the 15th ult. spot bars closed at 26¼d. During the latter half of December the market was rather lifeless, but the undertone was a little better and on December 31 spot bars stood at 26⅜d.

STATISTICS

OUTPUTS UNION OF SOUTH AFRICA.

(Other than Gold.)

	September.	October.	November.
Coal..... Tons	1,434,957	1,448,465	1,422,320
Copper, metallic . Tons	249	985	991
Tin concentrate.. Tons	190	194	181

PRODUCTION OF GOLD IN THE TRANSVAAL.

	Rand.	Elsewhere.	Total.
	Oz.	Oz.	Oz.
January, 1928	808,209	36,648	844,857
February, ...	780,038	36,095	816,133
March	840,837	36,543	877,380
April	789,823	36,084	825,907
May.....	849,155	37,031	886,186
June	825,143	37,220	862,363
July	828,482	38,729	867,211
August	854,172	37,691	891,863
September	819,341	38,390	857,731
October	858,945	38,775	897,720
November	832,461	40,023	872,484
December.....	821,582	38,179	859,761
Total, 1928	9,968,188	451,408	10,359,596

NATIVES EMPLOYED IN THE TRANSVAAL MINES.

	Gold Mines.	Coal Mines.	Diamond Mines.	Total.
November 30, 1927 .	188,879	16,686	4,329	209,894
December 31	188,516	16,590	4,668	209,774
January 31, 1928 ...	193,063	16,720	5,167	214,950
February 29	197,340	16,696	5,664	219,700
March 31	199,487	16,943	5,742	222,172
April 30	199,820	16,870	5,650	222,340
May 31	198,461	16,695	5,189	220,345
June 30	197,186	16,553	4,839	218,578
July 31	194,584	16,724	4,535	215,843
August 31	194,788	16,767	4,807	216,362
September 30	194,936	16,803	4,889	216,628
October 31	193,147	16,506	4,762	214,415
November 30	190,870	16,241	4,481	211,592

COST AND PROFIT ON THE RAND.

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

	Tons milled.	Yield per ton.	Work'g cost per ton.	Work'g profit per ton.	Total working profit.
		s. d.	s. d.	s. d.	£
Dec'ber, 1927.	2,414,950	28 7	19 11	8 8	1,044,800
January 1928	2,428,600	28 2	19 9	8 5	1,021,891
February	2,357,900	28 1	19 11	8 2	959,824
March	2,552,100	27 11	19 9	8 2	1,039,078
April	2,381,800	28 2	20 0	8 2	971,128
May	2,571,900	28 0	19 7	8 5	1,084,465
June	2,500,100	28 2	19 10	8 4	1,038,851
July.....	2,528,600	27 11	19 8	8 3	1,048,432
August	2,580,700	27 11	19 7	8 4	1,079,152
September ...	2,485,700	27 11	19 7	8 4	1,040,368
October	2,612,500	27 9	19 5	8 4	1,092,162

PRODUCTION OF GOLD IN RHODESIA.

	1925	1926	1927	1928
	oz.	oz.	oz.	oz.
January.....	48,159	48,967	48,731	51,356
February	48,284	46,026	46,461	46,286
March	45,858	46,902	50,407	48,017
April	47,386	51,928	48,290	48,549
May	48,686	49,392	48,992	47,323
June.....	47,647	52,381	52,910	51,762
July	49,453	50,460	49,116	48,960
August.....	49,245	49,735	47,288	50,611
September.....	48,319	48,350	45,838	47,716
October	48,896	50,132	46,752	43,056
November	50,364	51,090	47,425	47,705
December	49,307	48,063	49,208	—
Total	581,104	593,426	581,428	531,141

TRANSVAAL GOLD OUTPUTS.

	November.		December.	
	Treated Tons.	Yield Oz.	Treated Tons.	Yield Oz.
Brakpan	83,500	£137,794	81,500	£134,934
City Deep	88,000	23,736	89,000	23,936
Cons. Main Reef	60,000	22,788	58,200	22,389
Crown Mines.....	217,000	71,377	207,000	69,362
D'rb'n Roodepoort Deep	40,600	13,577	40,300	13,997
East Rand P.M.....	141,000	37,783	141,000	38,050
Ferreira Deep	30,000	6,457	29,100	5,206
Geduld.....	82,500	25,796	85,000	26,262
Geldenhuis Deep	66,300	14,573	65,000	14,313
Glynn's Lydenburg ...	6,100	2,012	6,300	2,078
Government G.M. Areas	198,000	£387,232	192,000	£378,389
Kleinfontein	50,200	10,984	50,600	11,175
Llanglaagte Estate	79,000	£106,835	76,000	£105,420
Luipaard's Vlei	22,500	5,033	22,300	5,854
Meyer and Charlton ...	16,700	£18,910	17,200	£18,805
Modderfontein New ..	140,000	72,025	142,000	72,911
Modderfontein B	69,000	25,610	69,500	25,728
Modderfontein Deep ..	44,200	23,360	43,000	22,643
Modderfontein East ...	64,000	20,208	62,000	19,018
New State Areas	77,000	£137,193	73,000	£134,502
Nourse	60,500	16,962	54,200	16,397
Randfontein	209,000	£207,048	209,000	£206,708
Robinson Deep	76,700	21,509	77,000	21,573
Rose Deep	55,000	11,417	55,700	11,179
Sabie	3,450	£3,735	—	—
Simmer and Jack	78,100	19,069	79,100	18,463
Springs	67,500	£140,924	66,300	£135,706
Sub Nigel	25,000	23,367	25,000	23,247
Transvaal G.M. Estates	15,385	5,308	14,540	4,691
Van Ryn	39,000	£40,683	39,000	£40,123
Van Ryn Deep	64,000	£103,173	61,000	£101,251
Village Deep	59,000	16,027	58,000	15,653
West Rand Consolidated	75,000	£77,672	81,200	£87,289
West Springs	60,000	£78,504	59,000	£76,712
Witw'tersr'nd (Knights)	53,000	£47,333	54,000	£46,347
Witwatersrand Deep ..	44,000	10,015	43,000	9,236
Wolhuter.....	29,100	6,500	25,300	6,298

RHODESIAN GOLD OUTPUTS.

	November.		December.	
	Tons.	Oz.	Tons.	Oz.
Cam and Motor	24,500	12,126	25,000	11,041
Globe and Phœnix ...	6,044	5,448	—	—
Lonely Reef	5,200	2,898	—	—
Rezende	6,400	2,976	6,400	2,943
Shamva	47,000	£27,477	—	—
Sherwood Starr	4,700	£7,975	4,700	£8,319

WEST AFRICAN GOLD OUTPUTS.

	November.		December.	
	Tons.	Oz.	Tons.	Oz.
Ashanti Goldfields	8,585	9,068	8,710	9,305
Taquah and Abosso ...	9,300	£12,629	9,730	£13,257

GOLD OUTPUTS, KOLAR DISTRICT, INDIA.

	November.		December.	
	Tons Ore	Total Oz.	Tons Ore	Total Oz.
Balaghat	3,950	2,389	4,050	2,735
Champion Reef	9,525	5,075	9,770	5,729
Mysore.....	18,002	9,450	18,254	9,991
Nundydroog	10,500	6,351	10,575	6,367
Ooregum	14,000	8,399	14,000	8,401

WEST AUSTRALIAN GOLD STATISTICS.

	Reported for Export Oz.	Delivered to Mint Oz.	Total Oz.	Value £
December, 1927 ...	168	38,673	38,841	164,990
January, 1928	248	28,313	28,561	121,319
February	99	32,021	32,120	136,436
March	614	22,989	23,603	100,259
April	213	36,274	36,487	154,986
May	72	29,192	29,264	124,305
June	348	39,101	39,449	167,568
July	184	29,215	29,399	124,877
August	120	37,871	37,991	161,374
September	426	31,871	32,297	137,613
October	75	36,490	36,565	155,317
November	390	31,076	31,466	133,658
December	547	35,550	36,097	153,329

AUSTRALIAN GOLD OUTPUTS BY STATES.

	Victoria.	Queensland.	New South Wales.
	Oz.	Oz.	Oz.
January, 1928	891	3,906	1,336
February	2,276	886	1,103
March	2,098	1,339	4,176
April	2,311	846	318
May	2,990	321	397
June	3,932	498	487
July	3,208	772	154
August	2,637	690	3,447
September	—	644	364
October	—	—	—
November	—	—	—
December	—	—	—
Total	21,843	9,902	11,787

AUSTRALASIAN GOLD OUTPUTS.

	November.		December.	
	Tons	Value £	Tons	Value £
Associated G.M. (W.A.) .	5,532	8,6 '8	3,957	6,314
Blackwater (N.Z.)	3,605	6,628	2,782	5,044
Boulder Persev'ce (W.A.)	6,987	19,991	4,128	12,083
Grt. Boulder Pro. (W.A.)	10,305	27,825	—	—
Lake View & Star (W.A.)	8,213	14,268	—	—
Sons of Gwalia (W.A.) ..	14,270	11,608	7,100	7,724
South Kalgurli (W.A.) ..	9,100	16,447	—	—
Waihi (N.Z.)	18,249*b*	{ 5,783*g* 37,214*s*	22,864*a*	{ 6,810*g* 70,851*s*

a Four weeks to December 31. *b* Four weeks to November 17.
g Oz. gold. *s* Oz. silver.

MISCELLANEOUS GOLD, SILVER, AND PLATINUM OUTPUTS.

	November.		December.	
	Tons	Value £	Tons	Value £
Chosen Synd. (Korea) ..	7,240	9,839	—	—
Frontino & Bolivia (C'lbia)	1,720	4,134	1,740	6,008
Gabait (Sudan).....	400	2,345	410	1,455
La Noria (Mexico)	12,850	120,595*d*	—	—
Lampa (Bolivia).....	—	41,000*s*	—	—
Lydenburg Plat. (Trans.)	3,510	748*p*	3,330	671*p*
Marmajito (Colombia) ..	700	3,847	720	3,765
Mexican Corp. Fresnillo .	87,838	126,052*e*	—	—
Mexico El Oro (Mexico) .	—	—	—	—
Nus River (Colombia) ..	—	—	—	—
Onverwacht Platinum...	2,363	476*p*	2,260	495*p*
Oriental Cons. (Korea) ..	—	90,500*d*	—	90,500*d*
St. John del Rey (Brazil)	12,480	31,200	11,800	33,500
Santa Gertrudis (Mexico)	55,155	130,044*e*	—	—

d dollars. *p* Oz. platinoids. *e* Profit in dollars.
s Oz. silver.

Pato Mines (Colombia) : No. 1 dredge, 32 days to December 21, 80,289 from 203,206 cu. yd. ; No. 2 dredge, 38 days to December 22, 126,171 from 204,385 cu. yd.

COPPER, LEAD, AND ZINC OUTPUTS.

		Nov.	Dec.
Broken Hill Prop.	Tons lead conc. ..	—	—
	Tons zinc conc. ..	—	—
Broken Hill South	Tons lead conc. ..	5,574*b*	3,895*a*
	Tons zinc conc. ..	5,386*b*	3,918*a*
Burma Corporation ...	Tons refined lead	6,500	6,546
	Oz. refined silver	603,918	604,784
Bwana M'Kubwa.....	Tons copper oxide	595	725
Electrolytic Zinc	Tons zinc	3,811*g*	3,824*f*
Messina	Tons copper conc.	1,344	1,211
Mount Lyell	Tons copper	—	—
	Oz. silver	—	—
	Oz. gold	—	—
Namaqua	Tons copper	186	—
North Broken Hill.....	Tons lead conc. ..	7,570	—
	Tons zinc conc. ..	5,920	—
Poderosa	Tons copper ore..	1,059	—
Rhodesia Broken Hill..	Tons lead	393	414
	Tons slab zinc ...	910	932
San Francisco Mexico .	Tons lead conc. ..	3,000	3,538
	Tons zinc conc. ..	2,985	3,680
South American Copper	Tons Matte.....	—	—
Sulphide Corporation ..	Tons lead conc. ..	2,002*d*	—
	Tons zinc conc. ..	3,023*d*	—
Tetiuhe	Tons lead conc. ..	498	—
	Tons zinc conc. ..	1,132	—
Union Minière	Tons copper	9,250	—
Villemagne (Russo-Asiatic)....	Tons lead conc. ..	—	—
	Tons zinc conc. ..	—	—
Zinc Corporation	Tons lead conc. ..	4,898	5,124
	Tons zinc conc. ..	4,313	4,653

b Four weeks to December 1. *g* Four weeks to November 14.
d Four weeks to November 17. *f* Four weeks to December 12.
a Four weeks to December 29.

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

		October.	November.
Iron Ore	Tons ..	330,569	420,158
Manganese Ore.....	Tons ..	17,481	16,923
Iron and Steel	Tons ..	261,404	232,767
Copper and Iron Pyrites	Tons ..	30,829	29,535
Copper Ore, Matte, and Prec. . . .	Tons ..	4,190	2,686
Copper Metal	Tons ..	14,392	15,644
Tin Concentrate	Tons ..	7,113	7,726
Tin Metal	Tons ..	1,191	2,333
Lead Pig and Sheet.....	Tons ..	21,499	19,620
Zinc (Spelter)	Tons ..	10,941	13,253
Zinc Sheets, etc.	Tons ..	1,626	2,550
Aluminium	Tons ..	1,435	1,188
Quicksilver	Lb.....	728,072	114,079
Zinc Oxide	Tons ..	962	1,108
White Lead	Cwt....	13,603	15,437
Red and Orange Lead	Cwt....	3,961	3,504
Barytes, ground	Cwt....	53,267	78,872
Asbestos	Tons ..	3,972	2,725
Boron Minerals	Tons ..	—	1,686
Borax	Cwt....	4,805	3,220
Basic Slag	Tons ..	8,696	7,959
Superphosphates	Tons ..	4,651	5,301
Phosphate of Lime	Tons ..	23,146	30,641
Mica	Tons ..	274	342
Sulphur	Tons ..	11,522	1,184
Nitrate of Soda	Cwt....	90,641	130,132
Potash Salts	Cwt....	321,163	305,333
Petroleum : Crude	Gallons	59,426,728	19,565,851
Lamp Oil	Gallons	24,693,047	12,081,236
Motor Spirit	Gallons	52,386,202	40,291,406
Lubricating Oil	Gallons	8,258,795	5,122,829
Gas Oil	Gallons	7,143,605	12,746,091
Fuel Oil	Gallons	34,576,478	37,388,111
Asphalt and Bitumen	Tons ..	11,472	10,120
Paraffin Wax	Cwt....	134,970	103,355
Turpentine	Cwt....	40,389	23,369

IMPORTS AND EXPORTS OF GOLD AND SILVER.

	October.		November.	
	Imports.	Exports.	Imports.	Exports.
GOLD :				
Unrefined Bullion £	174,615	—	191,673	—
Refined Bars.... ,,	2,995,835	9,187,057	1,305,998	7,978,833
Coin ..... ,,	81,256	182,486	2,574,231	649,419
SILVER :				
Unrefined Bullion oz.	2,611,822	—	183,871	—
Refined ..... ,,	4,140,372	7,819,031	4,321,595	10,143,675
Coin ..... £	91,842	30,693	165,312	5,51

OUTPUTS OF NIGERIAN TIN MINING COMPANIES.

In Long Tons of Concentrate.

	October.	November.	December.
	Tons.	Tons.	Tons.
Amari	7⅛	10	—
Anglo-Nigerian	60	65	—
Associated Tin Mines	255	252	—
Baba River	8½	7½	—
Batura Monguna	7	6	—
Bisichi	42	60	50
Daffo	7	7	6
Ex-Lands	65	65	—
Filani	7½	4	2½
Jantar	40	40	—
Jos	25⅛	26	25½
Juga Valley	—	4½	—
Junction	12	21	—
Kaduna Prospectors	37⅝	52½	—
Kaduna	29½	30½	—
Kassa	17	17	—
Lower Bisichi	7	6½	—
Madubi	5½	—	—
Mongu	50	50	—
Naraguta	57	43½	—
Naraguta Acquisitions	1⅜	—	—
Naraguta Extended	25	25	—
Naraguta Karama	37½	31	25
Naraguta Korot	14	15	—
Nigerian Base Metals	25⅜	36½	—
Nigerian Consolidated	20	20	20
N.N. Bauchi	150	150	—
Offin River	2⅜	3½	9½
Ribon Valley	20	18¾	—
Ropp	83	84	80
Rukuba	5	4½	4
South Bukeru	6½	7½	6
Tin Fields	7	4⅜	6½
Tin Properties	—	19	—
United Tin Areas	10⅜	10½	—
Yarde Kerri	10	10	—

OUTPUTS OF MALAYAN TIN COMPANIES.

In Long Tons of Concentrate.

