The Mining Magazine

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Published on the 15th of each month by Mining Publications, Limited, at Salisbury House, London, E.C. 2.

Telephone: *London Wall* 8938. Telegraphic Address: *Oligoclase.* Codes: *McNeill*, both Editions, *& Bentley.*
Branch Offices { New York: Amer. Inst. M. & M.E.
Chicago: 360, N. Michigan Blvd.
Subscription { 12s. per annum, including postage.
U.S.A., $3 per annum, including postage.

Vol. XLI. No. 1. LONDON, JULY, 1929. PRICE ONE SHILLING

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EDITOIRAL

ROAD and water transport is to be developed in Uganda. The Kagera River is to be opened to barge traffic and a depôt port established at a point about 60 miles from Mizinda, on Lake Victoria. From this point a system of roads will afford communication with Western Uganda and Ruanda-Urundi.

IN continuation of references made last month to railway and other developments in Rhodesia, it is of interest to record that steps are being taken to construct a line, primarily for the development of the chrome industry, from a point some 45 miles north-west of Salisbury, along the western side of the Umvukwe Mountains, to Kildonan, about 25 miles distant.

THE railway between Oodnadatta and Alice Springs has been completed and the first train arrived at the latter township on June 27. This line is part of the trans-continental railway planned to connect Adelaide and Port Darwin. At the present time the opening of the line cannot be said to have any very direct bearing on the development of mineral deposits, but it will eventually, no doubt, encourage prospecting.

THE Department of Scientific and Industrial Research has recently appointed a Committee to advise on the investigation of geophysical methods generally. The personnel of the Committee is as follows: Colonel Sir Henry G. Lyons (Chairman), Colonel Sir Gerald P. Lennox-Conyngham, Sir John S. Flett, Professor G. I. Taylor, Dr. G. W. C. Kaye, Professor A. O. Rankine, Sir John Cadman, Professor A. H. Cox, and Dr. H. Moore.

WHAT may be regarded as a new factor in the economics of petroleum production is the progress which has been made in the development of hydrogenation for application to crude petroleum, as originally proposed by a number of German and other investigators for coal. Now, by the action of hydrogen under pressure, at a suitable temperature and in the presence of a catalyst, it is possible to convert nearly all the oil into light spirits commonly known as petrol.

THE importance of Dominion representation in London is fully recognized nowadays, and the news that the offices of the Ontario Government are to be enlarged is welcome. The present site in the Strand has recently been extended by the purchase of adjoining premises and a new building of attractive appearance and adequate accommodation is to be erected. The Ontario Government offices are well known to mining men, who have always found the official representative, Mr. W. C. Noxon, keenly interested in the Province's mineral resources.

The Royal School of Mines Dinner.

The 52nd Annual Dinner of the Royal School of Mines, under the auspices of the Old Students' Association, was as much of a family party and as pleasantly informal as these functions usually are in these days. Dr. William Cullen, in his capacity as President of the Institution of Mining and Metallurgy, was selected for the all-important task of proposing the toast of the School and, after dealing with past associations and paying tribute to the famous scientists who were instrumental in bringing the present institution into being, he dwelt on the character of the product, finding therein a remarkable phenomenon in the *camaraderie* which exists between teaching staff and students. Here Dr. Cullen has put his finger on the spot—if we may be allowed the plagiarism—in seizing on this spirit, which is undoubtedly a noteworthy element of the School of Mines. This co-operation, which amounts to a close friendliness, is, indeed, a characteristic and one which has done much to foster the corporate life and promote general well-being and "good health." There were, and probably still are, "brown-baggers," by which euphemism those individuals who hurried off to station or 'bus on conclusion of their daily lecture and course were known. These by their conduct avoided the fraternal life of post-working hours and thus incurred the youthful ire of their more sociable fellows. We are of opinion that antipathy to the brown-bagger is not an unkind sentiment, but is rather another reflection of the spirit to which Dr. Cullen alluded and that the quality of which these two are the outward and visible signs is of fundamental importance to the maintenance of the high traditions of the School.

In responding to the toast, Dr. Sidney Smith, after dealing with several outstanding figures in the past and present by name, took the examination of the spirit already alluded

to a step further by pointing out that in the very nature of things this disposition was to be expected when in the process of evolving the School of Mines, from the time before the University of London existed, various types of men from all parts of the country were brought together and blended by a common interest. Thus the position which School of Mines men occupy throughout the world, whether in English-speaking countries or elsewhere, is due to nothing so much as to this understanding between different types, added to which is the fact that the workers can feel that the tasks which are demanded of them have been performed, and are still capable of being performed, by those in charge.

In responding to the toast of the guests, which had been proposed by Mr. Edward Halse, the President-elect, Mr. R. E. Palmer, who is a Canadian by birth and education, uttered a plea to which we would like to give our strongest support. This was that the Association should cease from " hiding its light under a bushel " and forthwith proclaim itself. He found the excellence of the educational facilities at the School of Mines both in the theory and practice of mining and metallurgy worthy of the highest praise and suggested that these should be much better known, particularly at a time when many mining companies were scouring the world for men. Mr. Palmer may be quite correct in his view that Royal School of Mines men are not as well known in the world as large as they should and could be, but whose fault is this ? To some extent it may be that the Association has laid itself open to the charge of neglect. It may be remarked here that one of the most regrettable results so far as the Royal School of Mines is concerned, of closer union between the Imperial College and London University would be for the identity of the School to be lost. No effort should, therefore, be spared to maintain the status and individuality of " The Mines "—as it is more familiarly known—and its Associateship, which is, after all, a coveted mining distinction in the world to-day.

In further response to this toast, Mr. Guy Kendall, the Headmaster of University College School, inspired doubtless by the remarks of Mr. Palmer and referring to the shortage of men of the right type for mining engineering, introduced a new theme in speaking of enterprise. That, he thought, was what was lacking so often and instanced the cases of boys under his charge who preferred the comparative quietness of office employment to the adventure of mineral and metal seeking overseas and in strange climes. Here, indeed, is food for thought, especially if Mr. Kendall's experience is to be taken as representative of that of Headmasters of other Public Schools in the country. It is to be hoped it is not and that something of the old spirit of adventure is still to be found. Nevertheless there is no gainsaying the fact that certain changes are taking place and acute observers are disposed to account for present altered circumstances by pointing to the extent to which sport and games have become part of our national life. Thus it is suggested that, should a young man enter a business house after leaving school or college he can, and most certainly will if he is any good at it, continue to play that game or pursue that sport which gave him the coveted " cap." This is an additional inducement for him to remain at home rather than seek fortune and pastime abroad.

The subject is an intriguing one, worthy of detailed inquiry and consideration. By way of comparison, analyses of the same problem have of late been made in both Canada and the United States. In the former an increase in candidates for mining engineering training has been revealed ; in the latter a falling off. In these two countries the training of mining engineers is mainly for the development of home resources and the supply of men may fairly be regarded as an index to the prosperity of the industries concerned. In Canada the mineral development is but beginning ; in the United States the climax of mineral production has almost been reached, if indeed it has not been passed. In this country, however, the training is primarily for colonial and foreign employment and we must view with some misgiving the tendency of young men to look elsewhere than to mining as a profession, if such is in truth the prevailing trend.

Minerals Separation.

The directors' report for the year 1928 and the chairman's speech to shareholders, excerpts from which are given elsewhere in this issue, do not afford quite so much information as has been customary on some previous occasions, which may be attributed to the fact that there have been some adverse features of late. Nevertheless a company which can pay a dividend of 25% on a

capital of £200,000, as compared with one of 12½% the year before, cannot be said to be doing badly. As our readers are aware, the company was originally formed to develop and apply the flotation process of concentration and more recently it invested funds in Rhodesian mining properties where processes in which it is interested were applicable. The events of its early years are now matters of history and a younger generation has sprung up that forgets the long fight for the rights of the process in which bubbles and small proportions of light oils raise the heavy sulphides to the surface. A very large amount of money was spent in London, Australia, and the United States in defending the patent rights centring round the Sulman-Picard-Ballot process. Concentration by flotation is one of the most remarkable processes ever invented. Causing a storm of opposition at first in many quarters, owing to the supposed absurdity of expecting heavy minerals to float preferably to the light minerals, it gradually won the attention of technical men until it is now standard practice, by means of which not only are tailings beneficiated but complex ores hitherto untreatable are of value to the metallurgist. Minerals Separation, though not the first to demonstrate the selective quality of oil for sulphide minerals, was the first to prove that its application in ore-dressing practice could be made a commercial success. Other inventors, especially in the United States and Canada, have by research added to the general knowledge in connection with selective flotation as between various sulphide minerals and have introduced varying types of plant employed in the process, but it may quite justly be said that the metallurgists and physicists associated with Minerals Separation in this country and Australia are still in the forefront of investigators connected with the process. Many of the patents of Minerals Separation have expired, but the company's advice is as widely sought as ever.

Coming to the report for the year 1928, the most notable item of news is that the Minerals Separation plant of the Union Minière du Haut-Katanga treated 593,888 tons of ore, as compared with 119,035 tons in 1927. This ore is all oxidized and is treated by the ordinary flotation process, with a modification of the reagents employed. Another item of importance is that the Andes Copper Co., which operates the Potrerillas mine in Chile and is under the control of the Anaconda Copper Mining Co., treated 3,849,339 tons of sulphide ore during 1928, as compared with 1,728,541 tons the year before. The only application of flotation which is stagnant at present is the washing of fine coal. In this country the coal-owners, many of whom watch the process with interest, do not care to go ahead with the development of the process in the present condition of the coal-mining industry and operations are at a standstill. In Spain, however, the process has proved acceptable and 245,927 tons were cleaned in this way during 1928, as compared with 201,107 tons the year before.

Eight years ago Minerals Separation, in association with others, formed the company known as Metals Production, Ltd., with the object of investigating other metallurgical processes. The first of these to be applied in practice was the ammonia process for treating oxidized copper ores, a full-size plant, after experiments with a pilot plant, being erected at Bwana M'Kubwa. The history of this plant has been recorded in our pages and need not be recapitulated here. Suffice it to say that Minerals Separation is not now associated with this company and the plant, and no mention is made in the present report of the ammonia process as a likely process for oxidized copper ores. Instead, Metals Production is developing the "copper segregation process," by means of which metallic copper is reduced from the ore and collected by flotation. No commercial plant has yet been erected, but vigorous testing of the process is in hand, both in this country and in New York.

As regards Minerals Separation's holdings in copper mining companies in Rhodesia, its connection with Bwana M'Kubwa has ceased, as already mentioned. Its speculation in Southern Rhodesia Base Metals has proved a failure so far owing to the deposits at Copper King and Copper Queen proving to be less extensive and of a lower grade than was supposed. The company's chief holdings of importance at the present time are in Rhodesian Congo Border Concession and its subsidiary N'Changa Copper Mines, and it has smaller interests in Rhodesia Minerals Concession and Luiri Gold Areas. N'Changa started as a copper oxide proposition, but like most of the Northern Rhodesian copper companies now depends on the cupriferous shale beds first discovered at Roan Antelope, and later found by boring at many other places. The latest report from N'Changa describes a bore-hole in which 100 ft. was in

copper shale containing 5·1% copper in the form of chalcocite. Early this year the company made a tentative deal with the American Smelting and Refining Co., with the object of raising capital for development, but shareholders objected to the terms, and eventually an English group arranged the finance. Most of the members of this group are already associated with Rhodesia, but the surprise was the presence of Rio Tinto among the subscribers. The importance to Minerals Separation of this new accession to Rhodesian copper interests may be judged from the fact that Rio Tinto has been a large purchaser of Minerals Separation shares and one of its directors has joined the board. It is too early as yet to judge of the extent of the benefit to Minerals Separation of this new N'Changa deal, but it is to be hoped that its Rhodesian fortunes will be improved thereby.

Tin

The question of stabilizing the price of tin—to which a good deal of attention has been recently directed—is not a new one, and whether the present movement will succeed where others have failed remains to be seen. It might, however, be as well at this juncture briefly to examine the pros and cons of this controversial matter. In a general consideration of this topic it seems important to emphasize that production of the metal at too low a price tends to lead to its wasteful use, with consequent rapid depletion of the world's known resources. Whilst opinions differ as to what these resources really are, and as to how long they will last, there is general agreement that before many years are past the peak of production will be reached, and so far there are no new areas of any importance. As in the past, so at the present time, unanimity among British producers has not been attained, and this is surely necessary to the success of any scheme. In this connection it should be noted that those who are sceptical are prepared to consider any suggestion put before them. Whilst we know that more than one scheme is in existence, we do not know how far these have been considered by what might be called the opposition, or even if they have been submitted to them.

In settling a matter of this sort, a difficulty is the great discrepancy between the cost of production on the different properties. Even in Malaya—where tin can be produced cheaper than anywhere else—costs are a long way from uniform. At the present price of the metal some companies operating there experience a difficulty in making any profit, while many of the Chinese workers have temporarily suspended operations. It is felt in some quarters that when certain properties are shut down, owing to the low price ruling for their product, the quotation for the metal will at once appreciate, but this will only serve to bring the majority of those that have suspended operations into the producing list again, thus increasing stocks and reducing the price, and this process will continue *ad infinitum*.

The view is sometimes expressed that this question should be left to settle itself by the natural law of supply and demand, but it is doubtful whether the adoption of this course is in the best interest either of the producer or consumer. If by agreement between those concerned the price of tin could be stabilized in the neighbourhood of, say, £250, a company would show a larger margin of profit than with the metal at its present figure, thus benefiting the producer. As to the consumer, the closing down of certain properties, consequent upon the low price ruling for the metal, and the resultant restriction of supplies, would doubtless force the price much higher than the stabilized figure and this would prejudicially affect him. A word of warning against any attempt to fix too high a price, based on bringing consumption into line with production, might with advantage be uttered here, as suggestions have been made for finding new uses for the metal. Such a procedure must also tend to hasten the inevitably approaching exhaustion of world resources.

Owing to the many new companies joining the producing list and the number of established companies adding to their production by the installation of new plant, it is not easy to propound a scheme acceptable to all parties. Such a scheme is, however, stated to have been drawn up, and if this is the case it is to be hoped no time will be lost in submitting it to all who are interested, for there is no reason why the success which has been attained in dealing with other metals should not also be reached with regard to tin. We understand that a meeting of those interested has been called for July 11, the day on which we have to go to press with this issue. Much will depend on whether this is of a fully representative character.

REVIEW OF MINING

Introduction.—The change of Government—which caused misgiving in some quarters—has not resulted in any setback in either trade or financial circles. Those connected with South African mining are naturally disappointed at the result of the election, but there is no indication yet as to General Hertzog's future policy. In the metal markets tin is now in a more encouraging position than it has been of late. Though the new supplies during the first half of the year, at 73,485 tons, were 11,000 tons greater than during the corresponding period of 1928, the visible supplies showed a decrease at the end of June. The American deliveries last month were 7,455 tons, which was a record figure, and the total American deliveries for the first half of 1929 were 48,190 tons, as compared with 38,460 tons during the first half of 1928.

Transvaal.—The output of gold on the Rand for June was 821,352 oz. and in the outside districts 34,677 oz., making a total of 856,029 oz. The natives employed on the gold mines at the end of the month totalled 192,595, as compared with 195,733 at the end of May.

The chairman of Henderson's Transvaal Estates, Ltd., at the meeting in London, held last month, reviewed the progress made by the many African companies in which they are interested. The profit for the year was £36,195, out of which £35,210 was paid as dividend, the rate being 5%, the same as for the previous year. Among the points mentioned was that prospecting for asbestos is being undertaken at some of the company's farms in the Barberton district. It was also recorded that the Delagoa Bay Development Corporation had paid a dividend after an absence from the list of some years.

Mr. John Martin, in his first quarterly address as president of the Transvaal Chamber of Mines, referred at some length to the question of the Rand labour supply. He pointed out that other industries are competing with the mines for native labour and that in some of them higher wages are being offered. This holds good both in British territory and in Mozambique, and in the latter the supply threatens to fall of its own accord to the limit imposed by the recent Convention. Mr. Martin pointed out that the Rand Mines require an increasing number of natives owing to the greater depth of the workings, and that the coal mines will suffer from shortage owing to these greater requirements of the gold mines. He reiterated the Chamber's appeal to the Government to remove restrictions to recruiting and to open certain native areas now closed to them.