	Oct.	Nov.	Dec.
	Tons.	Tons.	Tons.
Ampang	21½	25	—
Chenderiang	21	26	24
Gopeng	71½	74½	77½
Idris Hydraulic	46	47⅜	38⅜
Ipoh	50⅛	46⅜	42
Kamunting	115	110	97
Kent (F.M.S.)	57	58	59⅞
Kepong	26	34½	24
Kinta	31	34½	34⅛
Kinta Kellas	33½	34⅜	—
Kramat Pulai	20⅜	24½	24⅜
Kuala Kampar	—	145	—
Lahat	17⅜	20⅜	21⅜
Malaya Consolidated	72	75	79
Malayan Tin	148⅜	148⅜	160¾
Meru	29½	30	—
Pahang	207	208½	209½
Pari	—	—	—
Pattani	6	5½	5
Pangkalan	60	71½	65½
Petaling	209	192	178½
Rahman	41⅜	53½	59½
Rambutan	14	14	15
Rantau	36	40	52
Renong	50¼	57	60⅛
Selayang	23	26	25⅜
Southern Malayan	80⅛	92½	104½
Southern Perak	53½	107½	80½
Sungei Besi	44	44	46
Sungei Kinta	41½	35⅜	29⅜
Sungei Way	32¾	32⅜	35¾
Taiping	47	34	35
Tanjong	41¾	46	41¾
Teja Malava	—	—	—
Tekka	46	48	48
Tekka-Taiping	48	49	51
Tronoh	65¾	89	108

PRODUCTION OF TIN IN FEDERATED MALAY STATES.

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

	Tons.		Tons.
January, 1928	4,877	July, 1928	5,488
February	4,325	August	5,499
March	5,174	September	5,071
April	4,772	October	5,161
May	5,321	November	5,483
June	5,478	December	5,249
		Total 1928	61,898

OUTPUTS OF OTHER TIN MINING COMPANIES.

In Long Tons of Concentrate.

	Oct.	Nov.	Dec.
	Tons.	Tons.	Tons.
Anglo-Burma (Burma)	17⅞	28	19½
Aramayo Mines (Bolivia)	359	327	—
Bangrin (Siam)	32⅜	32½	33¾
Berenguela (Bolivia)	30	32	—
Briseis (Tasmania)	27	28	—
Consolidated Tin Mines (Burma)	—	84*	107*
Dolcoath (Cornwall)	—	—	—
Eastern Siam (Siam)	12	9	11
East Pool (Cornwall)	82¼	81	—
Fabulosa (Bolivia)	115	125	158
Geevor (Cornwall)	60	64	70
Jantar (Cornwall)	12½	11	—
Kagera (U'ganda)	23	23	23
Leeuwpoort (Transvaal)	—	—	—
Levant (Cornwall)	—	—	—
McCreedy (Swaziland)	—	—	—
Rooiberg (Transvaal)	—	—	—
San Finx (Spain)	37⅜*	38	—
Siamese Tin (Siam)	80⅞	103	117½
South Crofty (Cornwall)	67	69	73¾
Tavoy Tin (Burma)	35	40	—
Theindaw (Burma)	5	6	—
Tongkah Harbour (Siam)	51	81	87
Toyo (Japan)	30	25	—
Wheal Kitty (Cornwall)	29	27	—

* Tin and Wolfram.

STOCKS OF TIN.

Reported by A. Strauss & Co., Ltd., Long Tons.

	Dec. 31.
United Kingdom Stocks :	
Straits	1,879
Australian	99
Banka	152
Other Standard	5,378
Banka Straits and Australian Landing	445
United Kingdom Afloat :	
Straits	1,438
Australian	45
Banka	76
Continent :	
Banka in Holland	—
Do. Afloat	1,826
Straits do.	625
Other Countries :	
Straits and Banka Afloat	618
United States Straits and Standard :	
Afloat	8,500
Landing	1,733
Stock	695
Total	22,508

SHIPMENTS, SUPPLY, AND CONSUMPTION OF TIN.

Reported by A. Strauss and Co., Ltd., Long Tons.

	Dec.
Imports of Bolivian Tin into U.K.	3,603
Total Shipments of Bolivian Tin	3,287*
Imports of Nigerian Tin	856
Shipments of China Tin	680
Shipments of Straits Tin	7,958
Shipments of Banka Tin	1,080
Supply :	
Straits United Kingdom	1,248
,, Continent	610
,, United States	5,570
,, Other Countries	530
Banka	1,730
Australian	75
Standard U.K. and U.S.A.	3,086
Total	12,849
Consumption :	
United Kingdom deliveries	1,238
Dutch ,,	920
United States ,,	7,155
Continent ,,	869
Other Countries ,,	590
Total	10,772

* November.

OUTPUTS REPORTED BY OIL-PRODUCING COMPANIES.

In Tons.

	October.	Nov.	Dec.
Anglo-Ecuadorian	13,306	13,378	13,679
Anglo-Egyptian	20,351	20,342	25,442
Apex Trinidad	28,900	33,530	31,970
Attock	2,665	5,150	—
British Burmah	6,013	5,520	—
British Controlled	22,656	28,880	37,559
Dacia Romano	3,120	3,110	—
Kern Mex	1,720	1,541	—
Kern River (Cal.)	5,729	5,359	—
Kern Romana	4,187	3,732	—
Kern Trinidad	4,194	3,646	—
Lobitos	24,455	23,604	25,722
Mexican Eagle	69,285	78,286	100,714
Phœnix	31,168	29,502	29,236
St. Helen's Petroleum	4,849	4,626	—
Steaua Romana	65,110	63,420	64,430
Trinidad Leaseholds	38,050	35,350	35,150
United of Trinidad	4,411	4,570	4,883
Venezuela Oil Concessions	445,510	445,295	575,666

QUOTATIONS OF OIL COMPANIES SHARES.

Denomination of Shares £1 unless otherwise noted.

	Dec. 6, 1928			Jan. 7, 1929		
	£	s.	d.	£	s.	d.
Anglo-American	3	13	9	3	2	6
Anglo-Ecuadorian	1	5	0	1	5	0
Anglo-Egyptian B	2	18	9	3	0	0
Anglo-Persian 1st Pref.	1	7	3	1	8	9
" " Ord.	4	5	0	4	13	9
Apex Trinidad (5s.)	1	3	9	1	5	0
Attock	1	7	6	1	7	6
British Burmah (8s.)		7	3		7	6
British Controlled ($5)		6	3		6	0
Burmah Oil	4	11	3	4	13	9
Kern River, Cal. (10s.)		8	6		8	6
Lobitos, Peru	2	11	3	2	7	6
Mexican Eagle, Ord. (4 pesos)		15	6		15	6
" " 8% Pref. (4 pesos)		14	9		15	0
Phœnix, Roumania		15	6		15	6
Royal Dutch (1,000 fl.)	33	10	0	33	15	0
Shell Transport, Ord.	5	17	6	5	16	3
" " 5% Pref. (£10)	9	15	0	9	17	6
Steaua Romana		11	6		12	3
Trinidad Leaseholds	3	17	6	4	0	0
United British of Trinidad (6s. 8d.)		9	0		8	6
V.O.C. Holding	4	5	0	4	8	9

PETROLEUM PRODUCTS PRICES London, January 4.

Refined Petroleum: Water white 8½d. per gallon; standard white, 7¼d. per gallon; in barrels 3d. per gallon extra.

Motor Spirit: Inner London Zone: Aviation spirit 1s. 6½d. per gallon; No. 1, 1s. 2¾d. per gallon; No. 3, 1s. 0¾d. per gallon.

Fuel Oil: Furnace fuel oil, £3 7s. 6d.; Diesel oil, £4 per ton.

American Oils: Best Pennsylvania crude at wells, $2·85 per barrel. Refined standard white for export: in barrels 14·25 cents. Refined water white: in barrels 15·25 cents.

DIVIDENDS DECLARED BY MINING COMPANIES.

During month ended January 10.

Figures in brackets represent par value of shares and the dates are the days on which the dividends are payable.

Apex (Trinidad) (5s.), final 20% less tax.
Cam and Motor (£1), 7½% less tax.
Globe and Phœnix (5s.), interim 1s. 6d. tax paid, January 10.
Gopeng Consolidated (£1), interim 9d. less tax, January 7.
Idris Hydraulic (5s.), interim 10% less tax, January 28.
Kamunting Tin Dredging (5s.), interim 6d. tax paid, January 31.
Kinta Tin (5s.), interim 3d. less tax, December 22.
Malayan Tin Dredging (5s.), interim 20% less tax, December 19.
Onverwacht Platinum (10s.), interim 3d., February 4.
Pengkalen (5s.), 10% less tax, January 25s.
Rezende Mines (£1), interim 12½% less tax.
San Francisco Mines (10s.), final 2s. 6d. less tax, January 9.
Shamva (£1), interim 6d. less tax, January 17.
Sherwood Starr (£1), 5% less tax.
South Kalgurli (10s.), interim 1s. less tax, January 21.
Southern Malayan Tin Dredging (£1), interim 5% less tax, December 19.
Southern Perak Dredging (£1), interim 10% less tax, December 19.
Sungei Besi (5s.), interim 5% less tax, December 28.
Tanjong Tin Dredging (5s.), interim 3d. less tax, December 22.
Tronoh (5s.), interim 5% less tax, December 29.

PRICES OF CHEMICALS. January 4.

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

		£	s.	d.
Acetic Acid, 40%	per cwt.		17	0
" 80%	"	1	16	0
" 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	19	0	0
" Carbonate	"	26	0	0
" Nitrate	"	24	0	0
" Phosphate	"	41	0	0
" Sulphate, 20·6% N.	"	10	10	0
Antimony, Tartar Emetic	per lb.		1	3
" Sulphide, Golden	"			7
Arsenic, White	per ton	16	10	0
Barium Carbonate, 92%	"	5	5	0
" Chlorate	per lb.			5
" Chloride	per ton	11	10	0
" Sulphate	"	6	0	0
Benzol, standard motor	per gal.		1	6
Bleaching Powder, 35% Cl.	per ton	7	10	0
" Liquor, 7%	"	3	5	0
Borax	"	20	0	0
Boric Acid	"	30	0	0
Calcium Chloride	"	4	15	0
Carbolic Acid, crude 60%	per gal.		2	0
" " crystallized, 40°	per lb.			6½
Carbon Disulphide	per ton	24	0	0
Citric Acid	per lb.		2	6
Copper Sulphate	per ton	27	0	0
Cyanide of Sodium, 100% KCN	per lb.			7
Hydrofluoric Acid	"			7½
Iodine	per oz.		1	0
Iron, Nitrate	per ton	7	0	0
" Sulphate	"	2	0	0
Lead, Acetate, white	"	40	0	0
" Nitrate	"	35	0	0
" Oxide, Lithage	"	28	0	0
" White	"	37	0	0
Lime, Acetate, brown	"	9	0	0
" " grey, 80%	"	17	0	0
Magnesite, Calcined	"	8	0	0
Magnesium, Chloride	"	6	10	0
" Sulphate	"	3	7	6
Methylated Spirit 64° Industrial	per gal.		1	5
Nitric Acid, 80° Tw.	per ton	21	0	0
Oxalic Acid	per lb.			3
Phosphoric Acid	per ton	30	0	0
Potassium Bichromate	per lb.			4
" Carbonate	per ton	26	0	0
" Chlorate	per lb.			3
" Chloride 80%	per ton	9	0	0
" Hydrate (Caustic) 90%	"	33	0	0
" Nitrate, refined	"	21	0	0
" Permanganate	per lb.			5
" Prussiate, Yellow	"			7
" " Red	"		1	9
" Sulphate, 90%	per ton	10	0	0
Sodium Acetate	per ton	21	10	0
" Arsenate, 45%	"	26	0	0
" Bicarbonate	"	10	15	0
" Bichromate	per lb.			3½
" Carbonate (Soda Ash)	per ton	6	5	0
" " (Crystals)	"	5	5	0
" Chlorate	per lb.			3
" Hydrate, 76%	per ton	15	0	0
" Hyposulphite	"	9	0	0
" Nitrate, 96%	"	10	5	0
" Phosphate	"	12	0	0
" Prussiate	per lb.			4½
" Silicate	per ton	10	0	0
" Sulphate (Salt-cake)	"	2	12	6
" " (Glauber's Salt)	"	2	10	0
" Sulphide	"	9	10	0
Sulphur, Roll	"	11	0	0
" Flowers	"	12	0	0
Sulphuric Acid, 168°	"	6	5	0
" " free from Arsenic, 144°	"	4	0	0
Superphosphate of Lime, 30%	"	2	15	0
Tartaric Acid	per lb.		1	4
Turpentine	per cwt.	2	8	6
Tin Crystals	per lb.		1	7
Titanous Chloride	"			10
Zinc Chloride	per ton	12	0	0
Zinc Dust	"	35	0	0
Zinc Oxide	"	£40	to	£42
Zinc Sulphate	"	10	10	0

SHARE QUOTATIONS

Shares are £1 par value except where otherwise noted.

GOLD AND SILVER:	Dec. 6, 1928. £ s. d.	Jan. 7, 1929. £ s. d.
SOUTH AFRICA:		
Brakpan	4 13 9	4 15 0
City Deep	12 6	12 6
Consolidated Main Reef	19 6	18 9
Crown Mines (10s.)	3 7 6	3 7 6
Daggafontein	17 6	1 0 0
Durban Roodepoort Deep	10 0	11 3
East Geduld	1 15 0	1 13 9
East Rand Proprietary (10s.)	15 6	15 6
Ferreira Deep	5 6	6 3
Geduld	3 11 3	3 12 6
Geldenhuis Deep	4 6	4 9
Glynn's Lydenburg	5 0	5 0
Government Gold Mining Areas (5s.	2 0 0	2 0 0
Kleinfontein	3 0	2 9
Langlaagte Estate	1 2 0	1 2 6
Luipaards Vlei (4s.)	4 9	4 9
Meyer & Charlton	10 0	10 0
Modderfontein New (10s.)	5 6 3	5 7 6
Modderfontein B (5s.)	1 5 0	1 5 0
Modderfontein Deep (5s.)	1 15 0	1 15 0
Modderfontein East	1 13 9	1 11 3
New State Areas	1 12 6	1 12 6
Nourse	9 6	9 3
Randfontein	8 0	8 6
Robinson Deep A (1s.)	15 0	15 0
" " B	11 3	11 3
Rose Deep	6 6	5 3
Simmer & Jack (2s. 6d.)	3 3	2 9
Springs	3 12 6	3 12 6
Sub Nigel (10s.)	2 12 6	2 8 9
Transvaal Gold Mining Estates	10 6	10 6
Van Ryn	11 3	10 0
Van Ryn Deep	2 5 0	2 6 3
Village Deep	3 6	4 0
West Rand Consolidated (10s.)	11 3	12 9
West Springs	1 2 6	1 2 6
Witwatersrand (Knight's)	10 0	9 0
Witwatersrand Deep	5 6	5 0
Wolhuter	1 0	1 0
RHODESIA:		
Cam and Motor	2 2 6	1 18 9
Gaika	5 6	5 6
Globe and Phœnix (5s.)	12 0	13 9
Lonely Reef	1 13 9	1 12 6
Rezende	18 9	17 6
Shamva	15 0	13 6
Sherwood Starr	11 3	12 6
GOLD COAST:		
Ashanti (4s.)	19 6	1 3 6
Taquah and Abosso (5s.)	2 6	2 6
AUSTRALASIA:		
Associated Gold Mines (4s.), W.A.	1 0	1 3
Blackwater, N.Z.	2 6	2 6
Boulder Perseverance (1s.), W.A.	1 0	1 0
Great Boulder Proprietary (2s.), W.A	2 6	2 6
Lake View and Star (4s.), W.A.	10 0	12 0
Sons of Gwalia, W.A.	3 9	3 6
South Kalgurli (10s.), W.A.	16 9	16 9
Waihi (5s.), N.Z.	14 6	14 6
Waihi Grand Junction, N.Z.	1 0	1 0
Wiluna Gold, W.A.	1 3 9	1 2 6
INDIA:		
Balaghat (10s.)	6 3	
Champion Reef (10s.)	9 6	6 0
Mysore (10s.)	15 3	9 6
Nundydroog (10s.)	17 0	15 3
Ooregum (10s.)	13 0	17 3
		11 9
AMERICA:		
Camp Bird (2s.), Colorado	3 3	3 9
Chosen (Korea)	17 6	17 6
Frontino and Bolivia, Colombia	8 9	8 9
Keeley Silver ($1.00), Ontario	1 9	1 6
Mexican Corporation, Mexico	9 0	10 3
Mexico Mines of El Oro, Mexico	1 7 6	1 2 6
Oroville Dredging, Colombia (4s.)	3 3	3 0
Panama Corporation	12 6	11 3
St. John del Rey, Brazil	12 3	11 9
Santa Gertrudis, Mexico	14 0	14 3
Selukwe (2s. 6d.), British Columbia	7 6	7 6
Vipond ($1), Ontario	2 6	3 9
RUSSIA:		
Lena Goldfields	5 6	5 3
Orsk Priority	3	3