The dividends of the gold mines on the Rand for the first half of the year do not exhibit any great changes. In the Central Mining group Crown Mines shows an increase of 9d., whilst Geldenhuis Deep and Village Deep announce declarations of 6d. each, as against nil for the first half of 1928, and Modderfontein East is 3d. better, but Nourse, which a year ago was in the list for 6d., is now absent and Consolidated Main Reef's distribution is down 3d. Of the Anglo-American group Springs Mines and West Springs both show increases, whilst of the Johannesburg Consolidated Investment companies the New State Area's distribution is 6d. better, that of the Van Ryn Deep being down to the same extent. The 3s. of Geduld compares with 3s. 3d. for a year ago, but is this year on a larger capital. The Sub Nigel distribution is lower, for which shareholders were probably prepared, in view of Dr. Maclaren's report, referred to in the MAGAZINE for March last.

DIVIDENDS PAID BY RAND GOLD MINES.

	2nd half, 1927.	1st half, 1928.	2nd half, 1928.	1st half, 1929.
	s. d.	s. d.	s. d.	s. d.
Brakpan	5 0	4 9	5 0	4 9
Consolidated Main Reef	1 0	1 3	1 0	1 0
Crown Mines (10s.)	3 6	2 6	3 0	3 3
Geduld	4 0	3 3	3 6	3 0
Geldenhuis Deep	6	—	6	6
Government Areas (5s.)	2 3	2 3	2 3	2 3
Langlaagte Estate	1 0	1 6	1 6	1 6
Modderfontein, New (10s.)	6 6	7 0	7 0	7 0
Modderfontein B (5s.)	2 0	2 0	2 0	2 0
Modderfontein Deep (5s.)	3 6	3 3	3 6	3 3
Modderfontein East	1 0	1 9	2 0	2 0
New State Areas	1 0	1 0	1 6	1 6
Robinson Deep (A, 1s.)	1 6	1 6	1 6	1 6
Springs Mines	3 6	3 3	3 6	3 6
Sub Nigel (10s.)	3 6	3 0	3 0	2 0
Van Ryn	6*	6*	6*	6*
Van Ryn Deep	4 0	4 0	4 0	3 6
Village Deep	—	—	6	6
West Springs	9	9	1 0	1 0

* Free of Tax.

Rhodesia.—The gold output of Southern Rhodesia for May was 48,189 oz., as compared with 48,210 oz. for April. Other outputs for May were: Silver, 6,625 oz.; coal, 100,973 tons; chrome ore, 36,809 tons; asbestos, 3,632 tons; mica, 27 tons.

In our issue of November last it was announced that the Gold Fields Rhodesian Development Co. had acquired an interest in the Mayfair gold mine. A report issued by the Mayfair company states that the reduction plant, with a capacity of 2,000 tons per month, started operations on March 15. The ore reserve is estimated at 52,000 tons, of which 32,000 tons is fully blocked out, averaging 15 dwt. per ton over 40 in. Developments in depth are proving satisfactory and two other well defined ore-channels have been discovered on the line of old workings.

The first annual report of the Luiri Gold Areas, Ltd., records that the treatment plant at Matala Hill has been at work only intermittently since the last quarter of 1928 and that the crushing and power equipment required to place the plant on a sound basis was shipped during April and May, 1929. Further capital to the extent of £60,000 was subscribed in March of this year, partly for the purpose of paying for the additional plant and partly to continue development and actively prospect the concession.

Australia.—At the meeting of the Sons of Gwalia company Mr. C. A. Moreing referred to encouraging developments obtained under the new scheme whereby the Western Australian Government advanced the funds necessary for the work. Unfortunately this work has been hampered by the demand of the Workers' Union for a strict observance of the law limiting the wet-bulb temperature to 76°. Mr. Moreing contends that in a semi-tropical region such as Mount Leonora 80° is a more reasonable limit and, in fact, the estimate of costs was based on this higher limit. It is to be hoped that better counsels will prevail among the men and that plans of the engineers will not be rendered futile.

Malay.—Particulars are given elsewhere of the results obtained during 1928 at the Tronoh and other mines of the same group. In addition it is reported that during the year the Southern Tronoh was occupied in the erection of its two dredges. No. 1 started work in February last and No. 2 in May.

It is announced that the first tin dredges to be operated electrically by means of power supplied from the steam station of the Perak River Hydro-Electric Power Company are the new dredges of the Penawat and Kampar Malaya companies, which commenced operations on May 18 and May 9 respectively.

Owing to the Teja Malaya company's dredges not fulfilling expectations, certain alterations have been rendered necessary. With regard to No. 1, the recommendations of Mr. J. Gordon, of the Tronoh Mines, are being carried out, under his supervision, and it is expected this dredge will start next month. No. 2 has been working, so as to keep down overhead charges, but as soon as No. 1 restarts it will be stopped, in order to have certain permanent alterations effected. When both No. 1 and No. 2 are altered and at work, the completion of No. 3 is to be put in hand. During the period December 18, 1928, to May 31, 1929, the No. 2 dredge, although working outside the selected area, dredged 357,006 cubic yards for 73 tons, equivalent to 7·33 oz. per cubic yard.

Cornwall.—It has been known for some time that ore of higher grade had been found at Wheal Kitty, which is being developed by the Anglo-Oriental group. The yearly report of this company states that Wheal Kitty lode has proved of considerable value on the 880 ft. level, where 411 ft. driven westerly has averaged 84 lb. of tin oxide per ton over a lode width of 24 in. Two rises from this level have been in ore averaging 101 lb. per ton over 28 in. for a distance of 265 ft. Further development of this area is proceeding and future returns from the mill may be expected to show substantial improvement.

Colombia.—During the first half of the current year returns at the Frontino and Bolivia Company's Silencio gold mine have shown a marked fall in value and it is consequently impossible to declare an interim dividend on the ordinary shares. However, developments have been more satisfactory recently on the No. 18 level north and on No. 19 level south. On the latter level for 900 ft. from the shaft the ore has averaged 31½ dwt. per ton over 22·7 in. As this part of the mine has not hitherto given particularly good results, the present developments are of considerable interest, and when it is possible to extract the ore the returns from the mine will be more encouraging.

After the end of the current year the new electric power plant should be in operation and the position at the mine will show a corresponding improvement as regards costs.

Bolivia.—The Corocoro United Copper Mines, Ltd., which is controlled in Paris, reports a net profit of £4,389 for the year 1928, out of which £3,225 has been paid as dividend on the £100,000 preference shares. The rate was 4 francs per £1 share, the French franc being worth 124 to the pound. Owing to the decrease in ore reserves, M. Crussard, director of the Institute of Mining at Nancy, was commissioned to make a report and his recommendations are now being carried out.

Venezuela.—The South American Copper Company announces that the new concentration plant, designed to treat 200 tons of ore per day, has been shipped and it is hoped that it will be at work by the middle of August. Development on the main north drive on the 50 fathom level has disclosed important extensions to the ore-bearing area. Geophysical investigations have proved the existence of a new body of ore outside the west wall of the old orebody both above and below the Holman's adit level horizon. It has been definitely established by these geological investigations that the main Aroa orebody occurs between faults and is itself much folded and faulted. Hitherto it has been assumed that the westward limit of the orebody was marked by the wall in Holman's adit level. This wall occurs on the line of one of the strong faults and it was deduced that ore would again be found to the west. This conclusion has since been verified by an exploratory drive on the 16 fathom level, where sulphide ore of good grade is now being opened up.

Korea.—The Chosen Syndicate announces that electrical power supplied by a Japanese company became available on May 12 and that progress will in consequence now be more rapid. Hitherto work on the Syndicates' extensive concession has been confined to the Great Nurupi gold mine. Since electrical power became available it has been possible to start the unwatering of the East Nurupi mine. Development on Prospects Nos. 29 and 41 have yielded good ore and promise to become payable properties. A complete geological survey has been made of the Northern Concession, which has disclosed several ore occurrences of promise.

British American Tin Corporation, Ltd.—In another column particulars are given as to the registration of this company, which has a capital of a million pounds sterling in £1 shares. It will be seen that the list of subscribers is an influential one, including representatives of Messrs. Guggenheim, the Aramayo Mines of Bolivia, African and Eastern Trade Corporation, Consolidated Gold Fields of South Africa, and the Anglo-Oriental Mining Corporation.

Francois Cementation.—The financial results of the Francois Cementation Co. for 1928 were virtually the same as those for 1927, the profit, after allowance for depreciation of plant, being £47,517, as against £46,238. Dividends on the 8% preference shares absorbed £16,000 and on the ordinary shares £20,000, the rate of the latter being 50%. Some of the most important work of the company continues to be shaft-sinking in wet ground for British coal mines, and the repair of dams receives considerable attention, but the company's activities are manifold and extend over many parts of the world. The report speaks favourably of the results of working experiments with the Bicknell tunnelling machine. In order to finance the expansion of the company's activities, it is proposed to issue 400,000 new ordinary 1s. shares at 5s. each and offer them to shareholders in the proportion of one share for every two now held.

Anglo-American Corporation of South Africa.—The Anglo-American Corporation of South Africa is proposing to issue its reserve shares, create new shares, and subdivide each share into two, one being a preference share and one an ordinary share. The present nominal capital is £4,000,000 in £1 shares, of which 3,718,453 are issued. The remainder of the authorized shares, 281,547, are to be offered for subscription among present shareholders at £2 per share. It is proposed also to create 1,000,000 new £1 shares and to issue them later in such quantities and at such prices as may be deemed desirable by the board. The £1 shares will be divided into a 6% preference share of 10s. and an ordinary share of similar denomination. The business of the company is rapidly expanding and, in particular, Northern Rhodesian copper enterprises and the diamond business of the Cape Coast Exploration, Ltd., operating in Namaqualand, have required, and will continue to require, substantial amounts of capital.

THE RUSSIAN BAUXITE DEPOSITS

By ROBERT J. ANDERSON, D.Sc., Consulting Metallurgical Engineer

1. INTRODUCTION.—The present paper deals with the bauxite deposits situated in the Cherepovetz Government district of Tikhvin, Union of Soviet Socialist Republics (Russia). The information given is based in part on reports by Russian geologists (Maliavkin, Volkov, Ansheles, Vasilievski, and others) and in part on examination and study of the deposits by the writer.

So far as is now known, Russia is poor in bauxite resources. Occurrences of bauxite (aluminous laterite) have been reported at various localities in different parts of European Russia, ranging in latitudes from about the 40th to the 60th parallels, north. The only proven deposits of commercial value are those situated not far from Tikhvin, a small town about 137 miles south-east of Leningrad on the Northern Railway running from Leningrad to Vologda and beyond. It is possible that deposits of value may be found elsewhere by further prospecting, in view of the various reported occurrences. Bauxite was first found in the Tikhvin region in 1916 by P. Timofeev. The discovery was accidental. This discovery was confirmed by V. Iskul in the winter of the same year. In the summer of 1917, a prospecting programme was laid out by the Geological Committee at Leningrad. Detailed study of the field has been made almost uninterruptedly since 1921, with a view to determining the commercial value and quantity of ore available. The main results of the work carried out up to the winter of 1928 are given in this paper. Attention may be directed here to one special feature of the Tikhvin deposits which is unique, viz., their location between the 59th and 60th parallels, north. This locale is the farthest distance from the equator of any known bauxite deposit. In a later paragraph, reference will be made to various localities in Russia where occurrences of bauxite have been reported.

Acknowledgments.—The writer wishes to thank Professor S. Maliavkin and other members of the Geological Committee for information supplied. Reproduction of the illustrations, taken from reports published in Russia, has been made by Wm. F. Mahon, jun.

2. LOCATION OF THE SEPARATE DEPOSITS IN THE TIKHVIN REGION.—The prospected and partly developed Tikhvin bauxite deposits extend from the headwaters of the Volojba river (a tributary of the Sias river) towards the Bolshoi Dvor railway station (near Tikhvin) and further to North-North-east. Fig. 1 is a geological sketch map showing the separate deposits in the field. As will be seen, the deposits are found in a strip of land running in an almost meridianal direction but with a slight inclination to the East. The presence of bauxite and aluminous clays has been proven in the following places, among others :—

(*a*) Along the Kamenny creek (a tributary of the Terebeji river), between Bochevo village and Kooshighino village (12 on map).

(*b*) On the right bank of the Volojba river, between Parsevo village and Zolotovo village (9 on map).

(*c*) Along Lininka creek (a left tributary of the Volojba river) near Golovinski village (11 on map).

(*d*) Along Tobashny creek (a left tributary of the Volojba river) (10 on map).

(*e*) On the left bank of the Volojba river, near Roodnaya Gorka village (13 on map).

(*f*) Along the Nikomla river (a right tributary of the Volojba river), at Olekovo farm (8 on map).

(*g*) Between Krootoi creek and Piardomets creek (both streams being tributaries of the Volojba river). This is the so-called Krasny Roochei deposit, the largest in the field, so far as is now known (7 on map).

(*h*) Between Piardomets creek and Oosadische village. This is the Oosadische deposit (6 on map).

(*i*) Between Gooba village and Pochaevo village. This is the Goobsko-Pochaeviski deposit (5 on map).

(*j*) North of Podsosna village. This is the Podsosnenski deposit (4 on map).

(*k*) Between Radyn creek and a place referred to as Kransaya Glinka (meaning " red clay ") (3 on map).

(*l*) Near Segly village (2 on map).

(*m*) Between Senno village and Batkov Konets village (1 on map).

(*n*) Along Velikii creek (a right tributary of the Tikhvinka river) (not shown).

(*o*) Along Sarooya creek (a left tributary of the Yavosma river, in turn a right tributary of the Tikhvinka river) (not shown).

The map referred to above is Fig. 1. The following is a list of the six most important deposits arranged in order, from south to

north, of their distances from the Bolshoi Dvor railway station :—

Deposit, name.	Distance from Bolshoi Dvor, miles.
Krasny Roochei (*g*, above)	15
Oosadinski (*h*, above)	13
Goobsko-Pochaevski (*i*, above)	12
Podsosnenski (*j*, above)	10
Segolski (*l*, above)	8
Batkovski (*m*, above)	4

The total distance of the explored line of deposits at the time of the writer's examination in August-September, 1928, was about 33 miles.

3. Geology of the Tikhvin Deposits.—The bauxites and aluminous clays so far found in the Tikhvin area are considered, by Russian geologists, to be of Lower Carboniferous age. In passing, it is of interest to point out that all other bauxite deposits in the world have been assigned to formations belonging to Mesozoic or Cenozoic time, usually younger than Lower Cretaceous age. Some bauxites are thought to have been formed since Eocene time. If the Tikhvin bauxites are of Lower Carboniferous age, then they are the oldest aluminous-ore deposits on earth of which knowledge is available. These bauxites belong to a sandy-clayey complex lying directly on Upper Devonian sediments. The geological structure of the main formations which are of interest to the present discussion have been described as follows (16) :—

Upper Devonian Base.—A thick complex of sands and clays of various colours directly underlies the bauxite deposits. This is of Upper Devonian age. In the upper levels of this base, the clays show a predominance of blue tints. Often, abundant scales of ganoid fish and sharks' teeth are present. A most characteristic sign, distinguishing the Devonian sediments, is the presence of mica (chiefly muscovite) both in the sands and the clays, irrespective of their colour. Infrequently thin layers of sandstones, sometimes of a vitreous character, are found ; these have but inconsiderable lateral extension. Contact surfaces of sands and clays are numerous in the Devonian section, but in the upper part there is a predominance of blue clays. The sections examined show that the upper surface of the Devonian sediments has been much washed ; consequently, it is uneven. Spotted clays are found in numerous places, pointing to repeated washing. These sediments lie almost horizontally—with a very gentle slope to south-south-east.