DIAMONDS:	Dec. 6, 1928 £ s. d.	Jan. 7, 1929 £ s. d.
Consol. African Selection Trust (5s.)	1 6 3	1 7 6
Consolidated of S.W.A.	1 1 3	1 1 3
De Beers Deferred (£2 10s.)	12 7 6	11 17 6
Jagersfontein	2 12 6	2 7 6
Premier Preferred (5s.)	5 12 6	5 12 6
COPPER:		
Arizona Copper (5s.) Arizona	1 0 0	19 3
Bwana M'Kubwa (5s.) Rhodesia	10 9	14 6
Esperanza Copper, Spain	18 0	18 6
Messina (5s.), Transaval	16 6	18 0
Mount Lyell, Tasmania	1 17 6	2 0 0
Namaqua (£2), Cape Province	1 1 3	1 2 6
Rio Tinto (£5), Spain	60 0 0	63 5 0
Roan Antelope (5s.), Rhodesia	1 17 6	2 2 9
Tanganyika, Congo and Rhodesia	3 1 3	3 5 0
LEAD-ZINC:		
Broken Hill Proprietary N.S.W.	1 6 0	1 5 6
Broken Hill North, N.S.W.	5 2 6	5 2 6
Broken Hill South, N.S.W.	2 13 9	2 15 0
Burma Corporation (10 rupees)	15 3	19 6
Electrolytic Zinc Pref., Tasmania	1 15 0	1 15 0
Mount Isa, Queensland	1 12 6	1 13 9
Rhodesia Broken Hill (5s.)	4 9	4 9
Russo-Asiatic Consd. (2s. 6d.)	3 0	3 6
San Francisco (10s.), Mexico	1 11 0	1 13 9
Sulphide Corporation (15s.), N.S.W.	16 0	17 9
Tetiuhe (5s.), Siberia	4 0	4 0
Zinc Corporation (10s.), N.S.W.	2 6 3	2 8 9
TIN:		
Aramayo Mines (25 fr.), Bolivia	3 7 6	3 8 9
Associated Tin (5s.), Nigeria	14 3	12 3
Bangrin, Siam	2 0 0	2 0 0
Bisichi (10s.), Nigeria	10 6	9 9
Briseis, Tasmania	3 0	3 0
Chenderiang, Malay	13 0	12 0
Dolcoath (10s.), Cornwall	9	9
East Pool (5s.), Cornwall	2 0	2 0
Ex-Lands Nigeria (2s.), Nigeria	3 3	3 3
Fabulosa ($1.00), Bolivia	9	9
Geevor (10s.), Cornwall	8 0	8 0
Gopeng, Malaya	2 8 9	2 5 0
Idris (5s.), Malaya	17 6	18 0
Ipoh Dredging (16s.), Malay	1 12 6	1 10 0
Kamunting (5s.), Malay	17 6	17 0
Kinta, Malay	13 6	12 9
Lahat, Malay	14 6	13 6
Malayan Tin Dredging (5s.), Malay	1 5 6	1 6 0
Mongu (10s.), Nigeria	11 6	10 9
Naraguta, Nigeria	1 11 2	1 7 6
Nigerian Base Metals (5s.)	5 3	5 3
N.N. Bauchi, Nigeria (10s.)	1 3 0	1 2 9
Pahang Consolidated (5s.), Malay	10 6	10 6
Pengkalen (5s.), Malay	19 3	1 0 3
Petaling (2s. 4d.)	12 0	11 6
Renong Dredging, Malay	1 12 6	1 12 6
Ropp (4s.), Nigeria	10 0	9 6
Siamese Tin (5s.), Siam	19 6	17 6
South Crofty (5s.), Cornwall	6 3	6 3
Southern Malayan	2 10 0	2 12 6
Southern Perak, Malay	2 11 2	2 15 0
Southern Tronoh (5s.)	10 6	11 0
Sungei Besi (5s.), Malay	11 6	13 6
Tavoy (4s.), Burma	18 9	16 6
Tekka, Malay	1 0 0	1 0 0
Tekka Taiping, Malay	1 2 3	1 2 3
Toyo (10s.), Japan	11 3	10 9
Tronoh (5s.), Malay	18 3	19 9
FINANCE, ETC.:		
Anglo-American Corporation	1 18 9	2 0 0
Anglo-French Exploration	1 4 0	1 3 0
Anglo-Oriental (5s.)	11 6	11 3
British South Africa (15s.)	1 12 6	1 17 6
Central Mining (£8)	18 5 0	19 5 0
Chemical & Metallurgical Corp. (2s.)	4 6	3 9
Consolidated Gold Fields	2 18 9	2 18 9
Consolidated Mines Selection (10s.)	18 3	18 3
General Mining and Finance	1 7 6	1 7 6
Gold Fields Rhodesian (10s.)	10 6	10 6
Johannesburg Consolidated	2 7 3	2 9 6
London Tin Syndicate	4 1 3	3 11 3
Minerals Separation	2 15 0	3 0 0
National Mining (8s.)	3 9	4 6
Rand Mines (5s.)	3 5 0	3 7 6
Rhodesian Congo Border	2 0 0	3 2 6
Southern Rhodesia Base Metals	6 0	5 0
South-West Africa	16 6	16 0
Tin Selection Trust	1 13 0	1 11 9
Union Corporation (12s. 6d.)	4 10 0	4 11 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.

COPPER FROM MINE WATERS AT BRITANNIA MINE

The November *Canadian Mining and Metallurgical Bulletin* contains a paper by F. Ebbutt and W. E. Selnes on the precipitation of copper from mine waters at the Britannia copper mine, British Columbia. In giving extracts from this paper, it may be mentioned that the mine was described in our pages in September and October, 1923, and that the extraction of copper from the mine waters is a more recent development.

The waters treated for copper are derived from the Fairview mine; this was the first extensive copper producer of the Britannia ore-bodies, and consisted of a number of almost parallel veins, carrying good copper values, the ore consisting of chalcopyrite and pyrite in a quartz gangue. The rocks are sheared and altered, the resultant rock being a fissile quartz-sericite or quartz-chlorite schist. The mineralization invariably occurs in this chlorite schist. The Fairview veins outcropped on the summit of Britannia mountain at an elevation of 4,200 ft., within three miles of tidewater. Mining of the Fairview ore-body was carried out by a system of shrinkage stopes and glory-holes and has resulted in a glory-holed, caved, or crushed area of roughly fifteen acres on the saddle of Britannia mountain, and a partial crushing and cracking up of large parts of several of the upper levels. In this "crushed zone" much of the remaining low-grade sulphides have become tarnished with a thin bornite coating. Small quantities of sooty chalcocite and little crystals of copper sulphate have developed in cracks or on walls of old workings. Rainfall amounts to an annual average of about 100 in., made up almost entirely of heavy autumn and spring rains and deep winter snows, the summers being comparatively dry. Naturally a great deal of this precipitation runs off, but much trickles and seeps down through the crushed zone. The old glory-holes and caved areas constitute a good holding ground for large quantities of snow which acts as a reservoir and ensures a good percolation through the crushed zone till well on in July. Although it had been noted that copper precipitated out on the rails and on other iron with which the water came in contact, it was not at first realized that the water contained copper values worth recovering. In 1923, for the first time, serious thought was given to the matter, with the result that samples of the mine water were taken at various points, the assays indicating that the water contained appreciable amounts of copper in the form of copper sulphate.

In the summer of 1924 a flume was built near the 1,000 Bluff Portal at the site of the old Jane camp. Experiments were conducted to determine whether copper precipitation could be made an economic success, and several precipitation media were utilized. Tests conducted using scrap iron only gave a recovery of 45%; scrap iron and scrap tinplate used together yielded 55% recovery, whereas scrap tinplate used alone gave an 80% recovery. Thus it was readily seen that scrap tinplate was the most efficient precipitating medium. So far there has been no difficulty in obtaining sufficient scrap. These experiments in 1924 proved conclusively that copper precipitation could be carried on as a commercial enterprise, but the temporary experimental plant was dismantled, and the material recovered, as it was feared that otherwise the plant would be lost, owing to glory-holing nearby. In 1925, a precipitation plant—which is still in the experimental stage—was built to determine the profit to be obtained over a longer period. The site chosen was underground on the 1,200 level, and two parallel launders were built and continued a distance of 265 ft. These launders were joined and continued for 367 ft., making a total of 897 ft. The launders were built on a grade of 0·5% to facilitate the flow of water through them. They were made in 16 ft. sections, similar to those used by the Ohio Copper Company, of Bingham Canyon, Utah (see the MAGAZINE for November, 1923), but are of different cross-sectional area. The material used was 2 in. plank and the launders had inside dimensions of depth 32 in., width 16 in. Boards 1 in. by 12 in. placed upright on each side at the bottom supported the grating or grids upon which the scrap tin was placed. These grids were made in 4 ft. sections of 1 in. by $\frac{1}{2}$ in. cedar strips, tied together with $\frac{1}{8}$ in. by $\frac{1}{4}$ in. strips placed 1 in. apart. Thus, openings of $\frac{1}{2}$ in. by 1 in. permitted the cement copper to settle to the bottom of the launder. This type of grid was found unsatisfactory as the openings were too small, and from time to time grids with openings of larger cross-sectional area were constructed, until, in the plant now in operation, the openings are about $\frac{3}{4}$ in. square.

To prevent too rapid flow of water, baffles 28 in. high were placed between each launder and this facilitated the settling of the copper and prevented loss. Holes of $\frac{3}{4}$ in. diameter were bored near the end of each section from a height of 4 in. above the bottom to 28 in., these being used for the purpose of determining the amount of precipitate in the launder and also to draw off the water before removing the precipitate. The scrap tin was placed in the launders above the grids and the cement copper gradually settled as it was precipitated; and although the majority of it passed through the grids, some accumulated on the scrap tin and, by preventing the water from coming into contact with the iron, hindered precipitation. The formation of hydrogen gas, too, which collected under the scrap, also had the same effect, and to keep these injurious effects at a minimum the scrap was stirred daily with forks.

The launders were cleaned about every two weeks, and to do so the heads were cut off from the section being cleaned and the remaining water drained off by removing the spigots. The scrap tin was removed,

and the cement copper placed in small cars and taken to drying or settling tanks, where it was to stand for a few days to settle, after which the surplus water was siphoned off. The resulting cement copper, still containing about 40% moisture, was placed in bags containing about 100 lb. each, and transported from the mine for shipment to the Tacoma smelter.

In 1926, the first year for which records are available, smelter returns show that 200,000 lb. of copper were produced, using 400,000 lb. of scrap tin. The year's returns were as follows: Total expense, $19,813; gross revenue, $32,050; profit, $12,237.

It was found that these launders were inadequate to treat the water during high flow. During low flow conditions, the recovery was 94%, but with high water this decreased, the average for the year being only 61%. This figure takes into consideration only the water that flowed through the launders, an average of 4,500 gallons per hour being the recorded flow for the year.

Early in 1927, two additional launders of greater width and depth were constructed and the daily stirring of the tinplate was eliminated by utilizing air agitation, which has a purely mechanical effect. The air, introduced below the grids through a number of rubber hoses at a pressure of 70 lb. per square inch, bubbled upward, keeping the water agitated and the surface of the tinplate free from copper. Air agitation was found eminently successful, yielding a cement copper containing 60% to 70% copper, as compared with 35% to 50% for the launders operating without air agitation. This was due to the silt being kept in suspension instead of settling in the launders. The yield and recovery, too, increased, and it was necessary to clean these two launders every four or five days, the clean-up from each averaging from 1,000 to 1,500 lb. of cement copper. Further capacity was afforded in June, 1927, by the construction of two more launders identical with those just outlined.

It was evident that as the years passed, and as the crushed and worked out areas increased, it would be impossible to cope with the problem of precipitation in the limited amount of space available underground. The precipitation plant in the mine was at no time large enough to treat all of the water, and it was decided that a surface plant would effect economy in the operation as well as afford adequate space for expansion as necessity demanded. The site chosen was to the right of the 2,200 Portal near the shops, and a series of twenty launders, each divided into two compartments having inside dimensions of 5 ft. by 5 ft. by 5 ft., were constructed. The material used was cedar, and all metal parts were eliminated, as it was found with the old plant underground that the iron was readily attacked by the solution and consequently the cost for repairs would be high. The launders are built with the walls of 4 in. by 8 in. cedar planks, having grooves, ¾ in. by ¾ in., which butt together, and tarred splines, ¾ in. by 1½ in., were driven in to form the joint. The walls are reinforced by 6 in. by 8 in. upright timbers joined to the sill by mortise and tenon joints. This is made rigid by having a 1 in. hole through the sill and driving in fir trenails. Across the tops of the launders, braces, 3 in. by 8 in., are laid on edge. Wedges driven in a hole cut in the uprights bear down on the 3 in. by 8 in. planks, and hold the sides of the launders firmly. To ensure maximum recovery of copper, it is essential that the pregnant solution be in contact with the scrap for a sufficient length of time. This is accomplished by a series of baffles.

The bottom of the launder has an inclination of 1 in. to the foot and slopes towards a door through which the cement copper is removed. At each side of the door are placed 6 in. by 6 in. pieces having wedge-shaped grooves into which the door is driven. To make the door watertight, a soft rubber gasket, ¼ in. by 1 in. in section, is placed around the doorway. Considerable difficulty has been experienced in keeping the water from leaking out, and improvements in construction will be necessary before this doorway is entirely satisfactory.

The grids which support the scrap tinplate are made of 2 in. by ¾ in. material in sections 20 in. wide and 5 ft. long, having openings ¾ in. square. These grids are supported near the bottom of the launder, just above the lead pipes which introduce the air for agitation. These pipes, made of lead, extend from one side of the launder to the other, there being six pipes to each unit. Holes are drilled at intervals of 6 in., staggered so that the air jets out on each side and up through the water. The installation for supplying air consists of two units, each comprising a blower developing 3,450 revolutions, and each operated by a 30/36 h.p. motor. One unit makes sufficient air, the second being held in reserve. The air is held at 3½ lb. in a 16 in. sheet-metal pipe, which runs parallel to the plant, and from which the lead pipes introduce the air to the tanks.

In operating the plant the pregnant solution is allowed to run down to the 1,200 level from where it is delivered to a 12 in. wooden stave-pin, which runs down the mountain side for a distance of nearly half a mile, leading the water to a large surge tank where the velocity is decreased and a great deal of the silt and other foreign material settles out. The water enters at the bottom of the surge tank, and baffles are placed to retard the velocity. This surge tank is constructed with two compartments, so that the water can run through one while the other is being cleaned. During high water in the spring, it was found that the surge tanks could not settle sufficient silt from the water, and another settling tank will be constructed in the near future. Water leaving the surge tank enters a flume 6 in. in depth running the length of the plant, so that the water may be introduced into each launder separately, or into launders grouped in series, as desired.

For the storage of tinplate and cement copper, a building was constructed above the launders, and through a trap-door the cement copper can be lifted by a tugger hoist. The tinplate can be thrown into a small car which runs on a track above the launders, it thus being possible to deliver the tinplate to each launder without difficulty. The cement copper is scraped out through the small door at the bottom of the launder into settling launders, where the cement copper can be washed free of silt. The water is drained off through a number of spigots and cement copper escaping settles in the flume or collects in a large settling tank through which all of the tails must pass before going to waste.

It was not until the middle of January, 1928, that the entire plant was ready for operation, but six launders were available and charged with scrap and the water turned in on December 31, 1927. These six launders were unable to treat the

vast volume of water, which attained 13,000 gallons per hour owing to the heavy rains during the first half of January. However, they operated satisfactorily, considering the way they were overburdened and effected a 60% recovery from the water flowing through them. On January 11, when the full battery was put into operation, the percentage recovery made a huge leap and over 80% recovery was attained during the period of high flow. As the rains ceased, the water receded, and the copper content fell from 1·8 grams per litre to 0·6 grams per litre. It is due to the simultaneous dropping of the quantity of flow and the copper content that it is so difficult to design a plant capable of treating the water effectively under all conditions. A plant adequate for treating high-water will be too large for the smaller quantity during dry weather, and the problem is to decide the economic limit between recovery and plant capacity.

Scrap tinplate purchased from canneries has been found the most satisfactory precipitating medium. This scrap, obtained in bales weighing from 150 to 450 lb., is torn apart and shaken so that, when it is charged into the launders, it does not form too compact a mass. From 500 to 1,000 lb. constitutes an initial charge, and this is replenished from time to time as it is depleted by precipitation.

Originally, all of the launders were treated as separate units, the water entering the launder after being acted upon by the scrap being allowed to escape as tailings without further treatment. It was necessary to vary the quantity of water entering each launder, in order to determine the proper head requisite with a reasonable recovery, and it was found that, with a quantity of 300 gallons per hour, a recovery of 90% could be effected. Under these conditions, the entire plant could treat only 6,000 gallons per hour, or only half the quantity necessary, so experiments were conducted connecting the launders in series of twos, threes, and fours. The data obtained indicated that, whereas two launders in series could treat more than twice as much as each operating singly, three could treat six times as much without any appreciable lowering of the recovery.