Lower Carboniferous Sediments.—Bedded on the washed surface of the Devonian is a sandy-clayey complex of Lower Carboniferous age. It is characterized by remnants of such fossil flora as calamites, stigmariæ, and lepidodendrons. This complex (sediments) is expressed by layers of sands and clays, both variable in thickness and very variable in their horizontal dimensions. Fireclays are met with occasionally, and these may be interbedded with thin coal-bearing seams. In many places, the sandy facies of this complex show a sharply expressed diagonal foliation. Also, in many places, the sands are cemented up, forming a kind of sandstone ; this is sometimes friable but often becomes real quartzite. A cementation of the sands by iron oxides appears occasionally ; in some cases iron ore containing 30 to 60% iron oxide is formed. The sands are of the most variable colours, but in the upper parts of the complex they become light and finally turn to distinctly white quartzites. A typical example of this is shown by the sands near Falkovo village. The thickness of the sandy-clayey mass varies from about 49 to 98 feet (15 to 30 metres). This whole complex may be divided roughly into two horizons. The upper horizon is expressed chiefly by sands, more or less light in colour, and with a relatively small content of interbedded layers of clay ; the bulk of these sands show a pronounced normal bedding. The lower horizon is characterized by abrupt changes in facies, by a sharp diagonal foliation of the sands, by the presence of mineralized masses, and by fairly frequent lenses of fireclays. The lower horizon contains the bauxites and aluminous clays, which occur in irregular masses. Irregularity of shape is especially evident as regards the lower surfaces where they lie immediately on the Devonian clays. This lower horizon is referred to by Maliavkin as the " ore-bearing horizon," since it contains bauxites, iron ores, and fireclays. It disappears very infrequently, when it gives way to light coloured sands. Generally, this phenomenon is connected with the hypsometrical position of the Devonian surface. The " ore-bearing horizon " is considered as an important guide in prospecting for bauxite in this region. Mineralization is abundant in the lower horizon, and fossil flora are concentrated here. *Stigmaria ficoides* have been found in the body of bauxite specimens.

FIG. 1.—GEOLOGICAL SKETCH MAP, showing the separate deposits in the Tikhvin bauxite field.

The age of the Tikhvin bauxite deposits was, for a long time, not determined. The primary reason for this was that the first deposits discovered were found in localities where the sandy-clayey complex is bedded immediately under a glacial deposit (brown boulder clay). The idea of an " ore-bearing horizon " was based on the supposition of the existence of bauxites under the limestones of Lower Carboniferous age (so-called Productus stage), covering the sandy-clayey complex. This supposition was confirmed by the finding of bauxites under the limestones at Batkov Konets and Senno villages. The sandy-clayey complex occupies a relatively narrow strip lying in a nearly meridianal direction ; the width, on the prospected part of the surface, does not exceed about 1·2 to 1·9 miles (2 to 3 km.) and in some places is only about 1,600 feet (500 metres) wide. This strip is covered by a thick layer of glacial overburden, consisting mainly of boulder clay but sometimes of boulder sands. At the west, it is limited by outcrops of the Devonian sediments, while at the east it plunges under a mass of limestones belonging to the Productus stage of the Lower Carboniferous. It may be pointed out that from the valley of the Volojba river, running through the Devonian formation, the altitude of the landscape towards the east rises almost continually. Also, the right tributaries of the Volojba river (the Piardomla river and others) as well as the left tributaries of the Tikhvinka river cut through the sandy-clayey complex, forming in this way by their valleys, bays of the Devonian period.

Lower Carboniferous Limestones.—The sandy-clayey sediments above described are covered by a great complex expressed chiefly by limestones. This complex is assigned to the Productus stage of the Lower Carboniferous age, as based on its fossil fauna. Usually, the transition member from the sandy-clayey complex is a brick-red clay containing abundant fauna, in which a considerable amount of the brachiopod *Productus giganteus* is found. This limestone complex may be divided for convenience into three parts. The lower part of it is expressed chiefly by highly argillaceous limestones, about 26 feet (8 metres) thick. The middle part, about 20 feet (6 metres-thick, is represented by two layers of bluish) grey clays, separated by a thin layer of conglomerate, the pebbles of which consist of rounded fragments of light grey limestone. The thickness of this conglomerate layer is about 1·6 to 3·3 feet (0·5 to 1 metre). Finally, the upper part consists of limestones of different lithological compositions with interbedded clays of various colours. The thickness of this upper part extends up to about 262 feet (80 metres). As already indicated, the overburden is a glacial cover of boulder clays and sands. In some places, facial transitions into clays and sands are to be noted. The bedding of the limestone complex is very nearly horizontal with a slight inclination to south-south-east. The contact surface with the sandy-clayey complex is very generally regular and even.

In all the Tikhvin deposits, the character of the bedding appears to be the same. The bauxites are disposed in the lower part of the " ore-bearing horizon " and are overburdened directly by glacial matter or by the sandy-clayey complex. This complex, in most of the deposits examined, contains boulders of irregular form up to about 3·3 feet (1 metre) in diameter. The space between the boulders is occasionally filled with powdery (sometimes highly ferruginous) bauxite. Where the bauxites are overburdened directly by glacial formations, the influence of the glacier is plainly evident. Squeezing and replacement of the bauxite mass may be seen as well as the formation of diagonal foliation. The presence of a considerable amount of bauxite pebbles may be observed in the boulder overburden as a result of ploughing out and transportation by the glacier.

4. Genesis of the Bauxites.—As has been pointed out by Dr. C. S. Fox, there are few petrological problems which have been so difficult of solution as the genesis of bauxite (laterite). Many and varied are the theories which have been advanced to explain the formation of different bauxite occurrences. These will not be considered here, but it may be pointed out that there are at least two different processes of formation to which the so-called " laterite " and " terra rosa " types of bauxite correspond. It appears to the writer that the Russian (Tikhvin) bauxites are of the " laterite " type and have been re-deposited as secondary material. According to Maliavkin, the bedding conditions, the mineralogical and chemical compositions, and the geological structure of the region lead to a conclusion in favour of a lateritic character for the formation of the Tikhvin bauxites. The presence of plant remains, as a sign of a warm and damp

climate, suggests an extended process of lateritization (sub-aerial weathering) of rocks at the beginning of the Carboniferous or at the end of the Devonian period. The nature of the Devonian surface on which have been deposited the sediments of the sandy-clayey complex suggests a lagoon into which streams discharged. These streams washed out the lateritic and argillaceous formations and transported the dissolved, as well as loosened, material into the lagoon. Here the dissolved matter was precipitated, probably aided by coagulative agents, e.g., humic acid. This method of deposition (lacustrine) has been suggested by Mallet for the Irish and Indian bauxites and by Spencer for the Alabama-Georgia ores. Maliavkin states that various rocks of the Upper Devonian, now entirely eroded, may have been the mother rocks of the primary laterites. These rocks were chiefly feldspars and were spread out in the present locale of Onega lake or near by. The streams transported the material from here. This theory explains the linear extension of the deposits in a meridianal direction, and it also suggests that bauxites may be found further north of the present known deposits. Proceeding on this hypothesis, the Russian geologists found the bauxite deposits along Radyn creek, in the vicinity of Batkov Konetz and Senno villages, along the Velikii creek, and along Sarooya creek. Investigations undertaken in 1926 along a line further north up to the Kapsky river showed a large development of glacial deposits. It is thought that still further north, in the region of the Vytegra and Andoma rivers, new bauxite deposits may be found. Among other indications, fireclays of excellent quality occur here.

Ancheles, Arshinov, and others have ascribed the formation of the Tikhvin bauxites to the action of sulphuric acid. The sulphuric-acid theory has also been advanced by du Bois to explain the formation of the laterites of Dutch Guiana. Ansheles suggests that the Tikhvin bauxites were formed *in situ* from clays of Lower Carboniferous age. He states that sulphuric acid originating from the oxidation of pyrite decomposed the clays with the formation of aluminium sulphate. Aluminium hydroxide (alumina) could have been precipitated as a result of interaction between the sulphate and the limestone occurring in the mass of the horizon or by means of solutions of calcium bicarbonate flowing beneath the limestones, or by both processes. The precipitation of the aluminium hydroxide and solution of silica would have been favoured by the presence of alkali carbonates and bicarbonates, produced by decomposition of mica by sulphuric acid, as well as by interaction between alkali sulphates and calcium carbonate and bicarbonate. Some items suggesting the above conclusion as to the genesis of the Tikhvin bauxites are as follows: (*a*) Pyrite is an usual constituent of the coal-bearing horizon of the entire Moscow basin, (*b*) Pseudomorphs of iron oxides after pyrite show that the deposits of iron ores and of sands cemented by iron oxides, developed in the Tikhvin region, have arisen *in situ* from the oxidation of pyrite. Extensive reserves of iron ores constitute proof of large occurrences of pyrite formerly present here. (*c*) Oxidation of pyrite gives rise to sulphuric acid, which, acting on the clays, forms aluminium sulphate and more complex aluminium salts. Certain aluminous clays present in the Tikhvin region contain rather large amounts of water-soluble sulphates. Alunite and other aluminium minerals (containing sulphates) are found in the bauxite deposits. (*d*) Microscopic examination of bauxites and aluminous clays, as well as chemical analyses, often shows more or less calcite. The interaction of aluminium-sulphate solutions and calcium carbonate (calcium bicarbonate) yields precipitation of aluminium hydroxide. (*e*) As already pointed out, a belt of limestones overlies the bauxite deposits. Solutions of calcium bicarbonate percolating from beneath this layer would precipitate aluminium hydroxide from solutions of aluminium sulphate.

The formation of bauxite from clays and the enrichment of clays is suggested by the above sulphuric-acid theory. The formation of bauxite by the action of sulphuric acid on feldspars has been suggested by de Bois and others, but so far as the writer is aware the formation of bauxite from clays has not previously been advanced. According to Ansheles (15), the above theory explains the following observations:—

(*a*) The occurrence of bauxite deposits and aluminous clays not only in the Tikhvin district, but generally within the boundaries of the Moscow Carboniferous basin, i.e., in a zone where outcrops of the rocks of the "ore-bearing horizon" are confined.

The adjoining Borovichi region exhibits in its "ore-bearing horizon" the so-called "sukhari" (non-plastic) clays; these are

enriched in alumina. These clays are also well represented in the Tikhvin region, being closely connected with the bauxites by a series of transition formations. Analyses have proven the existence of highly aluminous clays, as well as actual bauxites, in the same horizon in the Kaluga, Tula, and Ryazan governments, and also in Perm (the so-called Zhuravlikhinski deposits). In the Moscow Carboniferous zone, there are outcrops of strata of the coal-bearing horizon that contain large amounts of pyrite which has in part been oxidized at the surface. These outcrops are accompanied by Lower Carboniferous limestones (of the Productus stage). In the southern wing of the Moscow basin, the coal-bearing strata are underlain by limestones of the Malievko-Muraevninski horizon.

(*b*) The localization of the bauxites in a definite stratigraphic horizon.

(*c*) The presence of large quantities of iron ores and of sands cemented by iron oxides found associated with the bauxites in the same horizons.

(*d*) A vesicular structure of the bauxites. The reactions mentioned above are accompanied by the formation of large volumes of carbon dioxide, this latter causing a swelling of the plastic mass with the consequent formation of bubbles. Afterwards, the mass is cemented by aluminium and iron hydroxides.

(*e*) The oolitic structure of some kinds of the bauxites may be explained by a secondary filling up of the vacuoles by iron and aluminium hydroxides, calcite, alunite, and other aluminium minerals. Microscopic examinations of the structure of the oolites points to their koriogene origin, i.e., a deposition and crystallization from the outer crust towards the centre. Minute cracks in the bauxites, being filled up by the same products, exhibit a similar structure.

(*f*) The intensity and long duration of the above mentioned reactions explain the total absence of kaolinite and of vermiculites in the bauxites of highest quality.

(*g*) The presence in all the bauxites of rutile, tourmaline, and zircon corresponding to that in the clays may be explained by the resistance of these minerals to attack by sulphuric acid. The present writer is inclined to the view that the Tikhvin bauxites were formed by the sub-aerial weathering of plagioclase feldspars, and that the primary bauxites so formed *in situ* were transported by stream action into lagoons where the material was laid down yielding the present detrital deposits.

5. Mineralogical Composition of the Bauxites.—The chief mass of the Tikhvin bauxites is composed of colloidal hydrated forms of alumina, iron oxides, and silica. In addition, a clayish substance (possibly halloysite) is present. Titanium is present, partly in the form of rutile needles, but the chief bulk of the titanium is probably in the form of a silicate. The quantity of fixed water present is such that these bauxites are to be regarded in the main as of the diaspore type and in part of a diaspore-hydrargillite type. Microscopic examination has been made of a large number of samples of the Tikhvin bauxites. According to Ansheles (15), the aluminium is present either as the gel of diaspore (most frequently) or as hydrargillite (rarely). The former will be referred to here as "sporogelite," using the nomenclature of Kispatic. The optical characteristics of the sporogelite vary considerably, depending upon the percentage of alumina and silica in the bauxites. Thus, its index of refraction gradually changes from 1·57 in poor grade bauxite to 1·68 in good grades. The bauxite of inferior qualities exhibit, besides the iron oxides, greater or lesser amounts of kaolinite; this is, however, entirely absent in the bauxites of high grade. Bauxites of poor grade usually contain minute scalae (generally assembled in fan-shaped or vermicular aggregates) of a mineral (not definitely identified) having an index of refraction of 1·57 to 1·58 and with birefrigence from that of mica to perfect isotropy. Judging from the rather frequent occurrence of transitional forms, varying from partly split and slightly curling mica plates to real vermiculites, these latter were evidently derived from the mica during the processes of bauxite formation. In all the bauxites, grains of rutile, tourmaline, and zircon are found. These minerals are also found in all the clays and sands of the Tikhvin and Borovichi regions. Quartz is present in the Tikhvin bauxites in a very fine state of division. Also gypsum, mica (chiefly muscovite), alunite, hematite, pyrite, and rarely chlorite are found. The total quantity of these latter is small.

6. Chemical Compositions of the Bauxites.—The appearance of the Tikhvin bauxites is very variable. Colours range from white to violet, while the structures are partly porous and partly compact

(massive), frequently with a considerable amount of oolites. The oolites consist of oxides of iron and aluminium, and sometimes of other aluminium compounds, e.g., alunite. With increase in clayey admixtures, the specific gravity and compactness of the bauxites is increased. A wide range of chemical composition is shown in the deposits. The rocks present transitions from aluminous clays, the aluminous character of which is proven only by the presence of hydrated forms of alumina, up to varieties with an alumina content of around 70% and silica of 2 to 2·5%. The average quantity of moisture (evolved by ignition at 105° C.) is around 12 to 14%, while the total quantity of water (including the moisture and the combined water) ranges up to 18 or 20%. The titanium content is fairly constant, running about 2 to 2·5%. Regarding the iron oxide, the quantity present varies from 3 to 5% in the white bauxites up to 30% in the highly ferruginous varieties. While the calcium oxide content is normally negligible, in some places there appears to be an enrichment of this, evidently of a distinct secondary character. The calcium oxide content runs as high as 2% in some samples. Chromium up to 0·2% has been found in some samples.

Maliavkin has adopted the following classification for use in calculating the reserves and in grading the deposits :—

Grade.	Composition.
" Prima."	Al_2O_3>50% ; SiO_2<10%
I	Al_2O_3>50% ; ratio of A_2O_3 : SiO_2>3
II	Al_2O_3>40% ; ratio of Al_2O_3 : SiO_2>2
III	Al_2O_3>30% ; ratio of Al_2O_3 : SiO_2>1

The above classification is quite arbitrary, and it is obvious that only poor grade bauxites and aluminous clays are represented by grades II and III. Metallurgical ore (suitable for the preparation of alumina by the Bayer process or modification thereof) is only represented by the so-called " Prima " grade.

The range of composition, in a general way, for bauxites is as follows :—

Constituent.	%
Al_2O_3	45 to 70
SiO_2	2 to 30
Fe_2O_3	3 to 25
TiO_2	1 to 3
Loss on ignition	12 to 40

Very many samples of bauxites from the Tikhvin area have been analysed chemically, not only from drill-hole borings and test pits but also from actual mining operations. Table 1 gives the average compositions of the four grades mentioned above, as well as mixtures of these grades. The analyses were made on samples from the Krasno-Roocheiski deposit. Two hand picked samples of " Prima " ore from the Krasno-Roocheiski deposit gave the following analyses :—

Constituent.	Sample 1. %	Sample 2. %
Al_2O_3	69·43	54·40
SiO_2	5·52	2·03
Fe_2O_3	6·10	22·33
CaO	0·10	1·75
TiO_2	1·56	1·60
Loss on ignition	15·48	12·51

Taking a large number of individual analyses on samples of " Prima " bauxite from the same deposit, the following range of composition was shown :—

TABLE 1.—AVERAGE COMPOSITIONS OF VARIOUS GRADES OF BAUXITES FROM THE KRASNO-ROOCHEISKI DEPOSIT.