Since January, 1926, a total of 1,125,000 lb. of copper has been obtained from the mine waters by these methods. The following table gives particulars of results :—

	Old Plant.		New plant.
	1926	1927	1928
Months in operation	12	12	
Average copper produced per month, lb.	19,439	38,422	52,892
Total cost per lb., cents	8·49	7·64	7·22
lb. of scrap used .	445,010	793,947	684,559
Scrap used per lb. of copper	1·80	1·72	1·62

During May, 1928, so far the peak month, 95,404 lb. of copper was produced, worth $13,847. Costs for this month were as follows :—

	$
Operating labour .	552·19
Cleaning and sacking .	350·49
Sacks . . .	396·86
Scrap tinplate . .	1,645·50
Air	35·91
Repairs . . .	187·53
Miscellaneous expense .	3,194·98
Total Cost . .	$6,343·46

MINING METHODS OF POTRERILLOS, CHILE

At the coming meeting of the American Institute of Mining and Metallurgical Engineers to be held in New York next month a paper will be presented on mining methods at the Potrerillos copper mine of the Andes Copper Mining Co., written by I. L. Greninger, mine superintendent. Some particulars of this enormous deposit of low-grade ore, which is under the control of the Anaconda Copper Mining Co., appeared in the MAGAZINE for March, 1918, and February, 1925. Mr. Greninger's paper is a lengthy one, and we give a brief outline herewith.

The Potrerillos mine of the Andes Copper Mining Co. is in the central part of Chile, Province of Atacama, 91·5 miles eastward by rail from the port of Chañaral, and is at a mean elevation of 10,500 ft. The ore occurrence has been known for many years, and many of the claims under individual ownership were worked in a small way before the property was acquired by the present owners. The highest grade oxide ores near the surface were mined by primitive methods, and, after sorting, the product, assaying around 15% copper, was hauled by mule carts a distance of about 50 miles to Pueblo Hundido on the State railway system, shipped to the port of Chañaral by train and thence to Europe by water. In 1913 William Braden acquired title to all the mining claims of the Compañia Minera de Potrerillos and in 1916 he sold his entire interest to the Andes Copper Mining Co.

The ore is found in an intrusion of porphyry, generally classified as quartz-diorite porphyry. This has been forced upward through thinly bedded sedimentaries, and the sedimentary strata have been broken and tilted as a result of the upward movement of the porphyry. The surface area of the intrusion measures about 1¼ miles from north to south and has a maximum width of ⅝ mile. Generally the width is greatest near the northerly limit, and the intrusion, having a rough wedge shape, tapers to a point at the extreme southerly end. All of the porphyry contains some copper, but a considerable portion of the intrusion is of too low a tenor to be considered as ore. The intrusion has left the sedimentaries—quartzite, limestone, and sandstone—tilted at an angle of from 50° to 60° from the horizontal, and the ore-bodies within the intrusion generally have the same dip as the sedimentaries.

The copper is found in the form of malachite, azurite, chalcocite, and chalcopyrite, with many other of the less common copper minerals in evidence. Of the total tonnage developed, about 35% is in the form of oxides and 65% in the sulphide form. Fortunately, the amount of mixed ore is small, the change from oxide to sulphide being sharp. At most points there is a thin blanket of leached porphyry between the oxide and sulphide ores, and the upper portions of the sulphide measures show the effect of this leaching through secondary enrichment in sulphide mineral. The zone of

secondary enrichment is generally not more than 65 ft. thick.

When the present owners became interested in the property, a campaign of churn drilling was inaugurated, and was continued for a number of years, 168 holes being put down. These holes varied in depth from about 164 ft. to 1,273 ft. The ground is soft and well suited to exploration by this method, except that caving of the holes was common, thus making necessary frequent changes in size of casing and reducing possible depth of holes: Prior to the year 1918, exploratory openings in the form of drifts and rises were driven to a total of 36,790 ft. This work, together with the churn drilling, served to prove the general position and form of the ore measures, and a plan of general development was decided upon early in the year 1917.

According to the plan adopted, an adit was to be driven under the then known ore. Driving of the adit was started in May, 1917, and the tunnel was completed to the location of the first ore bin in 1920. The general layout was to consist of: Main adit, at elevation of 9,754 ft., 2·17 miles long; intermediate haulage level, elevation 10,443 ft.; ore-passes connecting ore bins with intermediate haulage level; mining of sulphide and oxide ore above intermediate haulage level; driving of a second level at a point to be later determined, in order to serve for mining of sulphide ore below intermediate haulage level. This general plan has been adhered to, with such additions and changes as have seemed advisable from time to time.

The undercut caving system (sometimes called "block caving") was adopted both for mining

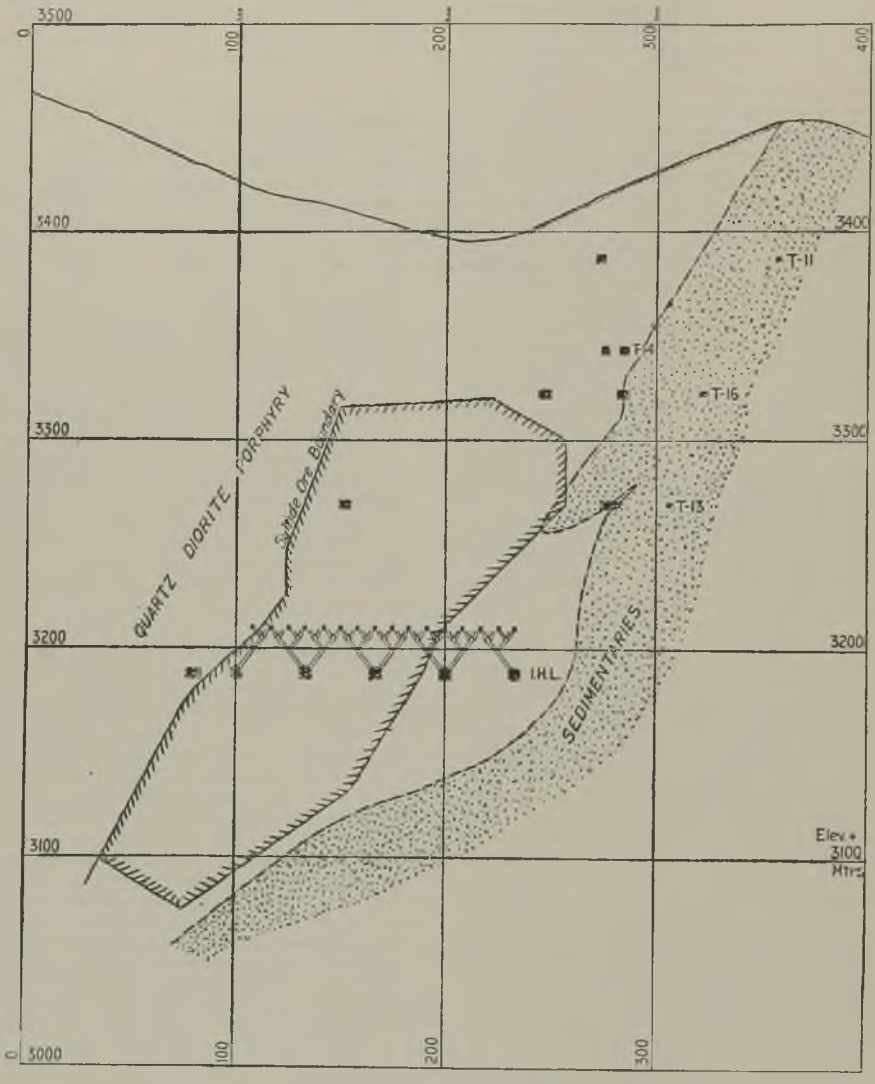


FIG. 1.—REPRESENTATIVE TRANSVERSE SECTION, SOUTH SULPHIDE ORE-BODY, SHOWING HAULAGE DRIFTS, AND MAIN AND BRANCH RISES.

ore and removal of waste. This system was first used in the United States in connection with non-ferrous metal-mining at the property of the Ohio Copper Co. in Utah and later was adopted by the Inspiration Consolidated Copper Co. at Inspiration, Arizona. It has since been used, with certain modifications, by the Nevada Consolidated at the Ruth mine, the Miami Copper Co., and others. Credit for pioneer work in connection with this system is largely due to Felix MacDonald, who is now, and has been for many years, mine superintendent for the Inspiration Consolidated Copper Co. at Inspiration.

Exploration by churn drilling showed that at some points the oxide ore reached the surface; at other points there was barren capping. It was determined that on some portions of the ore-body the capping was comparatively shallow and could be profitably removed, while in other localities the overburden was too thick to permit of its removal. Generally the northerly part of the ore-body has little or no capping, while the southern sulphide ore-body is covered to a vertical depth ranging from 328 to 656 ft. Metallurgical convenience dictated that mining should be started first on the sulphide ore, and it was therefore decided to begin work at the south end of the ore-body, as mining could be started there without waiting for removal of waste or oxide ore. As a matter of fact, there were several million tons of oxide ore in this locality which, while not directly overlying the sulphide ore to be mined first, was within the surface outline of the cave that would result as mining operations progressed. It was found that this oxide ore could be mined and stored for future recovery, in time to be out of the way before the cave resulting from the mining of sulphide ore endangered it.

Preparation for mining ore in the south sulphide ore-body was started in June, 1925, and in December, 1926, ore production was started. Fig. 1 represents a transverse section through the ore-body where mining was started, and also shows the workings on and above the intermediate haulage level. Fig. 2 is a plan of the intermediate haulage level showing the spacing of the drifts. Haulage drifts are driven at intervals of 109 ft. and are turned off from the gathering drifts at a angle of 42°. Main rises are located to conform to car lengths and are spaced at 20·5 ft. and 30·7 ft. The grizzly drifts are spaced 54·6 ft. from centre to centre, and located 39·3 ft. above the haulage drifts. Branch rises are driven at intervals of 27·3 ft. along the grizzly drifts, and the block served by each branch rise system measures 27·3 by 27·3 ft. Undercutting drifts are spaced 27·3 ft. centre to centre and 32·8 ft. above the grizzly level. The block first mined extended entirely across the ore-body from west to east, a distance of 656 ft. and measured 229·6 ft. from north to south. Experience has demonstrated that this block was somewhat larger than was advisable and new blocks are being laid out, extending across the ore measure but having a length from north to south of only 164 ft.

In each branch—or drawing off—rise, there is constructed a control set having four chutes. Branches are driven upward from these chutes and connect with the undercutting level at fixed intervals. Figs. 3 and 4 are a plan and section of the branch rise system showing the spacing of branch rises. Chute openings in control sets measure 3 by 3 ft., and have ordinary wooden gates. Angle iron 3 by 3 by $\frac{3}{8}$ in. is used for gate supports, as this material has proved much more satisfactory than wood.

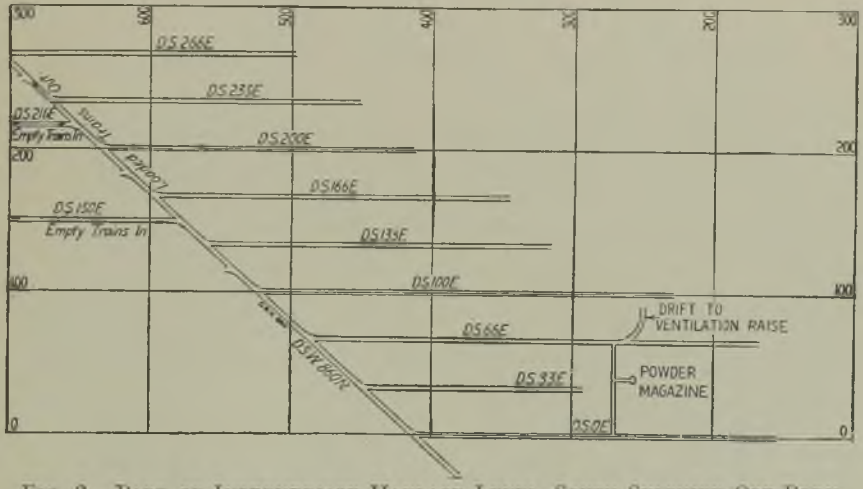


FIG. 2.—PART OF INTERMEDIATE HAULAGE LEVEL, SOUTH SULPHIDE ORE-BODY.

Undercutting is accomplished by driving a short cross-cut from a given undercutting drift where work is to be started. The cross-cut is used in order to provide room for handling long steel and to avoid the expense of supporting a large opening where ordinary widening of the drift is practised. The cross-cut is driven into the pillar a distance of 14·7 ft. and from this cross-cut undercutting holes 9·8 to 13·1 ft. long are drilled. Undercutting advances diagonally across the block and, in case of Block 1, was started at the westerly limit and carried across to the eastern side of the block, where it was completed.

Because the ore-body dips at an angle of about 50°, it is necessary for a large proportion of the grizzly and undercutting openings to be driven in the foot-wall. As the formation here is a badly broken sedimentary, crushing and closing of grizzly

drifts and branch rises have caused much trouble. In order to avoid this difficulty, recently the grizzly drifts have been lined with rubble masonry, the lining having an elliptical section. The major dimension of the ellipse is 7 ft. and the minor 4·5 ft. Limestone quarried on the surface is continual repairing of timbers in the grizzly drifts. It has also been found that if the grizzly drifts can be supported and prevented from crushing, very little trouble is caused by superimposed weight in branch rises and control sets.

Haulage drifts are supported by 10 by 10 in.

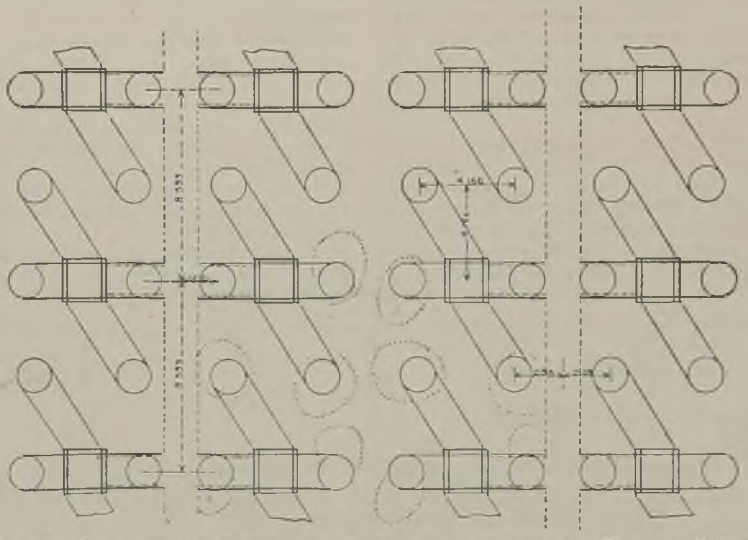


FIG. 3.—PLAN OF UNDERCUTTING LEVEL SHOWING TOP OF BRANCH RISES.

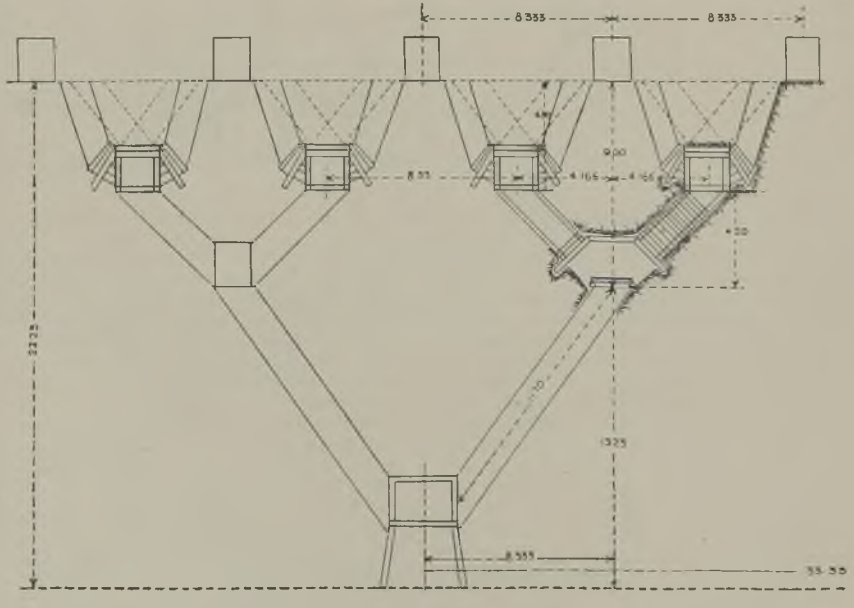


FIG. 4.—TRANSVERSE SECTION ON MAIN AND BRANCH RISE SYSTEM.

used for this purpose, and it is placed in cement mortar. The engineers are also experimenting with reinforced concrete for supporting grizzly drifts. So far the system (using masonry or concrete) has proved highly satisfactory, and although it is expensive, it is less so than the Douglas fir. Timber sets are placed 5 ft. centre to centre, except where chutes are constructed. Chute sets are spaced 3 ft. apart, and as 3 in. plank is used for building chutes, the inside width of chute is 30 in. All timbering is standardized, framing and cutting being done on the surface.

Where a connection is made etween haulage drifts, 8 in. by 10 in. H-beam steel is used for caps, as the span is too long to permit the use of timber where the ground is heavy; and where the ground is exceptionally heavy, 10 in. by 15 in. steel I-beams are used for caps. Practically all the main or transfer rises must be timbered, as the ground is broken and unstable. In the rises, 6 in. by 12 in. cribbing is used; the section of rise is 3 ft. 6 in. by 3 ft. 6 in. Cribbing is placed skin to skin and each set is protected with four pieces of angle steel, 3 by 3 by $\frac{3}{8}$ in., nailed to the upper corner of the 6 in. by 12 in. timber. For fastening angle steel, a $\frac{3}{8}$ in. by 4 in. chisel-point spike is used. These nails are much better than the ordinary wire spike for this purpose, as they are annealed and have a countersunk head.

It is also necessary that the branch rises above the grizzly level be closely timbered. The same system is used in these rises as for the transfer rises; that is, 6 in. by 12 in. timber cribbing placed skin to skin and protected with angle steel. A three-piece segment set is used over the grizzly and the posts of the segment set are placed at the proper angle and used as bearers for the cribbing above the grizzly.

As mining progresses toward the south, the bottom of the ore-body becomes progressively higher above the haulage level and transfer rises must be longer. These rises are being timbered with great care, as the loss of only a few sets would result in caving and closing of the rise. Where branches take off from main or transfer rises serving more than one grizzly, the sets are protected by 8 in. by 8 in. H-beams to prevent cutting out of the timbers. As noted before, grizzly drifts are supported by masonry lining where there is any danger of crushing. Undercutting drifts are not usually timbered when driven. When undercutting is started and caving begins it is sometimes necessary that timbers be placed in undercutting openings to support the ground until undercutting rounds have been drilled and blasted.

THE TAINTON ELECTROLYTIC ZINC PROCESS

In the MAGAZINE for April, 1924, a description was given of the high-acid electrolytic process introduced by U. C. Tainton for extracting zinc. In the *Engineering and Mining Journal* for December 1, Mr. Tainton describes the process and the plant erected by the Sullivan Mining Co. for treating zinc-bearing ores in the Cœur d'Alene district, Idaho. The Sullivan Mining Co. is controlled jointly by the Bunker Hill and Sullivan Co. and the Hecla Mining Co. and it should be mentioned here that this company is in no way associated with the Sullivan lead-zinc mine in British Columbia, owned by the Consolidated Mining and Smelting Co. of Canada.

The Cœur d'Alene ores cannot be classed as particularly favourable for electrolytic treatment, as they tend to form an unusually large amount of insoluble zinc ferrite in the roast, and they also yield considerable quantities of gelatinous silica in the leaching operation. In addition, they contain relatively large amounts of cobalt, which is one of the most troublesome of impurities from the standpoint of electrolytic zinc treatment. For these reasons the Sullivan Company's plant employs the high-acid process mentioned. In this process the return electrolyte used for leaching carries 28 to 30% free acid, and the electrolysis is carried out at a current density of 100 amperes per square foot, both of these two amounts being about three times as great as the corresponding figures in ordinary electrolytic zinc practice.

The plant is at a distance of about two miles south-west of the town of Kellogg and at an elevation of about 400 ft. above the Cœur d'Alene River. This site was chosen because it was already supplied with railroad tracks and afforded a convenient hill immediately behind the plant upon which the stack could be placed. The elevation so secured, together with the 250 ft. height of stack, permits the discharge of roaster gases at a point about 1,000 ft. above the valley bottom, and gives good insurance against smoke damage. The feed to the plant consists chiefly of concentrates from local mines. It is anticipated that the average grade of material heated will be not less than 40% and the plant was designed on this basis.

Concentrate comes into the plant on the upper track and is discharged direct into the ore bins below, which are of reinforced concrete and of a capacity of 1,200 tons. From these it is delivered by apron feeders to a conveyor belt, which passes along the front of the bins. It then goes over a weightometer, through a set of disintegrating rolls, and up an elevator to the feed bins of the roasters. The five roasters are of standard Wedge construction, 25 ft. outside diameter and provided with seven roasting hearths and one drying hearth. To secure increased capacity and better roasting, special attention has been paid to the circulation of the gases in the furnace. The drop-hole area has been greatly enlarged. Hot-air arms are provided on the lower hearths, having holes drilled along the length so as to produce a circular motion of the gases on the hearth. The air for these arms is provided by the cooling air from the rabble arms on the upper hearths. All rabble arms are air-cooled; and on the hot hearths the arms and rabbles are made of high-temperature-resisting alloy. Firing of the furnaces is done by means of Mahr oil burners, and temperatures are taken on each hearth by recording pyrometers.

Roaster gases travel through a steel flue of standard balloon type, 10 ft. wide and about 1,000 ft. long. The Cottrell treater, of the plate-and-wire type, is at the upper end of the flue at the base of the stack. The stack and flue system has been designed so that no extension will be required when the plant capacity is increased to 150 tons of zinc per day.

Calcine from the roasters is discharged to a Jacoby conveyor and thence to an elevator, which delivers it to a Leahy screen equipped with 20-mesh wire cloth. Oversize from this goes through a set of rolls and is returned to the roaster feed. Calcine passing through the screen goes directly to two magnetic separators of the Weatherill cross-belt type, built by the Dings Manufacturing Company. The main belt of each conveyor is 24 in. wide and has a rated capacity of 75 tons of calcine per day. The separators take out from 30 to 50% of magnetic material, and this drops directly to the ferrite bins below. That portion which is non-magnetic

drops over the end of the belt and goes to the oxide bins. From these bins the calcine is taken by a system of screw conveyors and elevators to the weighing bins above the primary agitators. There are three bins above each agitator—one ferrite, one oxide, and one for manganese ore. These bins are of 10-ton capacity and are equipped with individual feed, the entire unit being carried on Fairbanks dial scales so that the weights fed into the agitators can be read directly by the operator.

The primary agitators, three in number, are 20 ft. in diameter and 14 ft. 6 in. deep. When filled to a depth of 9 ft., they contain enough pulp at each charge to produce 15 tons of zinc metal in the cell room. In starting a charge, return electrolyte, previously heated to 60° C., is pumped into the agitator tank. A charge of ferrite is then run in, a quantity of manganese added to oxidize the iron, and the tank allowed to agitate for one hour to permit decomposition of the zinc ferrite. The feeder of the oxide bin is then started and the addition continued until all of the iron is precipitated, as shown by a test with thiocyanate spot paper. Before the end of the reaction the pulp comes up to boiling temperature and a considerable quantity of water is evaporated, stacks being provided to deal with the steam evolved. After the charge is neutralized, the pulp is dropped into a storage tank of the same size as the agitators, and thence it goes to the Burt filters. There are six of these, each 5 ft. in diameter by 40 ft. long, driven by a variable-speed motor, which allows a rotational speed of from two to eight revolutions per minute. A charge of pulp is dropped into a filter, the solution separated and the cake washed with water, after which the residue is repulped in the filter and sent to a Dorr thickener. From this thickener the residue is fed to an Oliver filter and thence to a Ruggles-Coles drier, which reduces the moisture to a point that makes it easy to handle the residue for shipment. Overflow from the Dorr thickener is not used as wash water, but is returned for repulping a fresh charge. The washing in a Burt filter is so complete that the amount of soluble zinc in the repulping water is unimportant.

The solution from the Burt filter goes into the purification system, where copper, cadmium, and cobalt are eliminated. This is done in mechanical agitator tanks, 22 ft. in diameter and 12 ft. deep, holding solution sufficient for the production of 28 tons of zinc at a single charge. Here the solution is agitated with zinc dust which, at a temperature of 80° C., precipitates these metals completely. The purified solution ordinarily contains less than 5 mg. per litre of cadmium and copper and less than 2 mg. of cobalt. After the metals are precipitated, the residue is pumped by means of centrifugal pumps through Shriver filter-presses having 35 frames, each 36 in. square. After filtration, the solution drops to two storage tanks known as check tanks, each holding 250 tons of solution. Each lot of solution is checked by the laboratory before being pumped over to the neutral storage tanks, whence it goes to the cell circuit. This system minimizes the danger of getting impure solution into the electrolytic circuit where it would lower the grade of the zinc produced and possibly give trouble in electrolysis.

The electrolytic division contains two circuits, each of 4,000 kw. capacity. Each circuit is supplied by a motor-generator set giving 8,000 amperes at 500 volts on the direct-current side. There are 150 cells in a circuit, each taking 8,000 amperes. The synchronous motor operates at 2,300 volts and is rated at 4,400 kva. Each cell contains 10 cathodes having a submerged area of 4 sq. ft. on each side and taking 800 amperes in normal operation. The cathodes are of ordinary commercial aluminium sheet, having an aluminium conductor bar welded at the upper end. Current is led into the conductor bar through a spring clip at the side of the cell, and the end of the bar is copper plated, to provide a good contact. This construction has proved greatly superior to the type previously used with copper bar riveted to the aluminium plate.

The cathodes slide in grooved wooden guides, which are fixed in the cell with a wooden framework. This framework also holds the anodes in fixed position and at a definite spacing from the cathode face. Two anodes are between each cathode, so that the electrode spacing may be readily varied. The anodes are perforated to permit free circulation of the electrolyte and decrease the terminal voltage. During operation, solution is circulated to all cells in parallel from a feed launder directly over the centre of each cell. The solution drops through a hard-rubber pipe to the centre of the cell and overflows at each end, also through hard-rubber pipe, down to a sump below. From this sump it flows through a thickener, where manganese dioxide is recovered, and the overflow then passes to a storage tank known as a balance tank, which is used to keep the circuit in balance when adding and withdrawing solution. From this tank the solution is pumped by means of Antisell-type hard-lead pumps through a system of cooling coils and back to the electrolytic cells. The solution circulates at a rate such that the entire volume passes around the circuit once every 1½ hours. This has the result of keeping the composition of the solution in all cells practically the same and produces uniform conditions for electrolysis.

Solution is admitted to the cell circuit in batches about once every 24 hours. This reduces the acid strength in the circuit down from about 28% to 22%, which is the normal range of electrolysis. When the acid has risen to the proper point, a batch is withdrawn from the circuit and pumped up to the acid-storage tanks. A corresponding quantity of neutral solution is then dropped in order to bring the volume of the circuit back to normal.

Manganese dioxide precipitated during electrolysis is pumped as a sludge from the manganese thickener, filtered, washed, and prepared for market. Ordinarily the manganese dioxide as produced at other plants carries so much lead as to be without commercial value, and it is therefore returned to the circuit. In the present case, the manganese dioxide is practically free from lead and in excellent condition, for instance, for use as an oxidizer in batteries.

One of the most important of the recent developments in the process has been the production of very high grade zinc. The author recounts the origin of this discovery. A research was instituted at the laboratory of the Bunker Hill company to determine whether it might be possible to lower the discharge potential of oxygen at a lead-peroxide surface by the addition to the anode of some other element. That improvement might be possible in regard to preventing disintegration of the plain lead anode, and so obtaining a zinc deposit and a manganese dioxide lower in lead

than had been obtained in the ordinary way, was also known to be a fact. The research has covered many elements, in fact, all that could be alloyed with lead metal. Although this work is not yet complete, it has been possible by employing an alloy of which lead represents almost 99%, to lower the terminal voltage by 5% and also to obviate almost entirely the disintegration of the lead surface. As a result, the lead in the deposit of zinc has dropped to about one-tenth of what had been present previously, and at the same time the lead content of the manganese dioxide is only about 5% of its former amount. After it became possible to produce practically lead-free zinc, more attention was given to the elimination of other impurities. Fortunately the conditions of the process, on account of the hot solutions, lend themselves to purification of the solutions to a high degree. The result has been the production of zinc of so high a grade that it required the development of special methods of analysis to detect any impurities at all. The average grade of the metal so far produced has been consistently above 99·99%.

PORCUPINE METALLURGY

The *Canadian Mining Journal* for November 9 contains a description of the new treatment plant erected the Coniaurum mine, Porcupine, Ontario. This plant has been designed by J. J. Denny, who has been for some years associated with the McIntyre Porcupine mine and the new plant is based to some extent on the most recent McIntyre practice.

At the McIntyre and Coniaurum mines the values are disseminated through both the pyrite and the quartz, but the pyrite is higher in gold content than the quartz. The quartz is more easily pulverized than the pyrite and the gold contained in the quartz is more amenable to leaching with cyanide solution than that in the pyrite. To give the ore the differential treatment which the character of its two chief constituents called for was the problem to which Mr. Denny has devoted himself for the last three years at McIntyre. One of the first changes made at McIntyre was to discontinue tube-milling of all the ore to 92% minus 200 mesh, which was the practice at that time, and rearrange the grinding sections so that the quartz portions would be reduced only to 100 mesh but all the pyrite to 200 mesh. This was accomplished without reducing the mill capacity but at the same time shutting down two of the five tube-mills. The three tubes and their Dorr duplex classifiers were operated to grind 100 mesh. Three duplex classifier overflows were pumped to a Dorr bowl classifier which in this case effected a concentration of the heavy valuable sulphides in the rake product. The bowl overflow 70% minus 200 mesh contained 100 mesh quartz and 200 mesh pyrite, due to the difference in specific gravities, and passed on to counter-current decantation followed by vacuum filtration. The bowl rake product was returned to one of the tube-mills where the pyrite was re-ground and retained in the double-closed circuit until reduced to 200 mesh. The concentration of pyrite in the circuit built up to about five times the concentration in the original ore, which is a fair indication of the relative period of detention of quartz and pyrite in the grinding circuit. In fact, it has been found that assays of the various Dorr classifier's rake products show approximately a doubling of the pyrite content for every classification step.

After several changes of a minor character, a change was made to provide selective agitation of quartz and pyrite so that in addition to selective grinding each might be given the period of agitation demanded by its leachability. Two Dorr agitators were accordingly moved from their position between the first and second thickeners and placed between the tube-mill classifiers and the bowl classifiers. These agitators handled 2½ to 1 dilution pulp overflowing the duplex classifiers and, after giving the period of agitation required by the quartz, delivered the pulp to the bowls. The 100 mesh quartz promptly overflowed with 200 mesh pyrite to the decantation plant while the sulphides were discharged as a rake product to re-grinding mills, returned to the agitators and given further agitation in addition to further grinding before finally overflowing from the bowl to decantation.

As a result of the selective grinding and agitation, the rich but refractory pyrite remained in the circuit about four times as long as the low-value easily-leached quartz. At present, with one less tube-mill and two bowl classifiers, the grinding capacity was increased 50%, the fineness of product to decantation was reduced from 92% minus 200 mesh to 70% minus 200 mesh, tailings dropped 60% in value, and the total milling cost per ton was reduced 30%. With this background of McIntyre developments it will be easier to understand why Coniaurum adopted the present system.

The Coniaurum ore is partially crushed underground in a jaw crusher. At the surface it is further reduced in a gyratory and delivered to two sets of dry rolls, the secondary roll operating in closed circuit with a ⅜ in. Leahy vibrating screen and the primary in open circuit. It is to be noted that dry crushing rolls are substituted for the usual primary grinding mills and that the ore is crushed dry, fine enough for tube-mill feed. Operating costs will be watched carefully, as the results secured in Coniaurum's dry-crushing plant should go a long way toward settling the question as to how far dry reduction can be carried profitably in competition with wet grinding.

The coarse-crushing equipment is designed to handle 250 tons of ore in an eight-hour shift. Although the total equipment is designed to treat 500 tons of ore per 24 hours, the mill will be operated at 250 tons per 24 hours at the start. By operating the coarse-crushing plant one shift per day, and the roll equipment another shift (storage between), the management will be able to regulate their power-demand peak which is one of the governing factors in their power costs.

Fine grinding is carried out in two 5 ft. by 16 ft. Allis-Chalmers tube-mills directly connected with 150 h.p. motors. Each tube-mill operates in closed circuit with a Dorr duplex classifier type DSD, 6 ft. wide by 30 ft. long. Classifier overflow is all 80–100 mesh and at a dilution of about 2½ to 1. An interesting point in the fine grinding layout is the method of feeding the crushed ore. Instead of feeding from the crushed-ore bins direct to the mills, the crushed ore is sluiced from the bins to the two classifiers. In this way any material crushed

fine enough in the rolls overflows from the classifiers and by-passes the tube-mills altogether, thus assuring the de-slimed feed to the tube-mills with its obvious advantages.

The classifier overflow is then elevated by Wilfley sand pumps to the first of two pairs of Dorr agitators, 24 ft. in diameter by 20 ft. deep, installed in steel tanks. The first of these pairs agitates the overflow of the primary grinding unit and discharges to the bowl classifier. The bowl rake discharge returns to the secondary grinding unit, whose overflow is agitated in a second pair of agitators. These agitators are driven by belts from a line shaft and operated at a higher speed than is standard, 8 to 9 r.p.m., on account of the segregating characteristics of the pulp, which are due to its high dilution and the coarseness of the ore particles.

The pulp discharged from the second pair of agitators is elevated by a Wilfley sand pump to the Dorr bowl classifier, 6 ft. wide by 30 ft. long by 18 ft. diameter bowl. This bowl classifier is located directly above the tube-mills so that its sand discharge may flow by gravity into the feed box of one of them. Owing to the difference in specific gravity between the quartz and the pyrite a concentration is effected in the bowl classifier. To overflow with the 100 mesh quartz the pyrite must be reduced to pass 200 mesh, otherwise it is discharged in the rake product and returned to the head of the mill for further grinding and additional agitation. It is expected that with heads containing 4% pyrite, the pyrite content in the double closed circuit will build up to probably 30% or more. When this concentration is reached the pyrite is not only ground much finer than the quartz, but is also agitated in cyanide about five times as long as the quartz.