Grade.	Constituent, %. Al_2O_3.[1]	SiO_2.	Fe_2O_3.
" Prima "	58·38	7·25	13·70
I grade	52·57	9·81	18·70
Prima + I grade mixed [2]	54·95	8·76	16·20
II grade	45·89	14·53	22·5
Prima + I grade + II grade mixed [2]	51·54	10·93	——
III grade A [3]	36·51	21·47	18·3
Prima + I grade + II grade + III grade A mixed [2]	42·99	16·92	——
III grade B [3]	27·5	19·5	——
Al_2O_3	49·00 to 72·00 %		
SiO_2	4·14 to 11·51 %		
Fe_2O_3	3·20 to 25·08 %		
TiO_2	1·10 to 3·71 %		
CaO	0·68 to 2·00 %		
Loss on ignition	11·34 to 16·04 %		

The average of 40 separate analyses made on samples of " Prima " from the Podsosnenski deposit was as follows :—

Al_2O_3	61·98 %
SiO_2	7·07 %
Fe_2O_3	13·77 %
TiO_2	2·71 %
Loss on ignition	14·02 %

In passing, it may be said that the average high silica content of the Tikhvin bauxites may point to (*a*) detrital or secondary character of the rocks, and/or, (*b*) arrest of the primary laterizing process. Roughly, the Tikhvin bauxites are characterized by medium water content, high silica, and fairly high iron. Similar bauxites are found in Southern Croatia, among other localities.

[1] The Al_2O_3 above also includes the TiO_2.
[2] Mixed means as mined together.
[3] III grade is divided into two grades referred to as A and B. The latter is inferior to the former.

(*To be continued.*)

MAGNETIC OBSERVATIONS ON THE SWYNNERTON DYKE

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Considerable interest has lately been aroused in the use of physical methods for determining the occurrence and form of rocks under cover ; the question how far the instruments and methods proposed in recent years could be utilized for the precise mapping of concealed structures has for some time engaged the attention of H.M. Geological Survey. In 1927 a test traverse was made across the Swynnerton Dyke with the Eotvos torsion balance,[1] and this was followed by torsion balance surveys at Drumry[2] near Glasgow and at Portobello.[3] One of the oldest and best-known methods of geophysical prospecting depends upon the measurement of the local variation in the magnetic forces over an area. In theory this is closely linked with the gravitational method, and it is of special interest to compare the results given by the two methods over a mass of rock which differs both in density and in magnetic permeability from the surrounding material. Of late years great improvements have been made in the magnetic apparatus, so that an accurate observation can be obtained in the course of a few minutes ; the present note records the result of a trial survey made during twelve days with the Schmidt vertical field-balance,[4] recently acquired by H.M. Geological Survey. The structure chosen was the southern end of the Butterton-Swynnerton Dyke in North Staffordshire.[5] The dyke forms a nearly vertical wall of nepheline-basanite intruded in the Keuper Marls ; it attains a thickness of over 100 feet near Yarnfield, but is only seen to the south of this point at one locality where it is represented by three four-foot dykes of a fine-grained chilled rock, in fairly fresh condition. The rock is strongly magnetic, being rather rich in iron ores, and it will be shown that by the field balance it could be traced with some certainty even under cover for a distance of nearly 2 miles south of Yarnfield. Beyond this the outcrop was obscured by the L.M. & S.R. Main Line (L. & N.W.R. section), which renders accurate magnetic survey impossible for a distance of at least 100 feet on either side of the railway.

Apparatus.—The Schmidt vertical field balance is extremely simple, consisting of a horizontal magnetized balance-beam, which can be swung on obtuse quartz knife edges. The beam, which is placed at right angles to the magnetic meridian, and is thus subject only to the vertical component of the earth's force, is brought approximately to the horizontal position by an adjustable weight. Small changes in the vertical force cause the beam to tilt and the displacement is read upon a scale, which is reflected in a mirror attached to the beam. Copper dampers bring the beam to rest in a few seconds and readings can be obtained with certainty to 0·1 scale division. Simple though this arrangement may appear, the mathematical investigation[1] of its behaviour has been much

ASKANIA VERTICAL FIELD BALANCE.

[1] Supplied by Messrs. Oertling, Ltd. See W. F. P. McLintock and J. Phemister, *The Mining Magazine*, Dec., 1927, p. 363. Summary of Progress for 1927 (*Mem. Geol. Survey*), 1928, pt. ii, p. 1.

[2] *Trans. Roy. Soc. Edin.*, vol. lvi, pt. i, No. 7.

[3] Summary of Progress for 1928 (*Mem. Geol. Survey*), 1929, pt. ii. Contribution No. 2.

[4] This instrument was manufactured by the Askania Company, Berlin.

[5] See " The Country between Stafford and Market Drayton " (*Mem. Geol. Survey*), 1927.

[1] For details see C. A. Heiland, *Geophysical Prospecting*, American Inst. of Min. and Met. Eng., 1929, pp. 261–314.

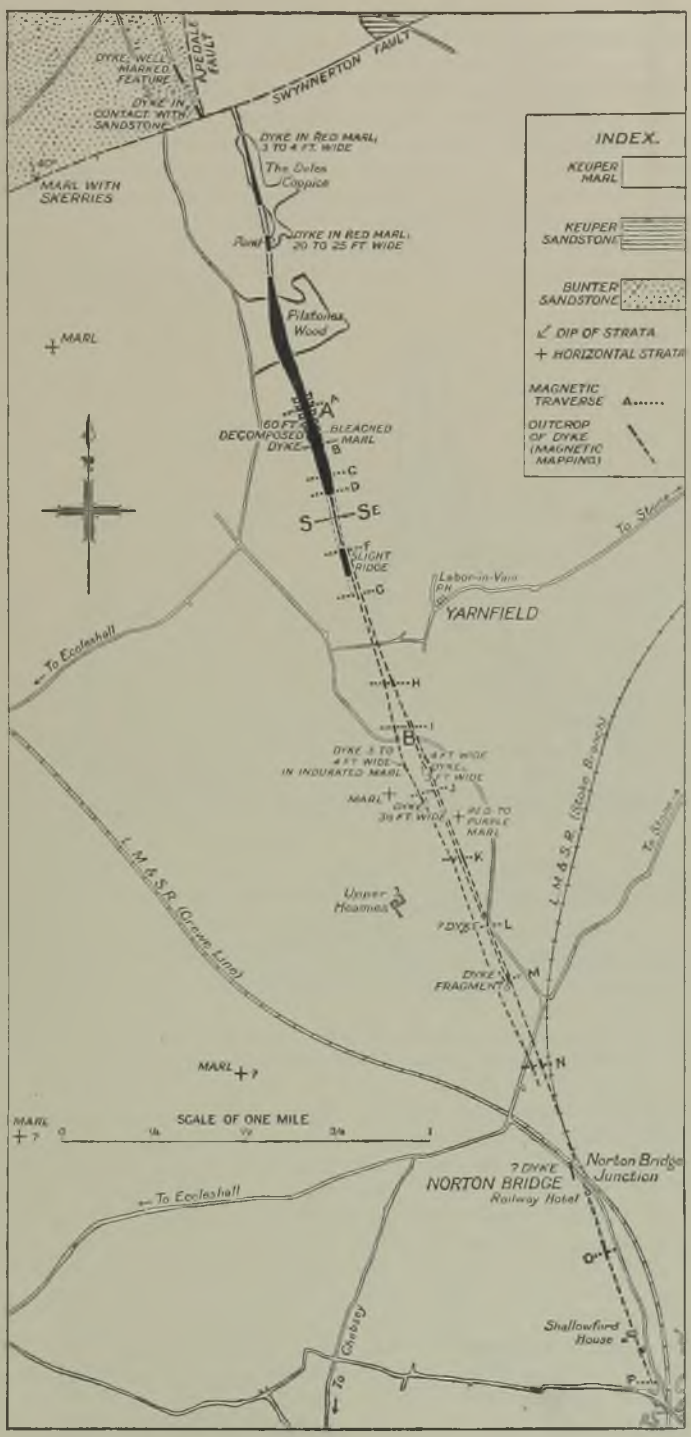


FIG. 1.—SOUTHERN END OF THE SWYNNERTON DYKE, MAPPED WITH THE VERTICAL FIELD-BALANCE.

discussed and has been the subject of numerous important corrections. Fortunately these chiefly concern the constructor; in use it is both simpler and safer to calibrate the instrument by placing it in a known magnetic field. Auxiliary magnets are provided to neutralize part of a strong magnetic anomaly so that the deflexion does not exceed the scale, and in the absence of an apparatus for producing a standard field these may be used to check the scale exposing any of the magnets to mechanical shocks or to stray magnetic fields.

Method of Survey.—In totally unknown ground observations are taken at a network of points, after which traverses may be made on selected lines to establish the nature of the outstanding magnetic features. In the present case, however, the general character of the feature to be mapped can be foretold on geological grounds; it consists of one or more walls of rock, probably of

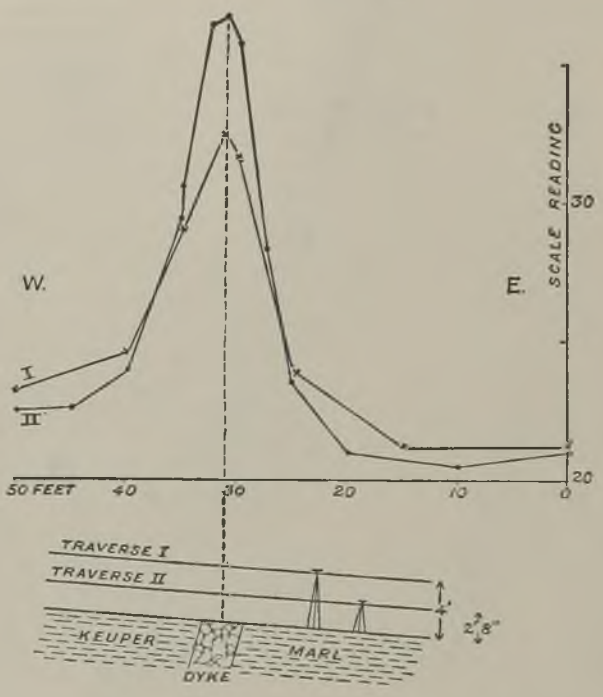


FIG. 2.—MAGNETIC TRAVERSES (VERTICAL FORCE) ACROSS THE SWYNNERTON DYKE WITH THE BALANCE AT DIFFERENT LEVELS. One scale division = 30 gamma.

value, provided that their moment is verified in the laboratory from time to time. For the most accurate work a small temperature correction must be employed, and also corrections for the value of the earth's force at the time of reading. In dealing with large anomalies, like those of the dyke at outcrop, these are unimportant, but they must be considered in the case of curves such as those for the dyke under cover, where the maximum value of the anomaly may be as low as 30 gamma (the unit of magnetic force, termed gamma, is 10^{-5} C.G.S.). The instrument is mounted on a tripod and has the weight and portability of a camera; but care must be taken to avoid fairly uniform north-south strike and very long in comparison with their width; traverses can therefore be at once employed. Since the general direction of the outcrop is in the magnetic meridian, the northward horizontal force due to the dyke will represent a balance between the forces exerted by those portions of the dyke north and south of the point of observation; it will be small and irregular and not subject to critical variations. The vertical force, on the other hand, increases sharply as the instrument passes over the dyke, and is therefore suitable for investigating the present structure. A number of traverse lines were chosen at right angles to the dyke and at roughly equal

intervals beginning north of Yarnfield, where the dyke outcrops with a width of over 100 feet, and ceasing at the railway south of Norton Bridge ; their positions are shown by broken lines on the map [1] (Fig. 1). Values of the vertical anomaly were determined at the scale readings of the vertical balance at the distances indicated on the horizontal scale. It will be noted that curves H, I, O and P are plotted on a vertical scale ten times greater than that for the other traverses. The curves have been placed so

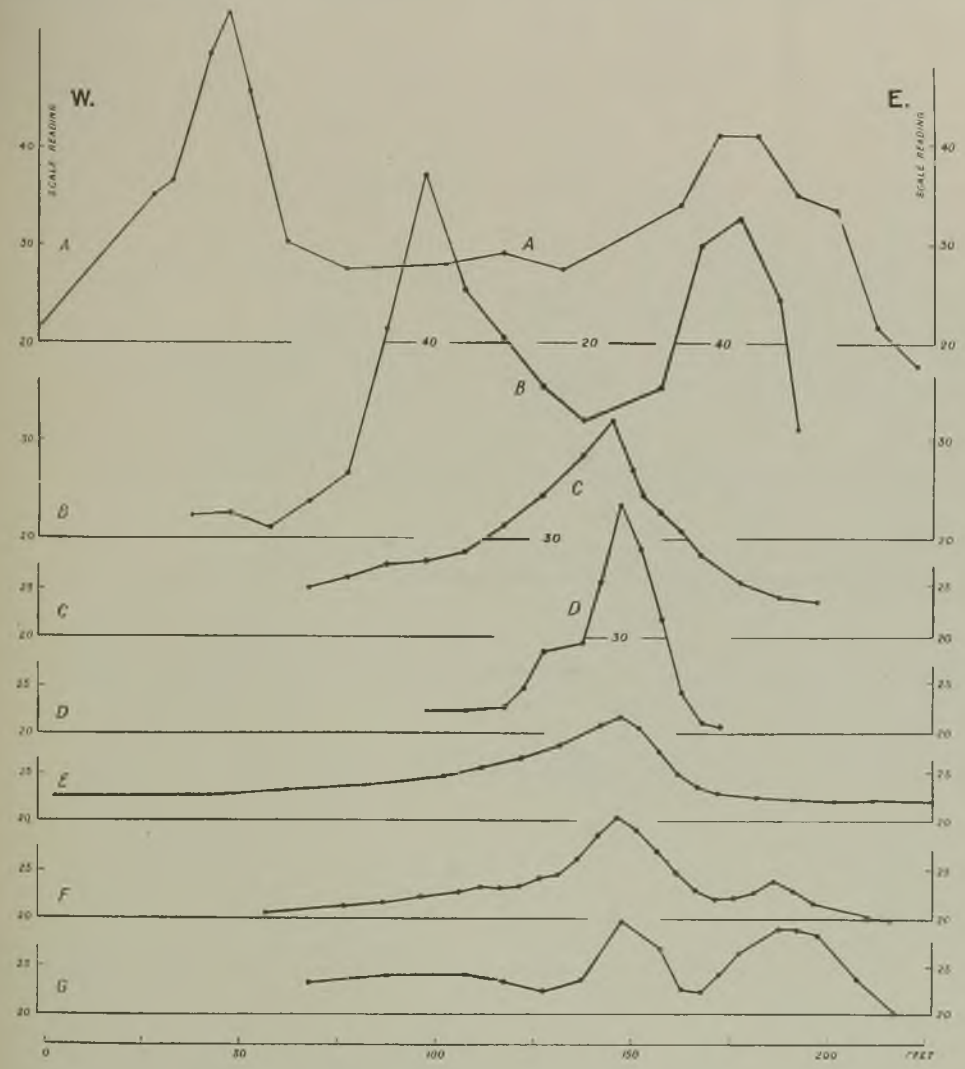


FIG. 3.—MAGNETIC TRAVERSES (VERTICAL FORCE) ACROSS THE LINE AP (FIG. 1).
One scale division = 30 gamma.

intervals of from 5 to 50 feet along these lines and the resulting curves are shown in Figs. 3 and 4, in which the ordinates represent that the features due to the right-hand (eastern) dyke are roughly in the same vertical line.

Interpretation.—In European latitudes a mass of magnetic rock exerts its maximum vertical force at a position almost vertically above, so that even under a considerable amount of cover the position of a dyke may

[1] This sketch-map is based upon that given in "The Country between Stafford and Market Drayton" (*Mem. Geol. Survey*), 1927, p. 64 ; it covers parts of one-inch Sheet 139 and 6 in. Sheets 29 N.E., 29 S.E., and 30 N.W., 30 S.W.

be inferred and mapped without special calculations. Determination of the thickness and the depth of cover involve further considerations to which it is hoped to refer in detail at a later stage. For the present purpose the dyke may be regarded as magnetized by the earth's field so that the upper surface has a south polarity. This exerts a strong positive (downward) vertical force, which quickly diminishes when the balance is no longer above the dyke. Since the balance stands about four feet above the ground it must be borne in mind that, even if the dyke is in fresh condition and at the surface, there is still four feet of cover and the anomaly does not fall to zero immediately the instrument crosses the edge of the exposure. Again, if the dyke is not quite vertical the sides also assume a weak polarity and the simple curve is rendered unsymmetrical,

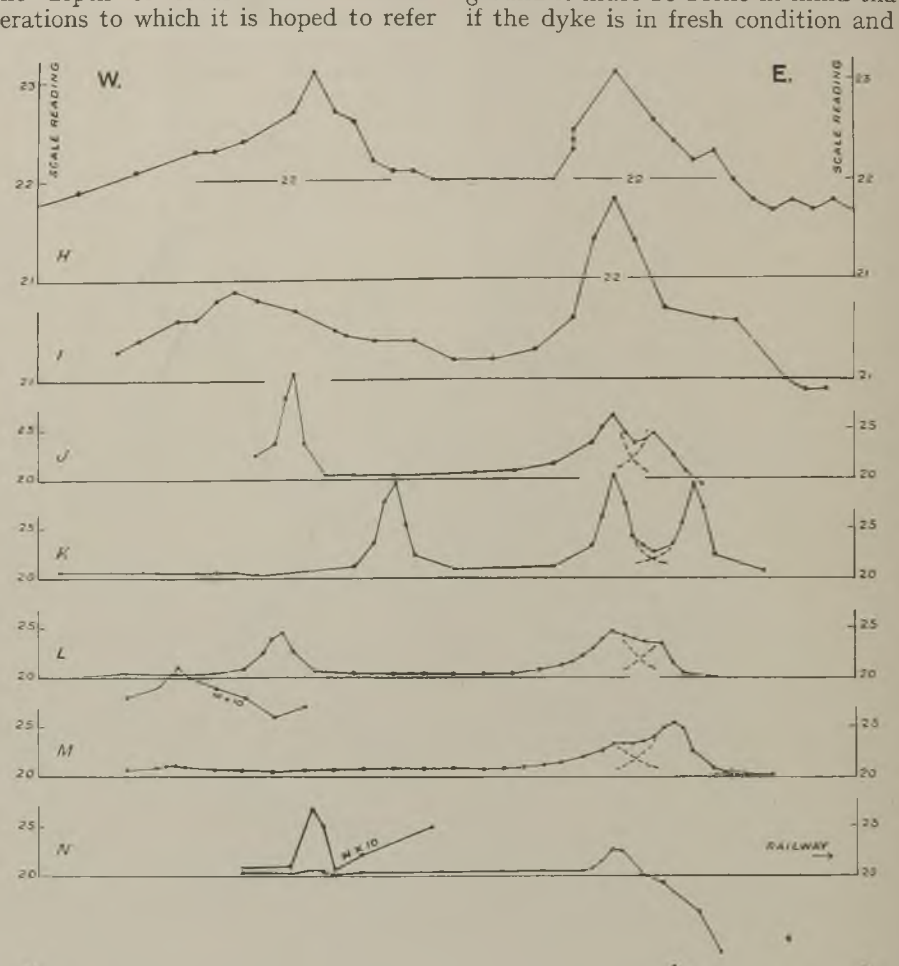


FIG. 4.—MAGNETIC TRAVERSES (VERTICAL FORCE) ACROSS THE LINE PA (FIG. 1) CONTINUED. Scale as before.

becoming higher over the hanging wall and steeper on the side of the footwall, as will be seen in the following example, which was chosen to illustrate the effects of dip and cover. At the top of the hill south of Yarnfield a four-foot dyke dipping about 70° W. is clearly exposed in a marl pit. A careful traverse was taken over it at about 20 feet from the edge of the pit, with the result shown in Fig. 2. Curve 2 indicates the values obtained when the tripod was lowered to a height of about two feet eight inches, while Curve 1 was obtained with the tripod at its usual height of four feet. The influence of the dip is clearly seen, though it is somewhat emphasized by the slope of the ground, which produces a similar effect.

Turning to the main traverses A to P, shown by dotted lines on the map (Fig. 1), the following details may be noted. Beginning from the north the first traverse A (Fig. 3) indicates a wide dyke (about 200 feet) with a less magnetic central portion. The latter feature is repeated in the second traverse, taken a few yards south of the quarry, where specimens of the rock were obtained. There is no doubt that the lower values in the central portion of the curve are due to the nature of the rock, which proved in the micro-section to be somewhat lighter, more weathered, and poorer in iron ores than the marginal parts of the dyke. This is of some importance, because a similar curve will be shown in the later traverses to arise from two parallel dykes under cover; the choice between the alternative interpretations depends largely upon the geological evidence. In traverse C, the curve exhibits only one peak, but the anomaly is appreciable for a considerable distance on either side, in a manner consistent with the presence of a thicker body of rock below the outcrop. D is on the level ground, immediately across the point of the main ridge. The anomaly diminishes at once on either side, as required for a dyke with nearly vertical walls and very little cover; it is clear that the width of the dyke has already diminished to about 35 feet. Traverse E[1] indicates a fairly narrow dyke of about fifteen feet, under a moderate amount of cover, and dipping to the west at a high angle. This is the only point where the dyke was found to give a simple curve. The next traverse, F, indicates the appearance of a second dyke, which attains full development in G. Two complete peaks occur with a very low anomaly between them, a result that can only be explained by the existence of two parallel dykes with very little cover. A third dyke to the west appears faintly in F and more clearly in G. From this point onwards three dykes are indicated in nearly every traverse up to the railway (see Fig. 4).

It will be clear from the example given with the tripod at various heights that the vertical force diminishes rapidly as the amount of cover increases. This is seen on comparing traverses H and I in marshy ground near Yarnfield with traverses J and K on the hill to the south (near Upper Heamies). On the hill the dyke is exposed in three branches each about four feet wide; traverses H and I in the valley show corresponding features, but the maximum amount of the anomaly is only about one-tenth of that due to the dykes at the outcrop (see traverses E, F, G, J, K) and the curves are blunted. A cover of about forty feet must be assumed for the western dyke in I, diminishing to sixteen feet over the eastern dyke. Traverse J, on the hill, agrees fully with the exposure near by, the blunting effect of slight cover being seen in the eastern dykes, but it is clear that the composite curve is the sum of two simple component curves (dotted lines) due to two parallel dykes and is not due to the outcrop of a wide dyke of variable magnetic character. In K all three dykes are apparently close to the surface, while L and M, taken toward the foot of the hill, show a certain amount of cover. Finally, the dykes approach the railway in the valley at Norton Bridge, where the eastern ends of the curves are distorted by a rapidly increasing negative force due to the railway (railings, bridges, etc.). On this account no very reliable conclusion can be drawn from the shape of the curves in N and P, but it is clear that the dyke persists as far as the cross-road south of Shallowford House, after which the outcrop again passes under the L.M. & S.R. Main Line.

The position of the dykes may be inferred from that of the maximum anomalies along the corresponding traverse, and can at once be plotted upon the traverse lines

[1] This traverse is upon the same line as that made with the torsion balance in 1927 by Drs. W. F. P. McLintock and J. Phemister, *loc. cit.* It will be seen that the present measurements are in substantial agreement with the conclusion drawn from the torsion balance survey.

in Fig. 1. The conclusions from the magnetic survey are in full accord with the known exposures on the hill at Upper Heamies, and there is sufficient correspondence between the successive traverses to justify the construction of the heavy broken line shown in the sketch map as the southward extension of the outcrop of the dykes. It will be noticed that although the dyke could not be mapped to the south of Yarnfield at the time the geological map was under revision, there are a number of isolated occurrences of fragments, etc., which find a satisfactory explanation in the course now proved for the southern end of the Swynnerton Dyke.

THE VALUE OF PYRITIC ORES AS SOURCES OF IRON ORE

By ARTHUR J. CADDICK, M.Inst.M.M.

The present communication deals with the classification of pyritic minerals in relation to their sulphur and iron contents, particularly from the point of view of their value as sources of sulphur for acid manufacture and of iron residues useful in iron and steel manufacture. object to show that the classification of pyritic minerals should be arranged on a basis whereby iron-ore residues are obtained down to the commercial limit of low-grade ore usable in the iron and steel trades. It will be appreciated that, having reached the bottom limit of quality for the iron-ore

TABLE I. COMMERCIAL LIMIT FOR LOW-GRADE IRON ORE.

CLEVELAND IRONSTONE.

Average composition per week ending	Raw Stone as Purchased.			Calcined Stone as Charged to Blast-Furnaces.			
	Fe %	SiO_2 %	Al_2O_3 %	Fe %	SiO_2 %	Al_2O_3 %	Further loss. %
Sept. 14	26·48	14·51	—	33·46	18·75	—	5·51
,, 21	26·24	13·23	—	32·95	16·51	—	4·15
,, 28	26·10	14·44	—	34·16	19·08	—	3·36
Oct. 4	26·00	14·65	—	33·02	18·61	—	4·66
,, 11	25·74	14·09	11·03	33·99	18·71	14·62	3·16
,, 18	26·63	13·85	10·55	33·72	17·20	13·44	5·63
,, 25	25·93	13·88	11·16	33·07	17·76	14·27	5·69
Nov. 2	25·63	13·66	11·07	32·63	17·20	14·06	5·90
,, 8	25·72	13·29	10·29	33·35	17·46	13·41	5·69
,, 15	25·22	13·11	11·38	33·28	17·53	14·90	4·21

Generally the onus of selling the iron-ore residues to the iron and steel trades falls largely on the sulphuric acid manufacturer. To protect himself on the total transaction it is obvious that a high sulphur content in the pyrites is called for, and the price he is prepared to pay for the pyrites is governed by the value of the sulphur to him, together with the receipts obtained by selling the iron residues to the iron and steel trades. In order to obtain the best return from the sale of their minerals it is necessary for the pyrites mining companies to consider both of these sides of the problem. It is the writer's

residues (on the classification proposed in Table II), there is still in the original pyrite ore samples quoted a quantity of sulphur greater than that which is regarded as the bottom limit by sulphuric acid manufacturers for efficient burning.

To understand the commercial limit of low-grade iron-ore it is convenient to give the author's experience in the manufacture of pig-iron from one of the lowest grades of Cleveland ironstone. Particulars of this practice are given in the accompanying Table I. The raw stone was calcined in Cleveland kilns, about 70 lb. of coal being

TABLE II. SHOWING RELATION OF COMPOSITION OF CRUDE PYRITIC ORES TO THAT OF IRON-ORE RESIDUES.

CRUDE MINERALS AS MINED.

Copper %	2·95	2·27	4·37	5·55	1·06	1·51	1·53	2·91	1·68	5·68	1·73	1·14	1·63
Sulphur %	46·31	44·20	46·76	44·80	48·62	38·92	32·96	27·00	23·21	24·61	13·57	11·84	8·73
Iron %	40·64	38·44	40·77	37·63	43·74	36·71	30·55	22·79	22·30	21·41	14·29	12·69	6·24
Silica %	3·50	3·96	4·20	4·50	5·63	13·60	25·20	39·60	40·82	41·60	55·58	59·04	77·30

LIXIVIATED IRON-ORE RESIDUE AFTER CHLORIDIZATION.

Weight of Crude Ore %	60·00	59·1	59·00	60·00	69·1	61·6	70·1	77·6	78·2	—	81·9	85·00	—
Copper %	Nil	0·20	0·15	0·20	0·36	0·11	0·33	0·44	0·16	0·41	0·25	0·15	0·06
Sulphur %	0·49	0·62	0·19	0·34	0·16	0·67	0·32	0·16	0·22	0·21	0·22	0·31	0·05
Iron %	62·44	61·35	64·25	60·74	63·69	50·88	41·27	30·43	28·95	25·42	17·00	13·64	9·18
Silica %	5·99	5·76	6·90	7·78	8·15	21·69	34·43	49·41	49·46	57·99	62·96	65·88	86·37
	Residues marketable as iron ore.						Residues not marketable as iron ore.						

used per ton of raw stone for calcining purposes. The price of the raw ironstone of 25% to 26% iron was about 5s. 2d. delivered works and the cost of the calcined ore of 33% iron and 17% SiO_2 was about 7s. 4d. per ton at the kilns. With these prices, and with coke at 16s. 2d. per ton it was just possible to make pig-iron commercially at about 48s. per ton.

From this experience it would appear that a ratio of about 33% iron to 17% silica is the commercial limit for the iron ore residues from pyritic minerals. The next question for consideration is the relation of the composition of pyritic minerals to that of their iron-ore residues. To ascertain this, a number of investigations were conducted on minerals ranging from 48·6% sulphur down to 8·7% and corresponding silica contents from 3·5% up to 77·3%. The results of these investigations, showing the relation of the composition of the pyritic minerals to that of the iron-ore residues after roasting, chloridization, and lixiviation for the extraction of copper and soluble salts are given on Table II.

From these results it will be seen that the commercial limit from the iron-ore point of view is reached from a crude pyritic mineral assaying 38·9% sulphur, 36·7% iron, and 13·6% silica. This means that pyritic mineral containing less than 14% silica may yield a marketable iron-ore residue and the separation or classification of such mineral from poorer grades may be profitable.

For pyritic minerals containing over 14% silica some means of concentration would be required before marketable iron-ore residues could be obtained.

For mineral containing under 14% silica, classification into different grades to meet market conditions is no doubt desirable and, in the opinion of the writer, minerals containing under 5% silicious matter might conveniently be considered as first class, between 5% and 10% silicious matter second class, between 10% and 15% silicious matter as third class, and over 15% silicious matter as mineral requiring concentration if iron ore residues are to be obtained.

It will be noted that the classification is given in terms of insoluble silicious matter, and not pure silica. The insoluble silicious matter is more readily determined, and the difference between this and pure silica allows for a working margin in classification or selection in the field. Where pyritic mineral is leached before burning, the sulphur content of the mineral as mined is different from that of the leached mineral, the reason being that the sulphur content of the crude ore is governed by the manner in which the sulphur is combined with the different metals in the crude ore, whereas in the leached ore the sulphur mainly exists as FeS_2. The other sulphur constituents of the crude ore, which all have lower sulphur contents, are in whole or in part eliminated during the leaching. Classification by sulphur content is therefore not reliable under these conditions.

In relation to the foregoing, the different sulphur constituents of pyritic minerals together with their sulphur contents are given in Table III.

TABLE III.—SULPHUR CONTENTS OF PYRITIC MINERALS.

	Sulphur Content. %
FeS_2	53·45
$FeCuS_2$	34·95
CuS	33·52
Cu_2S	20·14
ZnS	32·90
PbS	13·39
$CaSO_4.2H_2O$	18·62
$Fe_2(SO_4)_3.9H_2O$	17·11
$CuSO_4.5H_2O$	12·84
$FeSO_4.7H_2O$	11·53
$ZnSO_4.7H_2O$	11·15
$BaSO_4$	13·73

BOOK REVIEWS

The Profession of Engineering. Essays edited by D. C. JACKSON and W. PAUL JONES. Price 7s. 6d. New York: John Wiley and Son. London: Chapman and Hall, Ltd.

This book consists of nine separate essays or papers, three of them on the general profession of engineering and six on the six specialized branches into which it is commonly subdivided. In the preface five separate uses are indicated to which the book may be put. This gives the key to the whole character of the book. Each of the first six articles is a specification in detail of the qualities required in the profession, or branch of the profession, of engineering with which it treats. As specifications the articles are most complete and meticulous in detail. Each is as full of facts and sound advice to the young engineer as an egg is full of meat, but unfortunately the egg which these resemble is hard-boiled, and they make unattractive reading. The Seventh and Eighth articles, by John Hays Hammond, on "The Electrical and Chemical Engineer" are, however, much more attractive, while the final contribution, by Herbert Clark Hoover, on "The Engineer's Contribution to Modern Life" is, as might be expected, not only good sense, but fit to take its place in any literature.