The selective grinding and agitating layout is unique in that all the equipment is of standard make and in general use in other mills in the district. The arrangement alone is different, as it takes advantage of the differential settling characteristics of the two minerals in order to give each one that degree of grinding and leaching which its assay value warrants. The layout of various units is such that changes in flowsheet may be very readily made, as justified by experience gained under actual operating conditions.

The 70% minus 200 mesh bowl classifiers overflow is settled in a Dorr tray thickener of the extra heavy connected-tray type 40 ft. in diameter by 16 ft. deep. The pregnant solution overflowing this thickener is clarified in a 30 ft. Hardinge sand filter, deoxidized by the Crowe vacuum system, mixed with zinc dust from a Merrill feeder, and pumped by a two-stage Rees-Roturbo centrifugal pump to a Merrill press for the collection of gold sludge. The gold sludge is refined in a separate building.

Two Dorr duplex diaphragm pumps are used for withdrawing the slimes settled in the Dorr tray thickener. These slimes are fed to an 8 ft. 6 in. 8-disc American vacuum filter, where they are washed with barren solution. The cake from this primary filter is repulped at 1 to 1 with barren solution in a Dorr agitator 18 ft. diameter by 20 ft. deep, and pumped to the secondary vacuum filter which is of the same make and size as the primary one.

On the secondary filter a barren solution wash is applied during the first part of the washing period. This is followed by a water wash just before cake discharge. The amount of water which may be used for cake washing is limited by the amount of solution withdrawn from the circuit with the cake from the secondary filter.

Filtrate from both filters is collected in a weak solution storage tank. A portion of this solution is enriched in cyanide and sent to the head end of the plant for use as a diluent in the tube-mills and classifiers, for sluicing the crushed ore into the classifiers, and as a backwash for cleaning the classifier rake product. Another portion is utilized for diluting the pulp fed to the bowl classifier. At times some of the weak solution may be mixed with pregnant solution in order to adjust the strength of solution before precipitation.

Summing up, the objective of the Coniaurum mill has been to obtain practically the entire dissolution of values before the pulp leaves the grinding circuit. The attainment of this point eliminates the progressive extraction usually found all the way down the plant, and results in more efficient separation of gold-bearing solutions from gangue. In the grinding circuit it is desired to attain not only selective grinding but also selective agitation of the high-gravity minerals with which the values are usually associated. It is obvious that considerable saving in grinding cost is secured without sacrificing extraction and that an average pulp is produced on which no further extraction is demanded; a pulp, moreover, which, by reason of its coarseness, is more readily settled, washed, and filtered. These latter incidental advantages are, to no small extent, due to the reduction of overgrinding to a minimum by providing ample classification.

CONCENTRATION PROBLEMS IN WESTERN QUEBEC

The December *Canadian Mining and Metallurgical Bulletin* contains a paper on the concentration of the ores of the Rouyn district, Western Quebec, by J. S. Godard, of the Mines Department, Ottawa.

The mining developments in western Quebec have shown the ores of this district to be more complex in character than was at first expected. When the initial discoveries were made it was thought that the ores would be similar in character to those of Kirkland Lake and Porcupine areas. Developments have since shown that although the ores along the southern margin of the belt are somewhat similar, those within the belt, constituting by far the greater proportion, are vastly different, being complex mixtures of base-metal sulphides carrying values in the precious metals. These mixtures of base-metal sulphides of copper, zinc, and iron present several problems to the metallurgist, especially in their concentration into marketable products. The author classifies the ores in three groups: (1) Milling ores, (2) direct smelting ores, and (3) concentrating ores.

Group (1)—*Milling Ores*:—(*a*) Ores in which arsenopyrite is the predominating sulphide. In this class of ore the gold occurs in fractures in the quartz and is associated to a lesser extent with the arsenopyrite and pyrite.

(*b*) Ores in which pyrite is the predominating sulphide and gold is the valuable constituent. This may also be classed as a concentrating ore.

Group (2)—*Direct Smelting Ores* :—(*a*) Heavy-sulphide ores of copper and iron, in which the copper and gold content is above the point where it is more economical to smelt the ores direct after roasting, than to concentrate the copper and gold values into high-grade concentrate before roasting and smelting. The economic point between a direct-smelting and a concentrating ore will depend on the amount of contained gold values and whether these values are recovered in the copper concentrate. It will be somewhere about 4% copper. A large portion of the Waite-Montgomery ore-body and a number of the Horne (Noranda) ore-bodies are in this class.

(*b*) Highly siliceous ores carrying values in copper and gold required for fluxing purposes in the copper convertors. A number of the Horne ore-bodies, the gangue of which is a rhyolite with a high percentage of free silica, and the Chadbourne ore, are of this class. This class of ore may also be considered as a concentrating ore provided the gold values are recovered in the chalcopyrite. The tonnage of this class of ore to be smelted or concentrated will depend on the smelter requirements for flux, and whether it is more economical to sell such an ore as flux or to concentrate it.

Group (3)—*Concentrating Ores* :—(*a*) The disseminated chalcopyrite-rhyolite ore-bodies not required for fluxing purposes.

(*b*) Disseminated ores in which iron pyrite is the predominating sulphide and in which gold is the chief value. This type might also be classed as a milling ore, Group 2 (*b*), but owing to their proximity to the smelter it may be more economical to concentrate the values into a pyritic gold concentrate. Examples of this class of ore are the Francœur and Arntfield low-grade ore-bodies.

(*c*) Disseminated and heavy-sulphide ores of zinc containing varying proportions of iron sulphides such as the zinc ore-bodies of the Horne, Aldermac, and Abana mines.

(*d*) Disseminated ores containing small amounts of chalcopyrite, blende, and pyrite, but whose chief value is gold. Archean in Clericy township is an example of this type.

(*e*) Heavy-sulphide ores of copper and iron with pyrrhotite predominating, too low in copper and gold content to be of direct smelting grade, such as the massive pyrrhotite ore-bodies *F* and *H* of the Horne mine, and portions of the heavy-sulphide direct-smelting ore-bodies which will probably grade off into concentrating ores of this class. This ore presents a concentrating problem in the collection of the gold values into the copper concentrate.

(*f*) Heavy-sulphide ores of copper, zinc, and iron of low copper, zinc, and precious metal values, in which the predominating sulphide is pyrite. The outstanding example of this class is the large ore-bodies of the Aldermac mine. This class of ore presents a concentrating problem in the separation of the values into two or possibly three products.

(*g*) The heavy-sulphide and disseminated-sulphide ores of copper, zinc, and iron, with pyrrhotite predominating and containing some values in gold and silver, such as certain portions of the Waite-Montgomery ore-body, the Amulet ore-bodies, and the copper-zinc ore-body of the Abana mine. This class of ore presents several concentration problems due to unfavourable metal ratio of copper to zinc, the association of the precious metal values, and in some cases the oxidized condition of the ore.

Much experimental work has already been done on these complex ores, and the chief problems encountered in their concentration are as follows :—

(1) The concentration of the precious-metal values with the copper concentrates where the greatest monetary return for these metals will be received. In some cases gold and silver are the chief values and copper is of secondary importance. In all cases the recovery of the precious metal values in the copper concentrate is of the greatest importance to the net value of the ore mined. Whether they can be made to report with or in the copper concentrate depends on their association with the various constituents of the ore.

(2) The concentration of the copper-zinc ores into marketable copper and zinc products with high recoveries of both minerals. This has been found to depend on the metal ratios, namely, the proportion of copper, zinc, and iron sulphides in the ores, and on the condition of such ores as to oxidation.

The solution of the above problems will depend on very careful control of operating conditions, such as grinding, pulp densities, conditioning of the pulp, proper reagents and amounts of reagents, regularity of feed, and many other factors which affect the flotation of minerals, especially the selective flotation of admixtures of the types presented.

Shipments, ranging from a hundred pounds to car-load lots, of a number of the concentrating ores of this district have been made to the Ore Testing Laboratories of the Department of Mines at Ottawa for experimental purposes, and a brief summary of the results obtained and the difficulties encountered in their concentration is given herewith.

Group 3 (*a*) : Assay of head sample : Au, 0·04 oz. per ton ; Ag, 0·22 oz. per ton ; Cu, 4·60% ; Fe, 19·83% ; Insol., 50·64%. A number of small-scale flotation tests were made for the purpose of ascertaining how far concentration could be carried consistent with good gold recoveries. The results from three of these tests are shown in the following table :—

Test		*Weight.*	*Assay.*		*% of values.*	
No.	*Product.*	%	*Cu* %	*Au* oz.	*Cu*	*Au*
1	Concentrate	35·3	12·14	0·11	95·0	81·2
	Middling ..	8·5	1·39	0·04	2·6	7·1
	Tailing ...	56·2	0·19	0·01	2·4	11·7
2	Concentrate	17·9	23·18	0·15	92·3	71·2
	Middling ..	9·8	1·33	0·05	2·9	9·0
	Tailing ...	72·3	0·30	0·015	4·8	18·9
3	Concentrate	14·5	28·72	0·17	89·9	42·9
	Middling ..	8·2	3·00	0·07	5·3	9·9
	Tailing ...	77·3	0·29	0·035	4·8	47·2

Should this ore be treated as a concentrating ore, the selective action between the chalcopyrite and the pyrite cannot be carried too far ; if so, it will be done at the expense of the gold values. A copper concentrate containing about 12–15% copper and containing a large amount of pyrite appears to be as far as concentration may be carried. This will give a recovery of 95% of the copper and 80% of the gold. The 20% loss of gold would amount to about 20 cents per ton of ore of this grade.

Group 3 (*b*) : Assay of head sample : Au, 0·37 oz. per ton. Should this ore be considered as a concentrating ore no difficulty should be experienced in its treatment. Concentration by flotation recovered 87% of the gold in a concentrate assaying 2·40 oz. per ton with a concentration ratio of 1 : 8·3. Flotation followed by tabling recovered

91% of the gold in the form of a combined flotation and table concentrate assaying 2·30 oz. per ton with a concentration ratio of 1 : 8. Seventy per cent of the gold in this ore can be recovered by amalgamation. It is possibly amenable to cyanidation, or concentration followed by cyanidation, of the concentrate. It therefore can be considered either as a milling or a concentrating ore, depending on which is the more economical practice.

Group 3 (*c*) : Assay of head sample : Zn, 13·0% ; Fe, 3·28% ; Insol., 71·95% ; Cu, nil. Flotation yielded satisfactory results. No difficulty was experienced in making a marketable grade of zinc concentrate. The zinc concentrate assayed 49% Zn with a recovery of 92%, and a concentration ratio of 1 : 4·2.

Group 3 (*d*) : Assay of head sample : Au, 0·32 oz. per ton ; Ag, 0·26 oz. per ton ; Cu, 0·66% ; Zn, 0·46%. The gangue is chiefly siliceous, but contains considerable altered rock of a talcy nature. Concentration gave very satisfactory results. A concentrate assaying 14% Cu and 5·7 oz. per ton gold was made with a concentration ratio of 1 : 23, and recoveries amounting to 97% of the copper and 87% of the gold. This is about the maximum concentration that can be made with satisfactory gold recoveries. When the concentration ratio was increased to 1 : 33, the copper concentrate assayed 20% Cu and 6·2 oz. per ton gold. This gave a satisfactory copper recovery of 94%, but the gold recovery fell to 55%. The gold loss in the tailing was largely as free gold, as 81% of it was recovered by amalgamation, making a total recovery of 91·5% of the gold. The ore does not present any concentrating problem ; either flotation or a combination of flotation and amalgamation, depending on the grade of concentrate desired, gives satisfactory results.

Group 3 (*e*) : Assay of head sample : Au, 0·25 oz. per ton ; Ag, 0·28 oz. per ton ; Cu, 1·55% ; Zn, 0·28% ; Fe, 50·39% : S, 39·86% ; Insol., 2·93%. A number of flotation tests were made to determine whether the gold values could be recovered in the copper concentrate. The results of these tests are shown in the following table :—

Test		*Weight.*	*Assay.*		*% of values.*	
No.	*Product.*	%	*Cu %*	*Au oz.*	*Cu*	*Au*
1	Concentrate	58·2	2·50	0·48	96·2	95·5
	Tailing	41·8	0·14	0·03	3·8	4·5
2	Concentrate	21·5	6·30	0·74	87·3	62·8
	Tailing	78·5	0·25	0·12	12·7	37·2
3	Concentrate	8·7	13·98	1·10	76·6	39·6
	Tailing	91·3	0·38	0·15	23·4	60·4

It will be noted from these tests that as the grade of the copper in the flotation concentrate is increased a higher gold loss occurs in the tailing. How far the concentration may be carried consistent with good gold recoveries is a matter of more exhaustive tests under actual milling conditions.

The results recorded above are those from small-scale flotation tests. It is reported that this ore has been concentrated to 14% copper with recoveries of 85% of the copper and 70% of the gold, by grinding in a ball-mill in close circuit with a classifier, thus retaining in the grinding circuit any free gold until sufficiently fine for flotation.

A magnetic separation test was made, separating the pyrrhotite from the non-magnetic portion of the ore, for the purpose of ascertaining the association of the gold values. The results are tabulated below :—

	Weight.	*Assay.*			*% of values.*		
Product.	%	*Cu %*	*Au oz.*	*Fe %*	*Cu*	*Au*	*Fe*
Magnetic	45·4	0·62	0·07	57·73	19·1	12·0	51·4
Non-mag	54·6	2·19	0·43	45·32	80·9	88·0	48·6

Examining the iron content in these two products, it will be seen that the iron of the magnetic portion corresponds very closely with that of pyrrhotite, while that of the non-magnetic product corresponds closely with the composition of pyrite when due weight is given to the amount of chalcopyrite present. It is therefore evident that the gold is not associated with the pyrrhotite. The magnetic portion, weighing 45% of the total, contained but 12% of the gold. As the separation was made at minus 80 mesh, some unfreed chalcopyrite and pyrite, and some that was mechanically entrained, reported with the pyrrhotite. This could easily account for the 12% of the gold that was found in the magnetic product.

Group 3 (*f*) : Assay of head sample : Cu, 7·36% ; Zn, 6·53% ; Fe, 35·48% ; Au, 0·03 oz. per ton ; Ag, 2·05 oz. per ton ; Insol., 18·6%. Selective-flotation tests were made for the purpose of separating the copper from the zinc, and very favourable results were obtained. The copper concentrate assayed 24% Cu, 0·08 oz. per ton Au, 8·0 oz. per ton Ag, and 3% Zn. The concentration ratio was 1 : 3·8 and recoveries of 93% of the copper, 75% of the gold, and 76% of the silver were obtained. The zinc concentrate assayed 49% Zn, making a recovery of 75% of this metal with a concentration ratio of 1 : 11. This ore does not present any serious concentration problem. The separation of the chalcopyrite from the zinc blende was very good, and the reporting of a large percentage of gold and silver with the copper concentrate is favourable. The ore as received was freshly mined and free from oxidation, and this, coupled with a favourable flotation ratio of copper to zinc, are the contributing factors to the results obtained.

Group 3 (*g*) : Assay of head sample : Cu, 3·85 %; Zn, 9·25% ; Au, 0·24 oz. per ton ; Ag, 3·28 oz. per ton. Acidity equivalent to 9 lb. per ton H_2SO_4. A number of large-scale selective flotation tests were made. The flow sheet for the various tests was, with a few minor changes, as follows :—Ore crushed dry to 4-mesh and fed to a 4 ft. 6 in. by 13 in. Hardinge ball-mill operated in closed circuit with a simplex Dorr drag-classifier. The oversize from the classifier was returned to the ball-mill for regrinding and the overflow went to a Greenawalt 8-cell mechanically-agitated flotation machine. The final copper concentrate was taken from the first three cells, and the middling from the last five cells was returned to the ball-mill for regrinding. The tailing from the copper flotation was pumped into a launder leading to a flat-bottom Callow pneumatic flotation unit which was used for the flotation of the zinc. The Callow unit consisted of three cells, a rougher, a cleaner, and a recleaner. The middling from the cleaner and the recleaner was returned to the launder leading to the zinc cells. The results from three tests follow :—

Test		*Assay.*			
No.	*Product.*	*Cu %*	*Zn %*	*Au oz.*	*Ag oz.*
1	Head sample ..	4·35	9·90	0·24	3·46
	Cu concentrate .	19·78	8·71	0·61	12·16
	Cu tailing	0·35	7·79	0·04	1·16
	Zn concentrate .	0·93	42·77	0·04	0·75
	Zn tailing.....	0·28	1·27	0·04	1·16
	Recovery % ...	92·3	74·1	89·2	73·5

Table continued from previous page.