It is a pity that the subjects as a whole are not presented in a more readable form, for the main point emphasized by all the writers is one which is not yet realized in England as it is abroad. In England the impression still lingers that the engineer is a sort of superior tradesman, to be called on as occasion demands by the administration. All these articles suggest that administration should be the ultimate goal of the engineer, a theory which President Hoover has put into practice.

TUDOR G. TREVOR.

The Coal Industry of the Eighteenth Century. By T. S. ASHTON and JOSEPH SYKES. 261 pages. Price 14s. Manchester: University of Manchester Press.

No British industry bristles more with historical facts of human, economic, and technical interest than that of mining. True as this may be, the history of British coal mining is little known and still less regarded by our generation. The industry would be spared many pitfalls were its history studied by those who seek politically to solve its thorny problems, and the industrial world would be wiser in its choice of palliatives.

This welcome volume should be read by all students of British coal mining. Though the authors borrow largely from the remarkable hive of information contained in "The Annals of Coal Mining," by R. L. Galloway, they have added numerous facts and data which have not appeared elsewhere in print and have presented a history of coal mining in the 18th Century which is well written, extremely interesting, and valuable. Few people realise the patient research required to publish a book of this nature, the value of which is considerably enhanced by adequate references in the text to all their sources of information and in a useful bibliography at the end.

The book contains 14 chapters, the weakest part of the whole being Chapters II, III, and IV, which deal with mining practice and technical development. The authors might with advantage have solicited the help of a mining engineer to assist them to develop more fully this section of their work, though one appreciates the fact that as students of economics they would naturally specialize on the subject matter of the remaining chapters which are so full of social and economic interest. The conditions and terms of employment in mining in the 18th Century are given in Chapters V, VI, and

VII; and the effects of war, industrial development, and famine prices of wheat, are discussed in the three chapters which follow immediately after. Chapter XI is devoted to the question of royalties and wayleaves, and Chapter XII to the supply of coal to London. Chapters XIII and XIV deal with combinations in the coal trade and their effect upon the London and inland markets. The facts disclosed in these two chapters have a bearing on the marketing schemes of our day.

The authors also give interesting appendices dealing with employment, profits, duties on sea-borne coal, statistics on exports, and prices of coal in London and the northern ports during the century, and they are, in general, to be congratulated upon the publication of a piece of research work which is well worth the time spent upon it.

K. Neville Moss.

Electricity Applied to Mining. By H. Cotton. Cloth, octavo, 636 pages, illustrated. Price 35s. London: Sir Isaac Pitman and Sons, Ltd.

This book is written essentially for the use of the operating engineer, giving just sufficient theory to enable the characteristics and working of the various types of electrical apparatus to be easily understood. It goes much further than this, however, in that it sets out clearly the requirements of the driven apparatus not only from the engineering standpoint but also from the economic aspect.

The author reviews the necessities of the industry in general and throughout refers constantly to the regulations of the British Home Office and to certain standard text-books on the subject.

Power supply requirements are carefully analysed with respect to the load factor and a careful study is made of the economic side. Thus examples are given to show the effects of different tariffs. The possibility of improved load factor by re-arrangement of individual loads is also considered.

Private generating stations are dealt with at length, showing the comparative costs of various types of prime movers. The various types of switch-gear and protective devices are fully discussed. Transmission and distribution of power is also carefully considered.

The later half of the book is devoted to Ventilation, Compressed Air Service, Haulage Battery Locos, Winders, Cutters, Conveyors, and Underground Lighting, and finally the steps necessary to render the apparatus flame proof are fully dealt with.

The book is well arranged and illustrated and should be a welcome addition to the library of the colliery engineer.

J. W. Sims.

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

NEWS LETTERS

JOHANNESBURG

June 6.

A Rand Diamond Field?—Mr. C. P. Engelbrecht, a diamond prospector who was associated with Mr. Harold Harger in the discovery of the Lichtenburg diamond fields, says that geological investigations on farms lying to the south-west of Johannesburg suggest that they contain diamondiferous gravels, and it is quite possible that in the near future, should prospecting be allowed, diamonds will be discovered similar to those in Namaqualand. It is a well-known fact that diamonds have been found in gravel on farms to the west and south-west of Johannesburg and even in the gold mines, but, in every instance, they have been few and far between and many experienced men say that hitherto they have not met with or heard of any indications of any possibility of concentrations of precious stones such as have been found in Namaqualand and also in some parts of the Lichtenburg area where "pot-holes" have been struck.

Gordonia Uranium Deposits.—Arrangements are being made to put down bore-holes on the property of the South African Radium Company in Gordonia, with a view to testing the property and ascertaining whether it contains larger bodies of radio-active ore than those which have been exposed by trenching. The operations will be conducted by the man who discovered by means of the diamond drill the very important deposit of uranium in the Belgian Congo, which is providing the greater part of the world's supply of radium. It is hoped that the drilling which is to be carried out in Gordonia will lead to the discovery of the source of the uranium which has been found in the pegmatite, and it may also reveal

the existence of lodes carrying other valuable minerals, such as copper, tin, lead and tungsten, which are found in association with uranium. Geologists and mining engineers who have visited Gordonia say that there are indications that the district is highly mineralized, and that it offers a promising field to the conscientious prospector.

Great Wealth of the Sperrgebeit.—From official information just released it is gathered that further important discoveries have been made in the Sperrgebeit portion of the property of the Consolidated Diamond Mines of South-West Africa, and that the estimated value of the diamonds already located there amounts to considerably over five millions sterling. The terrace is covered by varying depths of dune sand which make the tracing of the strike, which has a general direction parallel to the coast-line, somewhat difficult and slow. The width and depth of the gravel bed varies, the average being approximately $4\frac{1}{4}$ feet and $3\frac{1}{4}$ feet respectively. The stones are of excellent quality and equal in value (over £10 per carat) to those recovered from the phenomenally rich terraces at Alexander Bay. A rough calculation indicates a total of at least 250,000 carats worth something like £2,400,000, which the company may expect to recover from the treatment of the terrace gravels within the limits of the systematic development work. This figure does not include such diamonds as may be contained in the stretch of undeveloped terrace of $3\frac{1}{2}$ miles previously mentioned. When this developed area is prospected it is confidently expected that the present reserves will be increased by at least another 250,000 carats. The average size of the diamonds so far recovered is approximately $1\frac{1}{2}$ carats and included among these were one from development weighing 246 carats, and one of 116 carats from mining operations. Mining conditions will not be difficult, but the presence of the overlying dune sand, which is at times of substantial thickness, will later necessitate the provision of mechanical devices for stripping the sand from the underlying diamondiferous gravel. Transport of material and supplies presents another problem, as the area to the north of the Orange River is not easily accessible either by sea or by land. A geological survey of the coast north of the Orange River mouth has been inaugurated, and other marine terraces similar to the one now being prospected have been found at Uubvlei and Kerbe Huk, $18\frac{1}{2}$ and 24 miles respectively north of the Orange River. As soon as labour is available, prospecting on these terraces will be initiated. It is anticipated that other rich terraces will be found along the coast between the Orange River mouth and the farm Marmora.

Promising Nickel-Copper Deposits.—It is understood that copper-nickel deposits of the Insizwa Range are at present being examined on behalf of a big American group. So far, there has not been sufficient work done to indicate whether the deposits are really payable or not. They occur in a great trough 10 or 12 miles wide under the Insizwa Mountains, and theoretically segregation will have concentrated the highest values towards the bottom of this trough. One incline only has been sunk from the margin towards the bottom, and that only for some 400 feet. The trough covers an area of at least 150 square miles, and may well prove to compare in values as it does in area with the famous deposits of Sudbury, Ontaria. The Insizwa deposits are regarded, so far, strictly from the base-metal aspect, and such platinum as they contain would be purely a by-product, as is the case at Sudbury, and in contradistinction to the Transvaal norite deposits, where platinum metals are the primary content and copper and nickel by-products only.

Scheelite in the Bushveld.—A Rand syndicate is opening up a promising occurrence of scheelite in the Bushveld on a farm situated about 60 miles north of the town of Pietersburg, Transvaal. When the discovery was made systematic exploration of the deposit was decided upon. In travelling due north-west various outcrops in the form of large boulders of scheelite were apparent; prospect holes were put down at intervals of 6 feet apart, and scheelite was located in each individual hole towards the end of the line. This cutting was done with the strike of the "flow" for about 260 feet until the main cutting (original prospect hole) was struck, 8 feet deep, 11 feet long, and 3 feet wide. As one advances further north, away from this lode, old granite, amphibolite (pyroxene) and massive quartz are clearly perceived out-cropping on the ridge of the adjoining hill, about 2 miles distant. Large quantities of scheelite associated with gold have been located, and further development

is in progress. These gravel deposits have also been determined to carry scheelite in substantial quantities. Labour is plentiful in the district for the work of preparing and packing the tungsten ores for export, and they will be shipped in bulk or as concentrates as the case may demand.

Pietersburg Asbestos Fields.—There are now eight asbestos mines operating in the Pietersburg district, and it is expected that there will shortly be a sharp advance in the output of amosite fibre. It is reported that 1,800 claims are to be thrown open at Dublin and about 400 at Malipsriver. Further discoveries have been made in the district recently, and options have been taken over farms and blocks of claims. People are coming from all parts of the Northern Transvaal to secure claims. The Dominions Blue Asbestos Corporation has increased its capital from £100,000 to £250,000. The recent acquisitions of the Turner group in the Pietersburg district will, it is understood, be handled by this subsidiary of Turner and Newall, Ltd. The Chunes Asbestos Co. is in negotiation with an important London house, which may acquire the control of the company outright.

Good Finds on Emerald Fields.—Now the fever season is over, increased activity is reported from the emerald fields in the Murchison Range. Some of the emeralds found lately are of excellent quality, and it is generally believed that when the workings of some of the companies reach a depth of 100 feet or so much more valuable gems will be brought to light. The Barbara Beryl Mining Syndicate, Ltd., has acquired four blocks of claims on the farm Barbara, and work has been commenced under the supervision of Professor P. Kovaloff. Emeralds of good quality have already been found at a depth of less than 10 feet from the surface. The claims acquired by the syndicate are the selected areas from some 2,000 claims which were originally under offer to the promoters.

Two New Shafts.—Excavations have been commenced on the East Geduld lease area for the shaft collar and the foundations for the necessary equipment, which is being assembled as rapidly as possible. The site of the shaft is about 2,800 feet from the west boundary, that is, the common boundary with the Geduld Proprietary Mines, and about 6,500 feet from the south boundary. It is anticipated that the shaft will cut the reef at about 2,850 feet, and it will be continued to a depth of 3,250 feet to allow for the ore bins. Connections will be made to the fourth and fifth level drives, which are already being developed in this neighbourhood from the main incline, and there will also be a cross-cut to the sixth level. The fact that the Witwatersrand measures at the shaft site are overlain by a thickness of about 850 feet of dolomite, in which cavities and water are liable to be encountered, makes it difficult to estimate with any degree of reliability the speed at which the shaft will be sunk. Given reasonable conditions, however, it is anticipated that the shaft should be in full commission for the purpose of hoisting stope ore within two and a half years.

A new vertical shaft is to be sunk in the main free section of the West Rand Consolidated Mines, with the object of opening up the huge unexplored area which lies below the 27th level. The shaft will be located at a central position in the property to the dip of the existing mine, and should encounter the reef at an approximate depth of 3,500 feet below the surface. It should enable the company later on not only to close down the existing main reef incline shafts, which are very expensive both in operation and maintenance, but also to reorganize the pumping arrangements to better advantage and adequately to ventilate the southern section of the mine.

Government Aid for Mines.—The report of the Director of the Geological Survey of Southern Rhodesia for the year 1928 shows that the mining companies have recognized the value of geological inquiry in their particular sphere and have largely co-operated with the Survey, to the mutual advantage of all concerned, by giving every facility for the examination of underground workings, assay plans, reports, and other data. A considerable amount of work has been devoted to the visiting of both large and small mines where such visits were desired, and in giving useful advice. As a result the attitude of mine owners generally has been greatly changed with regard to the Survey, and indifference, if not actual antagonism, appears to have given way to real interest and appreciation. As an example of the more practical side of the department's activities, it may be mentioned that in September a Government geologist spent three weeks at the Giant Mine, making a geological map of all surface exposures

within a radius of 1½ miles of the mine. The Giant lode, one of the richest concentrations of gold in Southern Rhodesia, was cut off by faults at a depth of 800 feet from the surface, and was never found again. During the life of the mine it was thought that the faulting would cause a large lateral shift on account of the intense smashing observed below the reef. After a careful examination of the records in the possession of the Geological Survey, it became obvious that there is a large sector underlying the lode which has never been explored. Cross sections were drawn and a model constructed, both of which showed up this unexplored zone very clearly. The probable effect of the complex faulting was worked out graphically, and it can be shown that a very likely position for the lost reef would be in the unexplored sector. The exploration of this unproved zone is considered to be a legitimate mining speculation. A summary of the evidence as to how this conclusion was arrived at was drawn up and handed to a syndicate interested in the reopening of the mine.

BRISBANE

May 20.

A New Government.—A general State election, which has just taken place in Queensland, has resulted in demonstrating a remarkable change in political opinion that is certain to assist in a revival in mining as well as other industrial pursuits in this State. A Socialistic Labour Government, which has been in power as long as 14 years, has been completely overthrown, and the erstwhile Opposition, consisting of what has been known as the National and the Country Party, has been returned with a majority in the State Parliament larger than that previously enjoyed by their opponents. One thing that has operated detrimentally to mining under the old regime has been the establishment of State enterprises that have checked the investment of private money in industrial concerns. This has particularly been the case with coal mining in which State collieries that have been run at a great loss have ruined the trade of several privately owned mines and prevented many from putting money into like enterprises. It is certain that the new Government will make a change in this respect. Another check, which has operated in all branches of mining, has been the ever increasing legislative provisions made not only to increase the wages and other concessions to the worker, but practically to tie the hands of owners by granting preference to trade unionists. This preference, it is definitely promised, will now be removed as soon as possible after Parliament reassembles.

Queensland Minerals.—Official returns of the output of minerals in Queensland for 1928 are contained in the annual report of the Department of Mines published during the past month. The value of the total production of all minerals, including gold, was £1,386,900, which is £259,083 less than that for the preceding year. While there was a falling off with respect to nearly all minerals, the chief decline was in gold. The bulk of the gold decrease, as well as nearly half of the decline in copper output, were attributable to the closing down of Mount Morgan early in the year.

Mount Isa Mines.—As a result of the uncertainty of the rainfall in the north-western portion of this State, the construction of the dam which is to supply the Mount Isa mines and township with water has been watched with a good deal of interest. The position with respect to the new reservoir now is that the dam is practically finished to its intended height of 50 feet across a gorge at Rifle Creek; that in this year's wet season, which is now over, very little rain has fallen at Mount Isa since early in December last, when the wall of the dam was only 20 feet high; and that the present depth of water in the reservoir is 15 feet. Mr. F. W. Draper, chief engineer of the Russo-Asiatic Consolidated, who is now in charge at the mines, and who has just passed through Brisbane on his return from a visit to Sydney, would like to see the water 40 feet up the dam, so as to be sure of a safe supply. He assures me, however, that there is no cause whatever for anxiety, as the water at present available is quite sufficient to carry on all the preparatory work that has to precede active mining, production, and ore treatment, which will not begin probably till April next. Before that, another wet season will be due. A survey is now being made for the pipe-line which is to carry the water from the new dam to Mount Isa, a distance of 200 miles, and when this pipe-line is laid a very considerable quantity of water,

which has backed a good way up the creek from the dam, will be available to supplement the water supply which is being obtained now from wells and a small reservoir in the vicinity of the mines. It is estimated that the dam when full to its greatest capacity of about 600,000,000 gallons, will contain enough water to last for a period of about three years. From latest reports from the mines, it appears that work here is being mainly concentrated on the installation of the central power plant and machinery, as well as the building of house and office accommodation and the erection of the metallurgical plant. This plant, Mr. Draper says, will, when complete, be the largest and most up-to-date in the world. The establishment of an electrolytic refinery on the North Queensland coast to treat the zinc concentrates from Mount Isa, that was mentioned in the original programme of operations, is as yet a matter for the future. For one thing, it has not been ascertained whether sufficient water power is obtainable for such an undertaking; but apart from this, Mr. Draper says, it has first to be determined how the zinc concentrates are to be dealt with, and there are other methods besides treatment by electrolysis which may be adopted, including a new one of leaching by acids.

The Australian Coal Trade.—At last a start has been made in a direction which may lead to the establishment of an outlet for Queensland coal overseas. This State has many extensive seams of coal, but through the lack of demand only a small proportion have been exploited. The trade has been almost entirely confined to the supply of domestic demands, and of a small quantity of coal for bunkering, with the result that at nearly all the producing collieries frequently less than half-time has been worked. For coal, however, from the Bowen field, in the north, where there has been a growing demand for vessels requiring it for their bunkers, a few small orders have for some months past been filled and shipped at Bowen for overseas, probably for the East; but the most important move in this direction has been the starting, within the last two or three weeks, of a trade for Burrum coal for Java. Already two vessels have taken away shipments, and a third is about to load another lot, consisting of about 30,000 tons. The coal is loaded at Urangan, a port in Hervey Bay, 18 miles from the Burrum coalfield and about 150 miles north of Brisbane. Geographically both Urangan and Bowen have an advantage over Newcastle, in New South Wales, in supplying the East, and it is stated that the Burrum coal which is of good quality, is being disposed of at 6s. a ton less than the Newcastle price. The jetty at Urangan is accessible to vessels of moderate tonnage, but can be made available for larger ones by a little dredging, which will no doubt be done if the trade promises to warrant the necessary expenditure. While the contracts at present entered into are of an experimental nature, and may to some extent be attributable to the stoppage at the principal coal mines in New South Wales, little doubt is entertained that it will become permanent, especially if regularity of supply can be assured by the absence of industrial troubles. All further efforts for the reduction of the price of coal in New South Wales have failed, and all the associated mines in the Newcastle and Maitland district remain closed. The block every time is that the miners, or their representatives, absolutely refuse to bear any portion of the proposed reduction in the shape of less wages. A Royal Commission has now been appointed by the Commonwealth Government to inquire into the coal industry, but it will probably be the best part of a year before they can finish their investigations and furnish a report. It has already been stated that South Australia has been forced to get its coal from Great Britain; now consumers of large quantities in Victoria have been obliged to get their supplies from New Zealand and England.

Broken Hill.—Mr. F. J. Mars, consulting engineer, has returned to Australia from Europe, where he has been to consult with large engineering firms in Berlin, France, Switzerland, and Belgium, in regard to the installation of oil plants for a general power and air compressor scheme at Broken Hill for the South and North mines and the Zinc Corporation. Tenders for the supply of Diesel engines have been received from Great Britain and Europe; and those for the new plant, which is estimated to cost £300,000, are now under consideration by various companies in Melbourne. The earliest time at which delivery can be made is two years. The plant will probably consist of six generating units of 3,000 h.p. each

and four air compressors of 1,200 h.p. The number of men employed along the line of lode at Broken Hill is now about 4,500 of which the North mine has 1,064, the Central 665, and the Zinc Corporation 831. The chairman of directors of Block 14, which before it was closed down employed over 200 men, has stated that mining operations there will be resumed as soon as satisfactory arrangements can be made for the treatment of ore.

TORONTO

June 17.

Expansion of Mining Industry.—In recognition of the growing importance of the mining industry, the Dominion Geological Survey has arranged an unusually expansive programme of field work for the season. In all 52 parties will be engaged, while some of these parties will be sent into the little known parts of the country mainly to undertake topographical work, the larger number of the party will be located in known mineral areas for the purpose of ascertaining the extent and geological relationships of the mineral deposits and of the rock formations. Much attention will be given to the Coast Range batholithic formation which runs through British Columbia and the Yukon and is rich in metallic resources. Six parties will explore the foothills of the Rocky Mountains in Alberta in the neighbourhood of which occur coal, oil, natural gas, and other non-metallics. The Pre-cambrian Shield is now well known for the variety and importance of its mineral wealth. Sixteen parties will be scattered through this huge region of nearly two million square miles. The Completion of the Hudson Bay Railway and the use of aircraft have enabled explorations to be carried on further afield than was formerly possible. A party has been sent to Chesterfield Inlet on the north west corner of Hudson Bay and another goes to the Chibougamou area of northern Quebec, where rich copper-gold discoveries have been made. A report issued by the Ontario Bureau of Mines of metallic production of the Province for the first three months of the year shows a substantial increase of $3,937,990, or nearly 25%, above the figures for the corresponding period of last year. The output was valued at $19,780,780. The gold output was practically stationary, but there was a marked expansion in the output of the nickel-copper industry, and also a substantial gain in the production of silver.

Porcupine.—Production of bullion from the Porcupine mines during May amounted to $1,687,477, as compared with $1,498,671 produced in April. The McIntyre closed a highly successful fiscal year on March 31st. The annual report shows production to the value of $4,212,624, as compared with $3,987,685 for the preceding year. Net profits after providing for depreciation, etc., were $1,289,612, as compared with $1,160,648. The mill heads increased from $7·66, to $7·83 per ton. The surplus amounted to $3,809,536. Underground work is progressing satisfactorily. Connection has been made on all haulage levels with No. 11 shaft, which has been sunk to a depth of 4,100 feet, and it will shortly be put into operation. Ore reserves are estimated at a value of $16,179,205, or a little less than four years' supply. The Dome mines are treating an average of 1,500 tons of ore per day, with a recovery of $7·60 per ton. Production during May amounted to $409,518, which exceeded that of April by $56,164, and was $108,831 more than the output of May, 1928. During the three months ending April, the Vipond Consolidated, Ltd., produced $209,500 from 26,357 tons of ore. Development work has been continued on the new orebody at the 709 drift, and good ore has been disclosed on four levels. The cross-cut run at the 200 ft. level to tap a vein coming in from the Hollinger has encountered a mineralized zone carrying quartz stringers.

Kirkland Lake.—During May the mines of the Kirkland Lake area produced bullion to the value of $1,157,028, which was less than the April output, the decrease being largely due to the smaller tonnage handled by the Wright-Hargreaves. The Lake Shore is making good progress with its programme for enlarging the capacity of its mill to 2,000 tons. Equipment to the value of $500,000 has been ordered, including six new tube mills. The mill is now handling from 1,100 to 1,200 tons daily. The new Number 3 shaft has reached a depth of 1,900 feet. On the 1,800 ft. level a wide vein of high grade had been encountered. Stoping has been started on the 1,200 and 1,400 ft. levels, the ore showing an average value of $15 to the ton. Kirkland Lake gold has sunk a winze to a depth of 3,600 ft., which

is the deepest working in this camp. It will be continued to 4,000 feet, and from that horizon a diamond drilling compaign will be undertaken to test the formation down to 6,000 feet. A diabase dyke which occurs on the adjoining Teck-Hughes dips into the property at depth and will be followed up in the expectation that high-grade ore will be found in its neighbourhood, as was the case on the Teck-Hughes. The Kirkland Lake Gold has arranged to take over the property of the Chaput-Hughes adjoining, the stockholders of the latter company to receive one share of Kirkland Lake stock for each ten shares of their present holdings. The annual report of the Sylvanite for the year ending March 31 showed production valued at $737,573. The expenses were $655,020, leaving a profit of $95,479. The sinking of the main shaft to 2,000 feet has enabled the opening up of four new levels with good results. The Barry-Hollinger has cut the downward extension of No. 7 vein at the 1,500 ft. level, where it has a width of 9 feet, 4 feet of visible gold. Kirkland Eldorador is preparing to sink a shaft to a depth of 100 feet, surface work having disclosed a zone 50 feet in width carrying free gold and chalcopyrite. The Teck-Hughes is milling an average of 925 tons of ore per day. Six new levels are being opened up at depth, in one of which ore has been encountered of satisfactory grade and width. An important copper mining industry is being developed in the Boston Creek section of the field; the Amity Copper, which made several shipments to the Noranda smelter last year, has encountered high-grade ore on the 600 ft. level and has two cartloads ready for shipment. The Patterson Copper mine adjoining the Amity has opened up good ore on the 125 ft. level and is also preparing to make shipments in the expectation of being able to do so regularly.

ROUYN.—The programme of development now being carried out at the Noranda is expected to increase the output sufficiently to enable the smelter, the second unit of which has been completed, to operate at full capacity by October. The new shaft has reached the horizons of enrichment on the " H " orebody, at 975 feet in depth, and this deposit has been proved to extend considerably further than was previously known. Diamond drilling has proved the continuity of ore to a depth of 1,600 feet. Diamond drilling from the 300 feet level of the Waite-Montgomery has discovered an entirely new orebody, some 300 feet distant from the present workings. The shaft is to be deepened to allow of further explorations. Shipments averaging 4,000 tons per month are being made to the Noranda smelter. The shaft of the Abana is to be sunk to a depth of 500 feet and later work undertaken to prove the continuity of mineralization. The Granada has latterly considerably improved its position, the drift at the 625 ft. level has been in high-grade ore for 120 feet, this deposit has also been encountered on the 500 ft. level. The Newbec has made highly important discoveries of high-grade on the 125 and 250 ft. levels, and is likely before long to become a substantial producer.

SUDBURY.—Rapid progress is being made with the expansion programme of the International Company of Canada, approximately 2,250 men are employed on the construction of the new smelter at Copper Cliff and in the Frood mine development. The Frood mine alone is employing 1,400 men and the force will be considerably increased when the production stage is reached. At the Port Colborne Refinery three electrolytic units are being installed. The shaft of the Levack Mine is being deepened 300 feet, and additions made to the hoisting capacity. The net profits of the company for the three months ending March amounted to $5,590,191, and the balance after the payment of dividends and all deductions was $2,251,168. Shaft sinking at the Falconbridge is rapidly nearing the 1,000 ft. objective. Explorations at this horizon will be carried on by diamond drilling. Drill cores from the 1,000 ft. level indicate increased enrichment at depth. The ore above the 500 ft. level is estimated at 5,000,000 tons. Among other companies which are carrying on active development in this field are the Treadwell-Yukon and the Sudbury Nickel.

MANITOBA. — Mining men are much interested in the tin discoveries in the Lac du Bonnet area, and should that metal be found to occur in commercial quantities, more capital will be attracted to this field. On the property of the Jack Nutt Mines, Ltd., work is progressing steadily, and the shaft is down 60 feet. The Manitoba Flin Flon, a new company, has holdings comprising 1,600 acres in the northern mining area. A test

pit sunk on what is known as the Iron Horse group is reported to have revealed good copper and zinc values. Work of preparing the Flin Flon mine of the Hudson Bay Mining and Smelting Company is well advanced. Work has been speeded up by the installation of a temporary power plant of about 1,500 h.p. About 1,000 men are employed at the mine and the power development at Island Falls. The mill of the Central Manitoba mines is treating 160 tons daily, the returns being sufficient to defray expenses. A discovery of high grade has been made on the Tene property of the Company.

VANCOUVER

June 10.

The Kootenays.—The latest concern to enter the Pend d'Oreille district, which continues to attract a good deal of attention, is a Vancouver Syndicate, headed by Mr. R. H. Stewart, a former general manager for the Consolidated Mining and Smelting Company of Canada, and by British Columbia representatives of the Victoria Syndicate, of London. Mr. Stewart and his associates have secured a controlling interest in the Red Bird Mining Company, which owns a mine situated at the confluence of the Pend d'Oreille and Salmon Rivers, for a consideration on the basis of $1,000,000 for the mine. A vein, 20 to 25 feet wide, has been traced for 3,000 feet on the surface by a series of open-cuts, and exposed for 700 feet at 150 to 250 feet below the surface by an adit. The surface exposures and adit are in oxidized ore, running up to 40 per cent. of zinc, with low lead, silver and gold values. The syndicate is well provided with funds and is seeking nothing from the public at this stage. Diamond drilling will be started at once, and probably another adit will be started to give an additional depth of 700 feet on the vein. The fact that Mr. Stewart is president of the Grandview Mining Company, on the other side of the international boundary, and his close associates with the Victoria Syndicate, and hence, with the Reeves-McDonald and Pend Oreille Companies, seems to indicate that at some future time the whole of this district may come under one control. Grading for the Pend Orielle mill has been started.

Reno Gold Mines, which is said to have been amply financed by English capital represented by Mr. C. E. Hutton, is about to start on the erection of the first 40-ton unit of a mill and cyanide plant. Two shoots, one 200 feet long and the second 200 feet with the face of the drift still in ore, have been opened in No. 2 Adit. Part of No. 1 shoot has been exposed by No. 4 adit, 300 feet below No. 2. The vein is about 9 inches wide and the shoots are said to average about 3·25 ounces of gold and 1 ounce of silver per ton. Development has been confined to the main vein; six other parallel veins have been exposed on the property.

At the annual general meeting of the Slocan Consolidated Silver Mine it was decided to pay monthly dividends of one cent on the 20 cent par value shares. The company owns and operates the McAllister mine at Three Forks, which shipped 5,200 tons of dry silver ore to Tadanac last year. On account of its fluxing property the ore receives the specially low treatment rate of 50 cents per ton.

Britannia Beach.—The Howe Sound Company, holding company for the Britannia Mining and Smelting Company, in British Columbia, and the Calera and El Potosi Companies, in Mexico, made a net operating profit of $990,285 for the first quarter of this year, as compared with $754,514 in the last quarter of last year, after providing for all expenses and depreciation. The metal output from the Britannia was 10,214,981 pounds of copper, 3,454 ounces of gold, and about 50,000 ounces of silver. The company is sinking on the 2,700-foot level, with a view to determining the advisability of extending the main haulage tunnel on the 4,100th into the orebodies or below them if they do not persist to that depth. It has also started diamond drilling explorations at the Toric mine, in the Alice Arm district, and has resumed development at the Kootenay King, in the East Kootenay. Recently it purchased the Holden Copper Mining Company for $250,000. The Holden Company owns a mine near Wenatchee, in the State of Washington. It was staked 30 years ago, and some $200,000 is said to have been spent on its development. Britannia has sent 20 men to clean out the old workings.

Portland Canal.—By the recent purchase of Mr. and Mrs. W. B. George's shares for $171,000 and smaller blocks of original vendor's shares for amounts not stated, the

Consolidated Mining and Smelting Company of Canada has acquired 92 per cent. of the stock of George Gold-Copper Mines. The remaining stock is distributed among small holders. The Consolidated Company has been exploring the property with a diamond drill for the last two seasons. Though drilling has not proved the downward continuity of ore exposed on the surface, it has found at a depth of 1,100 feet a wide belt of copper-zinc ore, practically devoid of precious metals. This belt the company will attempt to develop underground, while continuing diamond drilling with more powerful drills, during the present season.

Vancouver Island.—At the annual general meeting of Pacific Tidewater Mines, held recently in Victoria, Mr. Herbert Carmicheal, Managing Director, announced that the directors considered it advisable to amalgamate the Company with Ladysmith Tidewater Smelters, on a basis of an exchange of 12 shares of the mining company for one of the smelting company. He stated that he had been authorized to make this offer by British Metal Corporation, which controls the smelting company. The proposal will come up before a special general meeting in the near future. Tidewater Mines has completed the electric survey of the Gabbro group, adjoining the Sunloch mine, and is about to start diamond drilling. It has dropped its options on Indian Chief mine, Blue Grouse group, and several other properties, and is concentrating its energies on the Gabbro.

Anyox. — The Granby Consolidated Mining, Smelting and Power Company made a net operating profit, after all expenses, but before depletion, depreciation, and income tax, of $940,364 for the quarter ended March 31, which compares with a profit, similarly computed, of $353,605 for the corresponding quarter of last year. The company produced 14,904,806 pounds of copper at a cost of 9·97 cents per pound, as compared with 13,561,345 pounds at a cost of 9·65 cents in the first quarter of 1928, the slightly higher cost this year being due to the higher wage rate, which by arrangement with the employees fluctuates with the market price of copper. The company is increasing the heavy crushing equipment at its Copper Mountain mine and the flotation equipment at its mill, and thereby expects materially to increase the output of that property.