Test No.	Product.	Assay. Cu%	Zn%	Au oz.	Ag oz.
2	Head sample ..	3·85	9·25	0·24	3·28
	Cu concentrate .	21·73	9·03	0·89	12·83
	Cu tailing	0·40	8·98	0·05	1·50
	Zn concentrate .	1·22	52·54	0·05	1·39
	Zn tailing	0·33	2·53	0·05	1·41
	Recovery % ...	90·2	64·4	84·0	61·6
3	Head sample ...	3·85	9·25	0·24	3·28
	Cu concentrate .	24·16	8·53	0·89	13·72
	Cu tailing	0·49	9·62	0·07	1·47
	Zn concentrate .	1·36	51·11	0·10	1·84
	Zn tailing	0·37	1·46	0·06	1·29
	Recovery %	88·2	75·3	76·9	61·8

The flotation reagents used were varied in kind and quantity, as was also the place they were introduced to the circuit. The following reagents gave in a general way the most satisfactory results :

For the copper.—Soda-ash, 12 lb./ton, was added dry to the ball-mill. Aerofloat No. 15 added to the head of the copper cells. As a depressant for the zinc during the flotation of the copper, sodium cyanide, 0·30 lb./ton, and zinc sulphate, 0·75 lb./ton, were added to the ball-mill discharge.

For the zinc.—Copper sulphate, 2·0 lb./ton, was added to the discharge of the copper cells ; xanthate, 0·30 lb./ton, was added to the launder leading to the zinc cells ; and steam-distilled pine oil, 0·05 lb./ton, was added to the head of the zinc cells.

A close check was kept on the pulp densities throughout the testing.

The following percentage of solids in the pulp at various points in the circuit gave the most satisfactory results :—

	%
Ball-mill discharge . .	56
Classifier overflow . .	38
Discharge copper cells .	29

Grinding to about 12% + 200 mesh was necessary for good results. A typical screen analysis was as follows :—

	%
+ 65	0·10
+ 100	0·84
+ 150	3·10
+ 200	7·80
— 200	88·16

A few difficulties were experienced. These were to be expected in an ore of this type, as the copper-zinc separation is a new problem and nowhere has it been attempted other than in the experimental or pilot stages.

The difficulties in the separation of the chalcopyrite from the zinc blende were greatly increased by the presence of a large quantity of soluble sulphates. These had a disturbing effect on the flotation and were largely responsible for the high zinc content in the copper concentrate. The problem of the separation of these two sulphides is made more difficult by the rather unfavourable metal ratio of copper to zinc, which in this ore is 1 : 2·4. The gold recoveries in the copper concentrate were somewhat erratic. It was found that better recoveries of the gold were obtained when "aerofloat" was used for the flotation of the copper instead of xanthate, and that the gold recovery dropped when the alkalinity of the pulp was increased. Some difficulty was at first experienced in making a satisfactory grade of zinc concentrate. In a soda-ash pulp, there was a tendency for the iron sulphides to float with the zinc. This condition was overcome by the addition of lime water to the tailings from the copper cells and agitating the pulp for 15 minutes in a contact tank previous to the flotation of the zinc. This had the effect of depressing a large amount of iron sulphides that otherwise appeared in the zinc concentrate.

Silver Alloys.—In the report of the Deputy Master of the Mint for 1927 there are a number of references to the new silver coinage and among these are notes by Dr. Sydney W. Smith on metallurgical investigations into suitable silver alloys for this purpose. The coins they supersede had the composition of equal parts of silver and copper and were subjected to a blanching process. These coins have not proved entirely satisfactory on account of the silver facing disappearing with wear, and an extensive series of experiments were conducted with a view of obtaining a more suitable alloy. The composition of the alloy now used is not divulged. A point of some interest arising recently is that as it is impossible to guarantee a regular distribution of the silver in a low-grade alloy it has been necessary to relax slightly the regulation relating to the maximum variation in composition allowed for each individual silver coin.

In Dr. Smith's notes he mentions that the assay work recorded was directed towards acquiring precise data regarding the possible variations in composition of various alloys under working conditions and also towards determining the degree to which the composition of large quantities of silver bullion of these various alloys could be controlled within the narrow limits required. The assays made in this connection represent the work of correlating dip samples from the molten metal with blanks (cut from fillets) both before and after the operation of blanching. With this information it is possible to determine the actual rise in fineness of the finished blanks, and the relation which this bears to the recorded losses of weight experienced in the blanching operation. Such information enables a suitable control of that operation to be made so that losses of silver in the blanching solutions may be avoided.

In addition to these silver assays large numbers of analytical determinations were made of base-metal constituents. For this purpose it was necessary to devise or adapt methods for the quick determination of these various elements. A number of these analytical methods have been standardized for daily use in accordance with particular requirements.

For the purpose of investigating the relative soundness of coinage bars of varying composition a large number of determinations of the specific gravities of these alloys was made. These determinations, in the majority of cases, were made on whole coinage bars and not on small pieces. It was found that only in this way could a real idea be formed of the relative soundness of bars cast from various alloys. A bullion balance was adapted for the purpose of these determinations and the results gave valuable indications as to the suitability or otherwise of particular alloys in relation to the existing casting practice.

The necessity also arose for making close comparisons of the colours of various alloys of silver and of gold. The usual procedure of comparing

polished surfaces, although giving broad indications of their relative colours, presents some difficulty and uncertainty in regard to small differences in colour. It was found that a very satisfactory means of comparing alloys which differ only slightly in colour is afforded by preparing fine spiral turnings which can be loosely packed in clear glass weighing bottles of uniform size, approximately 3 in. by 1¼ in. diameter. The changes of colour which result from small gradations in composition are thus readily revealed by the composite effect of the multiple reflections from the surfaces of these turnings.

Current metallurgical literature indicates that a considerable amount of attention has been given in recent years to the problem of producing silver alloys which shall be less susceptible to tarnishing by ordinary atmospheric conditions than either pure silver or the usual alloys of silver with varying amounts of copper. This work, however, has been mainly directed towards improving the resistance to tarnishing of the higher standards of silver alloys which are employed for plate and jewellery. The difficulties are very much accentuated when attempts are made to improve the tarnishing qualities of the lower grades of silver alloys. The various alloys containing 500 parts per 1,000 of silver which have been passed under review are all susceptible to tarnishing when freely exposed to atmospheric conditions. The problem of forecasting the probable behaviour of silver coinage alloys of low standard, after a period of active circulation, is clearly not determinable with any precision by direct analogy with their behaviour when merely exposed to atmospheric conditions, or when subjected to the action which various chemical reagents may have upon them under laboratory conditions. Variations in behaviour may arise both in active circulation and also during storage in bags. The factors which are present during active circulation may have a retarding or an accelerating effect on the ordinary processes of tarnishing. Thus, constant handling tends to maintain thin coatings of a greasy or oily nature which may be beneficial. The constant burnishing which results from the mild abrasion by friction with other coins tends to remove the effects of tarnishing. On the other hand, the storage of such coins is apt to be detrimental, since the reaction of fatty acids on coins from which the initial bloom or protective layer of finer silver has been removed is known to be more active.

SHORT NOTICES

Measuring Flow of Air.—The October *Journal* of the Chemical, Metallurgical, and Mining Society of South Africa contains a paper dealing with recent devices for measuring the flow of air in mines, by R. A. H. Flugge-de Smit.

Grinding Efficiencies.—In the *Engineering and Mining Journal* for December 15, W. H. Coghill writes on evaluating grinding efficiency by graphic methods.

Magnetic Separation.—The November *Journal* of the South African Institute of Electrical Engineers contains a paper by L. B. Woodworth describing a magnetic separator employed at the Rand Mines research laboratory.

Gold Metallurgy.—The *Engineering and Mining Journal* for December 22 prints Alfred James's annual letter on progress in cyanidation and other branches of gold metallurgy.

Geology of Cornwall.—In the *Geological Magazine* for December, Dr. F. Coles Phillips writes on metamorphism in the Upper Devonian in North Cornwall.

Chilean Nitrate.—In the *Engineering and Mining Journal* for November 24, A. W. Allen writes at some length on the nitrate industry of Chile.

Volcanic Pipes.—In the *Engineering and Mining Journal* for December 8, 15, and 22, R. T. Walker, geologist to the United States Smelting, Refining, and Mining Exploration Co., writes on mineralized volcanic explosion pipes.

Classification of Coal.—The American Institute of Mining and Metallurgical Engineers publishes in pamphlet form thirteen short papers on this subject, together with discussion thereon. These papers were presented at the meeting held in February, 1928.

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.*

17,411 of 1927 (297,876). H. M. Sutton and W. L. and E. G. Steele, Dallas, Texas. Improvements in the separation of dry materials.

18,089 of 1927 (298,520). R. S. Carreras, Barcelona, Spain. Improvements in the method of manufacturing white lead by electrolysis.

18,186 of 1927 (298,921). New Jersey Zinc Co., New York. Claim No. 1: The method of reducing zinciferous materials in which a charge of agglomerates of zinciferous material and reducing agent is progressively passed through a relatively long reducing chamber of relatively large reducing capacity and heated to a sufficiently high temperature to reduce the compounds of zinc and volatilize the resulting metallic zinc and in which the agglomerates pass through the reducing chamber without substantial breaking down and without slagging or fusion thereof and further in which the agglomerated charge as a whole possesses such porosity that the transfer of heat from the heated wall of the reducing chamber through the agglomerated charge is effected in large parts by currents of hot gases flowing through the voids of the agglomerated charge towards the gas outlet of the reducing chamber. Other patents follow, namely, 298,922, 298,923, and 298,924.

20,080 of 1927 (298,714). I. G. Farbenindustrie A.G., Frankfort-on-Main. Improvements in the method of making cobalt carbonyl.

21,918 of 1927 (298,736). I. G. Farbenindustrie A.G., Frankfort-on-Main. Use of oxidation products of paraffins and waxes as flotation agents.

26,176 of 1927 (298,527). H. M. Sutton and W. L. and E. G. Steele, Dallas, Texas. Air supply for sets of pneumatic separators.

34,614 of 1927 (283,133). Progres Minier et Metallurgique and A. de Samsonow, Belgium. Improved form of roasting and sintering furnaces.

6,853 of 1928 (286,616). Metallbank and Metallurgische Gesellshaft, Frankfort-on-Main. A copper alloy of great mechanical strength consisting of 87 to 99% copper, 0·5 to 10% nickel, and 0·5 to 3% ferrosilicon. Patents 288,314 and 288,974 follow.

18,716 of 1928 (298,670). I. G. FARBENINDUSTRIE A.G., Frankfort-on-Main. Improvements in the inventor's process for extracting iodine from natural nitrate of soda.

19,712 of 1928 (298,301). STANLEY C. SMITH, London. A method of precipitating cobalt from its solutions, particularly from solutions containing cobalt sulphate, which consists in treating the solution with lead peroxide in presence of a soluble nickel compound, without the addition of manganese.

14,891 of 1928 (298,684). STANLEY C. SMITH, London. Method of handling wet metallurgical products, especially lead-bearing materials, on screens and filters.

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 Geophysics. By Dr. R. AMBRONN, translated by MARGARET C. COBB. Cloth, octavo, 370 pages, illustrated. Price 25s. New York and London: The McGraw-Hill Book Co.

Practical Hints on Colliery Power Plant. By R. ROGERSON. Cloth, octavo, 240 pages, illustrated. Price 16s. London: Charles Griffin and Co., Ltd.

Rubber Producing Companies, 1928. Compiled by the Mincing Lane Tea and Rubber Share Brokers Association, Ltd. Octavo, paper boards, 710 pages. Price 7s. 6d. London: *The Financial Times*.

The Future of Tin. By HERBERT OAKLEY and EVAN PRITCHARD. New 1928 edition. Pamphlet, 34 pages. Price 6d. London: The St. Catherine Press.

Ignition of Fire-Damp by the Heat of Impact of Rocks. By M. J. BURGESS and R. V. WHEELER. Pamphlet, 12 pages, with illustrations. Price 9d. Paper No. 46 of the Safety in Mines Research Board. London: The Mines Department.

Pyritic Oxidation. By H. MACPHERSON, N. SIMPKIN, and S. V. WILD. Pamphlet, 24 pages, with illustrations. Price 1s. 6d. Paper No. 47 of the Safety in Mines Research Board. London: The Mines Department.

Relative Inflammability and Explosibility of Coal Dusts. By T. N. MASON and R. V. WHEELER. Pamphlet, 14 pages. Price 3d. Paper No. 48 of the Safety in Mines Research Board. London: The Mines Department.

The Country Between Wolverhampton and Oakengates. By T. H. WHITEHEAD and others. Cloth, octavo, 244 pages, illustrated. Price 5s. 6d. Being the explanation of sheet 153, published by the Geological Survey of England and Wales.

Safety of Certified Mine Signalling Bells when Connected in Parallel. By C. B. PLATT and R. A. BAILEY. Pamphlet, 16 pages, illustrated. Price 6d. London: The Mines Department.

Support of Underground Workings in the Coalfields of the South Midlands and the South of England. Octavo, paper covers, 86 pages, with many illustrations. Price 2d. Paper No. 45 of the Safety in Mines Research Board. London: The Mines Department.

Report of H.M. Electrical Inspector of Mines, 1927. Octavo, paper covers, 42 pages, illustrated. Price 6d. London: The Mines Department.

Mineral Industry of the British Empire and Foreign Countries: Statistical Summary of Production, Imports, and Exports 1925–27. Octavo, paper covers, 370 pages. Price 8s. London: The Imperial Institute.

Geology of the Area Between North Saskatchewan and McLeod Rivers, Alberta. By R. L. RUTHERFORD. Paper covers, 50 pages, with map and other illustrations. Edmonton, Alberta: The Geological Survey.

Production of High-Alumina Slags in the Blast-Furnace. By T. L. JOSEPH, S. P. KINNEY, and C. E. WOOD. Technical Paper 425 of the United States Bureau of Mines.

Studies of Basin-Range Structure.—By GROVE K. GILBERT. Professional Paper No. 153 issued by the United States Geological Survey.

Cyanide Extraction of Gold and Silver associated with Arsenic and Antimony in Ores, with special reference to those in Nevada and South Dakota. By E. S. LEAVER and J. A. WOOLF. Technical Paper No. 423 issued by the United States Bureau of Mines.

Trade Standards adopted by the Compressed Air Society. Third Edition. Quarto, paper covers, 48 pages, illustrated. Price 50 cents. New York: The Compressed Air Society, 90, West Street, New York.

Standards of the Hydraulic Society. Fifth Edition. Quarto, paper covers, 80 pages, illustrated. Price 50 cents. New York: The Hydraulic Society, 90, West Street, New York.

Das Pandermitvorkommen von Sultan Tschair. By A. SCHLUTER. Octavo, paper covers, 56 pages, illustrated. Price 5·80 marks. Halle (Saale): Wilhelm Knapp.

COMPANY REPORTS

Ferreira Deep.—This company belongs to the Central Mining-Rand Mines group and was formed in 1898 to work a deep level property in the central part of the Rand. The regular reserves are exhausted, and present output is drawn principally from old pillars, reclamation, and low-grade Main Reef. Mining is not expected to last much longer. The report for the year ended September 30 shows that 409,750 tons of ore averaging 4·4 dwt. gold per ton was raised and sent to the mill, where 83,052 oz. of gold was extracted, the yield being 4·05 dwt. per ton. The gold was valued at £352,511, and silver and osmiridium brought the revenue to £353,934, or 17s. 3d. per ton. The working cost was £303,854, or 14s. 10d. per ton, leaving a working profit of £50,080, or 2s. 5d. per ton. No dividend was paid.

Bwana M'Kubwa Copper.—This company was formed in 1910 to acquire an oxidized copper ore deposit in Northern Rhodesia. After some years of mining and metallurgical difficulties the reduction-ammonia process was adopted. In 1922 the company was reconstructed and a number of African and American groups have financial interests. Sir Edmund Davis is chairman. More recently the company acquired the N'Kana mine and the N'Kana Concession. The report for the year ended March 31, 1928, now issued, shows that 273,921 tons of reduced ore was sent to the treatment plant where it was treated by the reduction and ammonia solution process. Here 214,247 tons of sand was leached for a production of 6,345 tons of copper oxide estimated to contain

5,139 tons of copper. The production of metallic copper (best selected) was 3,278 tons. Improvements were made in the solution vat treatment by removing the slime content, which will be treated by a new plant now under construction. The income from the sale of copper was £189,842 and the value of stocks of copper and copper oxide at March 31 was estimated at £127,784. The working cost was £360,757. At the mine the reserve of oxidized ore is estimated at 3,007,366 tons averaging 3·74% copper. More recently diamond-drilling has revealed sulphide ore below the oxidized ore. The company also owns the N'Kana mine which is now in course of development. There is here a large amount of oxidized ore which will be sent to Bwana M'Kubwa for treatment. By means of diamond-drills sulphide ore has been located at N'Kana below the oxidized ore, and the extent of the ore thus indicated is estimated at 19,900,000 tons of sulphide ore and 4,000,000 tons of mixed sulphide and oxidized ore. The drill-holes have passed through ore varying in width from 14 ft. to 46 ft. with copper contents varying from 2·7% to 4·6%. The company also holds an extensive tract of country under the N'Kana Concession, which is now being explored by the Rhodesian Selection Trust. Here drilling has been done at Mufulira and Chambishi, where sulphide deposits resembling the Roan Antelope have been discovered, the size and copper content indicating the presence of deposits of great importance. The company's accounts for the year show a loss of £169,784, bringing the total debt balance to £289,458.

Sulphide Corporation.—This company was formed in 1895 to work the Central lead-zinc-silver mine at Broken Hill, New South Wales. For many years the lead concentrates were smelted at Cockle Creek, near Newcastle, New South Wales, but they are now sent to Port Pirie for treatment, while the Cockle Creek works are used for roasting zinc concentrates from Broken Hill ore, which afterwards go to Tasmania for electrolytic treatment, and for the production of acid, superphosphates, and cement. The company also operates a zinc-distilling plant at Seaton Carew, County Durham. The report for the year ended June 30 last shows that though the output of ore showed an increase the decline in the prices of metals caused a fall in the profits. The reduced metal prices also made it necessary in September, 1927, to discontinue extraction from the Junction mine. On the other hand, the various plants at Cockle Creek were continuously in operation with increasing advantage. At the concentrator 163,216 tons of ore was treated, averaging 14·6% lead, 15·2% zinc, and 12·3 oz. silver per ton, of which 125,478 tons was ore raised from the Central mine, 9,160 tons came from the Junction mine, and 28,578 tons was dump slimes. The output was 27,683 tons of lead concentrates averaging 63·7% lead, 9·9% zinc, and 50·5 oz. silver, together with 39,494 tons of zinc concentrates averaging 49·5% zinc, 5·3% lead, and 8·6 oz. silver. There were also produced 458 tons of slime zinc concentrates averaging 44% zinc, 9·8% lead, and 16·6 oz. silver, and 4,474 tons of special slimes of low grade serviceable for smelting. At Cockle Creek 37,909 tons of superphosphate, 20,541 tons of sulphuric acid, 211 tons of hydrochloric acid, and 68,375 tons of cement clinker were produced. At the zinc roasting plant 16,073 tons of zinc concentrates was roasted, and the sulphur used in the production of acid. At Seaton Carew 17,284 tons of zinc concentrate and other zinciferous material was roasted and the output from the distilling furnaces was 8,371 tons of zinc, 78 tons of metallic lead, and 14,681 tons of retort residues, the latter on concentration giving 1,892 tons of concentrate. The output of sulphuric acid was 13,787 tons. The company's total profit was £125,180, out of which £105,000 has been distributed as dividends, the rate being 10% on both preference and ordinary shares.

Broken Hill South.—This company has worked a lead-zinc-silver mine at Broken Hill, New South Wales, since 1893. The report for the year ended June 30 last shows that 336,280 tons of ore was sent to the mill, averaging 13·7% lead, 10·8% zinc, and 5·2 oz. silver per ton. The output was as follows :— 65,523 tons of lead concentrates averaging 65·6% lead, 6·5% zinc, and 23·6 oz. silver ; and 58,363 tons of zinc concentrate averaging 49·3% zinc, 2·6% lead, and 2 oz. silver. The amount of ore treated was slightly greater than the year before, and there has been a continued improvement in concentration practice. On the other hand the prices of the metals have declined, so that the net profit for the year was only £208,362, as compared with £320,818 the year before. Dividends absorbed £180,000, the rate being 22½%. The ore reserve is estimated at 4,250,000 tons, the figures being practically the same as the year before.

Associated Gold Mines of Western Australia.—This company was formed in 1925 to continue mining operations at the Associated gold mine at Kalgoorlie. The report for the year ended March 31 last, now issued, shows that 58,121 tons of ore averaging 37s. 10d. per ton was treated for an output of gold worth £93,045, the yield per ton being 32s., or 3s. 5d. more than the figure for the previous year. In addition £3,370 was received as royalty from tributers, bringing the revenue to £96,415. The working cost was £94,756, leaving a profit of £1,659. The improvement in the grade of the ore sent to the mill has been continued since the end of the year under review.

Boulder Perseverance.—This company was formed in 1923, as a reorganization of the Great Boulder Perseverance, for the purpose of continuing the operation of the gold mine of that name at Kalgoorlie, West Australia. C. F. Bell is chairman and Ernest Williams is manager. The report for the year ended September 30 shows that 47,501 tons of ore averaging 14·45 dwt. gold per ton, extracted by the company, was sent to the mill, where also 10,047 tons of tributers' ore averaging 17·5 dwt. per ton was treated. In addition ore from other sources amounting to 5,077 tons averaging 23·3 dwt. was sent to the mill. The total yield of gold was 46,384 oz. realizing £197,528. The working profit was £25,914, and after deducting cost of development, London expenditure, etc., the net profit was £13,164, out of which £12,479 is being distributed as dividend, the rate being 10%.

Malayan Tin Dredging.—This company belongs to the Tronoh group and was formed in 1911 to work alluvial tin ground in the Kinta Valley, Federated Malay States. The first dredge started in 1913 and there are now six in operation. In 1926 additional land acquired in the Tanjong Tualang district was transferred to a new company, the Southern Malayan Tin Dredging Co. The report for the year ended June 30 last shows that

the amount of ground treated was 5,458,940 cu. yd., and the output 1,607 tons, the yield per yard averaging 0·65 lb. The revenue was £248,988, and the net operating profit £112,701. There was also a profit of £76,803 derived from realizations of investments. Out of the total profit £130,000 has been distributed as dividend, the rate being 65%. The sum of £50,118 was written off property and plant.

Southern Malayan Tin Dredging.—This company was formed in 1926, as a subsidiary of Malayan Tin Dredging, to acquire alluvial tin property in the Tanjong Tualang district, Perak, Federated Malay States. No. 1 dredge started in October, 1927, and No. 2 in April, 1928. No. 3 is expected to commence operations almost immediately, and the erection of No. 4 should be completed in February. The report for the year ended June 30 last shows that No. 1 dredge treated 989,300 cu. yd. for an output of 245½ tons of tin concentrate, and that No. 2 treated 381,900 cu. yd. for a yield of 50½ tons of concentrate. The respective yields per yard were 0·55 lb. and 0·3 lb. The profit for the year was £10,714, out of which £7,500 has been distributed as dividend, the rate being 2½%. The property of the company has been extended during the year and the area is now 1,890 acres. The ground so far bored is estimated to contain 140,000,000 cu. yd. of ground averaging 0 53 lb. per yard. The capital of the company is now being increased by the issue of 100,000 £1 shares, bringing the total capital to £400,000. The new shares will be employed in liquidating the debt to Malayan Tin Dredging and in paying the same company for electrical equipment.

Southern Perak Dredging.—This company belongs to the same group as Malayan Tin Dredging and was formed in 1919 to acquire alluvial tin property near Temoh, Perak, Federated Malay States. The first dredge started in 1922 and a second in November, 1927. The report for the year ended June 30 last shows that No. 1 dredge treated 1,617,830 cu. yd. of ground for an output of 312½ tons of tin concentrate, the yield being 0·43 lb. per yard, while No. 2. dredge treated 567,100 cu. yd. during the eight months November, 1927, to June, 1928, and produced 242 tons of concentrate, the yield being 0·95 lb. per yard. The total output of tin concentrate was 554½ tons, and the revenue therefrom was £81,423. The net profit, after allowance for depreciation, was £29,083, out of which £26,600 has been distributed as dividend, the rate being 20%.

South Bukeru (Nigeria) Tin.—This company belongs to the Naraguta group and was formed in 1910 to acquire alluvial tin properties on the Bauchi Plateau, Nigeria. The report for the year ended June 30 last shows that the output of tin concentrates was 71½ tons, as compared with 126 tons the year before, and that the financial result was a loss of £863. This loss is due partly to the fall in the price of tin and partly to the poor results obtained at the properties worked. For some years the properties had been operated on contract, with the result that the best sections have been exhausted, and the remaining poor ground left for the manager after the contract system was revoked is not very satisfactory. With the aid of mechanical methods of treatment now being adopted it is hoped to increase the output substantially, and in the meantime a campaign of prospecting has been inaugurated.

Naraguta (Nigeria) Tin Mines.—This company was formed in 1910 to acquire alluvial tin properties on the Bauchi Plateau, Nigeria. In 1925 the Korot areas, and in 1926 the Karama and in 1927 the Sho properties, were sold to two subsidiaries formed for the purpose. The report for the year ended March 31 last shows that the output of tin concentrate was 281 tons, as compared with 434 tons the year before. The cause for this decline was the transfer of the Sho property and the postponement of decision as to the development of other properties until more detailed examination had been made. The profit for the year was £8,054, which is carried forward. As regards the development of other properties, it is reported that 1,000 tons of tinstone has been proved in the Russ deposit, and that an outside property of promise is on offer to the board which will later on be floated as a third subsidiary.

Camp Bird.—This company was formed in 1900 by F. W. Baker and associates to acquire a gold mine of that name in Colorado. After paying good dividends for ten years the richer ore became exhausted, and in the meantime the Santa Gertrudis silver mine at Pachuca, Mexico, was purchased and floated as a subsidiary in 1909. Many other interests have since been acquired and the company now has considerable financial business in many parts of the world. In 1926 the capital of the company was rearranged and additional funds were raised for the purpose of continuing the new type of business. The report for the year ended June 30 last shows that the lessees of part of the Camp Bird mine have established a mining and milling programme, but so far the company's receipts from royalties have been small. The geophysical survey of the district embracing the mine is being made by the United States Government. The Santa Gertrudis Company has been profitably operated and has yielded the Camp Bird a substantial income. Additional capital has been subscribed for the Durango Timber Co., and the company has important interests in the Mexican Corporation, the Lake George mine in Australia, the Wheal Buller in Cornwall, the Lagares Tin Mines in Portgual, the Anatolian Exploration Co., the Chemical and Metallurgical Corporation, the Creole Petroleum Corporation, and the Venezuelan Consolidated Goldfield. The company's profit for the year was £181,418, out of which £31,970 was paid as 8% preference dividend and £45,480 as ordinary dividend at the rate of 16⅔%. During the year 551,000 ordinary shares of 2s. each were issued at a premium of 2s. The balance carried forward was £122,881.

Santa Gertrudis.—As recorded in the foregoing paragraph, this company was formed in 1909, as a subsidiary of Camp Bird, Ltd., to operate a silver mine in Pachuca, Mexico. On the exhaustion of the mine, interests in additional properties in the same neighbourhood were acquired. Of these, the El Bordo, Malinche, and El Cristo have now only a short life in sight, but the Dos Carlos and Ohio groups have still a large area of favourable mineralized territory to be explored, and a geological survey of the region is being made. The report for the year ended June 30 last shows that 709,413 tons averaging $10·90 per ton was milled, 332,595 tons coming from the El Bordo group and 376,818 tons from the Dos Carlos. The yield was 10,603,733 oz. silver and 42,794 oz. gold, and the remittances to this country

by the local operating company was £300,000, out of which £233,010 has been distributed as dividend, the rate being 15%.

Mexican Corporation.—This company was formed by the National Mining Corporation in 1919 to operate on profit-sharing leases the Fresnillo silver mine, Zacatecas, and the Teziutlan copper-zinc property in Puebla, Mexico. The report for the year ended June 30 last shows that at Fresnillo 925,415 tons of oxidized ore was treated by cyanide, averaging 0·13 dwt. gold and 5·58 oz. silver per ton, from which was extracted 4,990 oz. gold and 3,962,516 oz. silver. The selective flotation plant treated 186,042 tons of sulphide ore, averaging 8·8% lead, 7·32% zinc, and 1% copper, and 0·97 dwt. gold and 13·94 oz. silver per ton, and the yields were: 26,813 tons of lead concentrate, averaging 54·5% lead, 6·1% zinc, 4·6% copper, and 4·7 dwt. gold and 68·6 oz. silver; 19,873 tons of zinc concentrate averaging 50·8% zinc and 15·1 oz. silver; and 8,831 tons of iron concentrate averaging 39·1% iron, 1·2 dwt. gold, and 15·3 oz. silver. The reserve of direct-cyaniding oxidized ore is estimated at 2,202,415 tons averaging 0·13 dwt. gold and 5·99 oz. silver per ton, and of manganiferous oxidized ore 555,564 tons averaging 0·14 dwt. gold and 6·42 oz. silver, which will be given a pre-treatment by the McCluskey process. The reserve of sulphide ore, positive and probable, is estimated at 477,680 tons averaging 10·7% lead, 11·5% zinc, and 0·6% copper, with 0·65 dwt. gold and 10·6 oz. silver per ton. Further large additions to the ore reserves are expected. The amount of ore treated at Teziutlan was 56,947 tons averaging 3·35% copper, 11·13% zinc, and 1·01% lead, with 0·5 dwt. gold and 2·3 oz. silver per ton, and the products were:—6,835 tons of copper concentrate, averaging 22·94% copper, 12·2% zinc, 6·71% lead, 1·44 dwt. gold, and 11·02 oz. silver; and 8,848 tons of zinc concentrate, averaging 55·18% zinc, 1·38% copper, 0·92 dwt. gold, and 3 oz. silver. The ore reserve is estimated at 54,918 tons averaging 3·3% copper, 11·6% zinc, 1% lead, 0·5 dwt. gold, and 2·3 oz. silver. Further supplies of ore will depend on the results of drilling based on geophysical survey. Remittances from Mexico were £72,299. During the year £35,500 of the five-year notes were purchased, and a similar amount has been purchased since, leaving an outstanding balance of £80,000. The board are proposing to amalgamate the interests of the company with those of the Mexican company owning the properties leased and operated under a profit-sharing basis by the corporation, and details of the scheme will be settled in a month or two.

Frontino and Bolivia Gold.—This company has worked the Silencio and other gold mines in Colombia since 1864. The report for the year ended June 30 last shows that 21,600 tons of ore was treated, yielding 24,937 oz. of gold, as compared with 24,840 tons yielding 27,562 oz. the year before, the average yield per ton, including some silver, being £5 as compared with £4 16s. The profit was £24,744, out of which £3,365 has been paid as debenture interest, £2,339 as preference dividend, and £10,500 as ordinary dividend, the rate being 7½%. The developments have not been very good during the year, and the reserve at June 30 was estimated at 50,500 tons averaging 16·5 dwt. per ton, as compared with 51,100 tons averaging 18 dwt. the year before. There are, however, indications that an improvement will once more take place. Additional hydro-electric power plant is to be provided and its cost is to be met partly by the issue of new shares.

Chinese Engineering and Mining.—This company was formed in 1900 to work the Kaiping collieries in the province of Chi-li, northern China. In 1912 an arrangement was made whereby the company's collieries and those belonging to the Lanchow company owned locally were worked jointly by an organization formed for the purpose, called the Kailan Mining Corporation. The report for the year ended June 30 last shows a substantial expansion of operations, the sales of coal, at 3,790,000 tons, being the highest yet recorded. The net profit of the Kailan Mining Corporation was $8,368,558, of which the company's proportion was $4,503,392. The company's net profit was £478,384, out of which £350,000 has been distributed as dividend, the rate being 25% tax paid. During the month of June, 1928, the conditions in northern China were disturbed by the retreat of the Manchurian armies before the armies of southern China, and owing to the occupation of the railway by the rival armies dispatches from the mines practically ceased for a time. An improvement took place in July and this has been maintained. For the four months July to October the sales of coal amounted to 1,123,154 tons, and subsequent messages show further improvement in dispatches.

Chosen Syndicate.—This company was formed in 1923 to acquire from a French organization certain concessions in Korea which include the Great Nurupi gold mine. E. T. McCarthy is consulting engineer, A. R. Weigall is general manager, T. C. F. Hall is head of the geological survey, and Aubrey Gow is chief metallurgist. The report for the year ended June 30 last shows that 94,061 tons of ore, averaging 7·94 dwt. gold per ton, was sent to the mill, as compared with 77,372 tons, averaging 8·73 dwt. the year before. The yield of gold was 29,366 oz. as compared with 25,739 oz. the year before. The revenue, including a small amount of silver, was £124,318, as compared with £108,047. The working profit at the mine, less depreciation, was £20,527, and after the payment of London expenses, etc., the net profit was £10,344, out of which £6,199 was distributed as dividend, the rate being 3d. per £1 share. The ore reserve is estimated at 154,102 tons averaging 7·57 dwt. per ton, as compared with 203,599 tons averaging 8·4 dwt. the year before. This fall in the figures for reserve is chiefly due to temporary shortage of power. As already recorded in these pages, the company has recently made arrangements with a Japanese hydro-electric company for the supply of current to the mine. As regards metallurgical difficulties, these are gradually being overcome, and the percentage of recovery has been raised to 83·8, with every prospect of further improvement.

NEW COMPANIES REGISTERED

London Nigerian Tin Trust.—Registered December 17. Capital £500,000 in £1 shares. Directors: Sir W. D. Henry, Richmond Temple. Office: 31/33, Bishopsgate, London, E.C. 2.

Bideford Black.—Registered December 20. Capital £100,000 in 5s. shares. Objects: To acquire the business of mineral black manufacturers carried on by Devon Anthracite, Ltd., at Bideford, Devon. Directors: Lt.-Gen. Sir R. Wapshare, W. L. Nickels, A. L. Broderick, T. Thornton. Office: 24, St. Mary Axe, London, E.C. 3.