RANGOON

June 1.

Notwithstanding that tin is now quoted at less than £200 per ton, there have been three sales of tin areas put through this year. All are in the Mergui District. The largest and most important deal effected is the sale of the Tonbu Chaung area, near Palauk. The Malayan and General Trust, Ltd., are the buyers and the purchase has been made solely on the mineralized hill sides. It is expected that these will be worked by means of large-scale ditching and fluming, bringing in water from many miles outside the mine. For this purpose the block is well situated, as it is in the hill mass which culminates in Myinmoletkat peak of 6,800 feet elevation, only a few miles to the east. The frontage of the area is also on the largest waterway in Palauk district, the Palauk River. This with its many and large tributaries should give a sufficiently ample supply to keep continuously at work a battery of monitors numerous enough to break down a yardage which many a dredge will not effect.

The adjoining block is under transfer to the Heinze Burmah Tin Syndicate, Ltd. The area is a promising one for underground developments and contains also dredging ground of about 9 million cubic yards. These two areas adjoin Tavoy border, across which there has been no activity or sale of mining properties. The much-bored Booth's Grant, situated near Kanbauk mine and south of Tavoy North dredging area, is included in the Heinze Burmah Tin Syndicate deal. It is partly dredging land, but a fair proportion of the acreage can only be treated by gravel pumps or dragline excavators.

The monsoon has definitely commenced on or about the 22nd of May. This is of great importance to the Consolidated Tin Mines of Burmah; with their 21 areas and with experienced local men at the head of affairs there should be a very large expansion of output after June 1, when their many miles of ditch will again be flowing full. It is not too much to expect

that the monthly tonnage will increase from about 90 tons to 250 in July and following three months. Labour shortage, it is feared, will go against them, but a determined effort has been made to remedy this, though only with untrained and undisciplined Yunnanese.

The monsoon just commenced is eagerly awaited by another company, which has been sadly handicapped by shortage of water for its elevators and gravel pumps. The Anglo-Burma Co. have at Heinda a most promising area and are, it is stated, undertaking underground work in search of tin-bearing lodes, as well as for other minerals. At present the main output standby is the elevator plant, which will come into full work this month or next. In their Mergui area there has been a set-back from mechanical trouble, which they are overcoming by tributing, which gives promise of outputs as large as formerly when the plant, expensive to operate, was running. In addition to these areas the Anglo-Burma Co., or its subsidiary, Burma Alluvials, Ltd., have recently acquired two dredging blocks in Mergui District. One is near Bokpyin, about 100 miles south down the coast from Mergui town. This is reported to contain about 7,000,000 cubic yards and is accessible from tidewater.

No more has been heard of payable cassiterite in the sea bed, nor has any additional work to find any been done in the open season just closed. The originator of this theory has, so he says, located in an island, off the usual steamer track, large deposits of manganese, mainly psilomelane. He is shipping some few tons home and elsewhere and states that phosphorus is under 0·65 per cent. Much will have to be overcome before any industry in working this can be initiated—proving and opening up the deposits, sounding, charting, and buoying in and among the surrounding islands; but paramount is the provision of cheap labour and the keeping such, when brought over from India, on an uninhabited isle in Mergui Archipelago. Labour may not be indentured; they are free to come and go and mainland mine owners state, if this project ever gets started, that their labour supply will receive considerable augmentation. As the deposits lie on the west side and are fully exposed to south-west monsoon swell there will be a 4½ month period annually when shipping of mineral will not be practicable.

CAMBORNE

July 1.

Dolcoath.—A number of Dutch mining engineers, said to be connected with the Billiton interests, have recently been examining the workings from the new Roskear shaft. This has caused much local speculation as to whether it may lead to the re-starting of the mine.

Siamese Tin Syndicate.—In addition to carrying out prospecting operations in the Fowey river valley, near Lostwithiel, we understand that this syndicate is investigating the possibilities of other "alluvial tin" areas in Cornwall. The word "alluvial" is somewhat loosely used in describing deposits which would be more correctly described as "mine residues" or "tailings" and which have accumulated along sea shores and in river beds as a result of some hundreds of years of mining and dressing operations.

Wheal Hope.—Wheal Hope is the name recently given to the workings for tin ore which have been carried out for a period of about two years by two "free-setters" on Prospidnick Hill near Nancegollan village. The promising nature of the lode so impressed the mineral owners, Messrs. Bickford-Smith of Trevarno, that they resolved to back up the work of the "free-setters" with the result that operations are now promised on a much larger scale. An adit is being driven in the hill from the valley some 150 to 200 feet below the present workings with the intention of opening out, and proving, the lode in depth. So far the results have been most encouraging and it is sincerely hoped that the splendid example of the mineral owners will be amply rewarded.

Magdalen Mine.—As a result of development during the past year or so at this small tin mine near Ponsanooth, the shaft has been sunk to a depth of 400 feet below the surface and levels driven from the shaft at this depth have intersected two lodes both of which carry high values. The mine was originally worked by the "old men" as an openwork and magnetite was often associated in large quantities with the cassiterite. At the depth now reached the amount of magnetite found is very much less, and it is assumed that it will entirely disappear at a greater depth.

Hemerdon Mine.—The maintained good price for wolfram has drawn renewed attention to this wolfram-tin property near Plymton, in Devonshire, and recent investigations are said to have had promising results.

PERSONAL

L. G. Attenborough is home from Malaya.
Ernest R. Bawden has left for the Gold Coast.
W. H. Beasley has left for Southern Rhodesia.
J. A'C. Bergne is leaving for Arizona.
H. H. W. Boyes is expected shortly from Nigeria.
E. L. Bruce has been appointed first Miller Memorial Professor of Research Geology at Queen's University, Toronto.
J. J. Calderwood is home from Panama.
G. W. Campion is home from West Africa.
L. Maurice Cockerill has left for Italy.
H. R. Davison has returned from Nigeria.
Victor Dolmage has joined the firm of R. H. Stewart, H. L. Batten and Associates, of Vancouver, as chief geologist, having resigned his position as manager of the British Columbia branch office of the Canadian Geological Survey.
A. Broughton Edge has returned to Australia.
Donald Foster has returned from Czecho-Slovakia.
Daniel Gibson is home from Panama on leave.
G. W. Gray and the Hon. R. M. P. Preston have left for Rhodesia.
R. T. Hancock is returning this week to Venezuela.
J. A. L. Henderson has left for Canada and the United States.
Sir Thomas Holland, who is presiding over this year's meeting of the British Association, having recently returned from Colombia, has left for South Africa.
Preston K. Horner has left for Rhodesia.
P. R. Hudson has left for West Africa.
William R. Jones has left for British Columbia.
F. H. B. Leggett has left for Venezuela.
F. W. Leighton has returned from Colombia.
Arthur E. Northey is on his way home from Cuba.
Sir Ernest Oppenheimer has accepted the presidency of the Empire Mining Congress, to be held in South Africa next year.
H. G. Payne is here from Rhodesia.
A. Gordon Plews has returned from Burma.
Thomas Pryor has returned from East Africa.
J. V. W. Reynders is here from New York.
W. H. Rundall has returned from East Africa.
R. de H. St. Stephens is leaving for India.
G. A. Smith is returning from Nigeria.
K. S. Twitchell has left for the United States.
Stanley G. Williams is home from Nigeria.
Harley B. Wright is home from the Gold Coast.

W. F. Robertson died at Everett, Washington, on June 11. He was connected with a number of mining and metallurgical enterprises in Canada, and in 1893 entered into private practice in New York which he left in 1898 to become Provincial Mineralogist for British Columbia, a position which he held for 27 years with much distinction.

TRADE PARAGRAPHS

Hardy Patent Pick Co., Ltd., of Sheffield, have issued a leaflet describing their simplex hammer drill types F.R.1. and F.R.W.1.

R. H. Kirkup and Co., Ltd., of Gateshead-on-Tyne, send us a leaflet devoted to their mechanical handling and screening plant including conveyors, elevators, and trommels.

Electric Control, Ltd., of Brighton, draw our attention to their " Empire " overhead line equipment and in particular to a form of isolating switch which has been proved in service under varied weather conditions in different parts of the world.

The Geophysical Co., Ltd., of 62, London Wall, London, E.C. 2, have issued a booklet containing a reprint from *Nature* of two articles by Professor A. O. Rankine on the subject of physics in relation to oil finding which deals with seismic methods of prospecting.

Drayton Regulator and Instrument Co., Ltd., of West Drayton, Middlesex, send us leaflets devoted respectively to a recording calorimeter, a time-temperature regulator, liquid level regulator, and double relay pressure regulator for air or water operations.

J. K. Smit and Zonen, of Amsterdam, recently published a handsomely prepared souvenir to mark forty years of diamond drilling. It contains some excellent photographs of diamond mining and diamond cutting, together with portraits of a number of the firm's Principals.

J. H. Steward, Ltd., of 406, Strand, London, W.C. 2, publish a catalogue of military instruments, including compasses of various kinds, signalling apparatus, range scales, map scales, plane tables, etc., many of which will prove to be of interest to the prospector and surveyor.

Ruston and Hornsby, Ltd., of Lincoln, inform us that at the Royal Show being held at Harrogate they are exhibiting petrol-paraffin engines, heavy-oil engines (one three cylinder 112 b.h.p. vertical and one 22 b.h.p. horizontal), pumps, and pumping plant, and various other specialities.

Andrews Toledo, Ltd., of Sheffield, inform us that, as a result of a scheme of reconstitution this is the name by which the steel manufacturing firm of Jno. Henry Andrew and Co., Ltd., will in future be known. The capital of the Company will be £300,000, as before, and the Board will comprise Messrs. J. F. Parker, G. St. J. Strutt, and Engr. Vice-Admiral Sir George Goodwin.

Sullivan Machinery Co., of Salisbury House, London, E.C. 2, publish particulars of the employment of their 12-in. coal-cutters as means for cutting rock salt. They also give us information concerning the use of remote control in the operation of their coal-cutter in a Yorkshire colliery. This control system operates with alternating current and results have been achieved in co-operation with the General Electric Co.

English Steel Corporation, Ltd., of Vickers House, Broadway, London, S.W. 1, which is an incorporation of the steel and allied businesses formerly carried on by Vickers Armstrongs, Ltd., at Sheffield and Openshaw and by Cammell, Laird and Co., Ltd., at Sheffield and Penistone, issue a catalogue of portable drilling rigs together with all accessory equipment such as boilers and parts, electric motors, pumping attachments, derricks, and drilling tools.

The Bureau of Information on Nickel, Ltd., inform us that in order to increase the efficiency of its work by avoiding overlapping and duplication of activities it is joining forces with the Research and Development Department of the **Mond Nickel Co., Ltd.,** the future title of the associated concerns will be the Bureau of Information on Nickel of the Mond Nickel Co., Ltd., and the address Imperial Chemical House, Millbank, London, S.W. 1. Mr. A. C. Sturney will continue as manager.

J. H. Sankey and Son, Ltd., of Essex Wharf, Canning Town, London, E. 16, draw our attention to the use of " Pyruma " fire cement for use in furnace building, which is stated to be considerably more effective in binding the bricks together. They also inform us of a new use for " Fosalsil " which is being developed by Shipwright Flooring and Engineering Co., Ltd., of 33, Victoria Street, London, S.W. 1. Special features of this flooring include speedy erection, strength and lightness, sound and heat proof and also fire proof, and finally low cost.

The Parker Producer Gas Plant Co., of 62, Conduit Street, London, W. 1, recently demonstrated before representatives of a number of official departments and public bodies their use of coke as a fuel for mobile internal combustion engines. The unit selected for the demonstration was a Fordson tractor (old type) from which the petrol or paraffin tank had been dismantled and replaced by a gas producer and the cylinder head of which had been changed for one of special design. The gas producer is especially intended to consume low-temperature semi-coke of which it is anticipated there will be increasing supplies in the course of the next few years in this country.

Westinghouse Electric International Co., of 2, Norfolk Street, London, W.C. 2, send us their *Westinghouse International* for June-July, which contains an article describing the use of synchronous motors and centrifugal pumps in pipe-line service, and it is pointed out that the incorporation of these booster stations has resulted in a considerable increase in the capacity of a given line. In this instance, the pumps are five-stage Cameron having a capacity of 650 gallons per minute when operating at a 1,660 ft. head and running at a speed of 1,800 r.p.m. Two pumps in each station are driven by 400 h.p., 2,200 volt, 3 phase, 60 cycle, 1,800 r.p.m. coupled type Westinghouse synchronous motors with direct connected exciters. Motor and pump are direct-coupled with a flexible coupling.

Evershed and Vignoles, Ltd., of Acton Lane Works, Chiswick, London, W. 4, issue a booklet devoted to the Midworth Distant Repeater which is an electrically operated system enabling movements as different in character as the motion of a sluice gate, lever arm, or instrument pointer, to be shown at any distance, and at any number of points. It can also be used for the distant control of any power driven apparatus. The system employs a transmitter actuated by the mechanical or electrical movement which it is desired to repeat, and any required number of repeating instruments, either indicating, recording, integrating or controlling. The actual transmission is of an angular motion, and normally the repeating instruments show a corresponding angular deflection. Where a movement in a straight line is to be repeated, it is therefore converted into angular motion. If, however, it is desired to repeat the original movement exactly, appropriate arrangements can be made at the repeating station. The principle underlying the system is the regulation by the originating movement (the deflexions of the pointer of an instrument, the variations of level of water in a reservoir or oil in a tank, the positions of valves or switches, or any other movement), of an electrical current which passes through the controlling and repeating instruments. The regulation is such that a definite current corresponds to every stage of the originating movement, quite independently of the voltage or resistance of the circuit.

International Combustion, Ltd., Grinding and Pulverizing Offices, of 11, Southampton Row, London, W.C. 1, report that new orders have been received for the following equipment: For England, Six 10 ft. by 48 in. Hardinge ball mills and six 7½ ft. Hardinge superfine classifiers for grinding coal; one 8 ft. by 60 in. Hardinge pebble mill and one 6 ft. Hardinge superfine classifier for grinding carbon black; one 3 ft. by 18 in. Hardinge pebble mill for grinding barytes; one Raymond-Lopulco mill for grinding coal; and two 4 ft. by 5 ft., type 39, Hum-mer screens for screening coke. For Spain: Two 10 ft. by 60 in. Hardinge ball mills for grinding chlorite ore; one 4½ ft. by 16 in. Hardinge ball mill for grinding limestone; and three 5-roller Raymond mills for grinding lignite. For Africa: Three 8 ft. by 60 in. Hardinge ball mills and three 6 ft. Hardinge air classifiers for grinding coal; one 4½ ft. by 13 in. Hardinge ball mill for grinding quartz rubble. For India: One 7 ft. by 22 in. Hardinge ball mill for grinding lead zinc ore. For France: One 6 ft. by 22 in. Hardinge ball mill for grinding lead zinc ore; one 3-roller Raymond mill for grinding mineral ore; one 6 ft. Raymond separator for separating aluminium dross; four 4 ft., type 39, Hum-mer screens and four 8 ft., type 37, Hum-mer screens for screening mineral ore; and one No. 0000 Raymond pulverizer and one No. 00 Raymond pulverizer for grinding colours.

SYMONS CONE CRUSHER

The introduction of this machine marks an important advance in the evolution of crushing machinery since it is the first crusher which allows of two stages of size reduction to be performed in one operation. It may be said to combine, in fact, the movements and functions of a gyratory crusher with those of a disc breaker and thus in one machine reductions of from 14 in. to ½ in., 11 in. to ⅜ in., 8½ in. to ¼ in., and 3 in. to ⅛ in., depending on the size and capacity of the crusher, may be effected.

It consists of a conical head gyrated (not rotated) by an eccentric that is driven through gears and a countershaft. The head is supported by a large socket bearing with no bearings or spider above the crushing cavity to obstruct the flow of material. Opposing the head is a crushing bowl threaded on its outer circumference for the purpose of raising or lowering it. The bowl is held in place by an adjustment ring, threaded inside to fit the bowl threads, and held down on the main frame by a circle of springs. A feed distributing and regulating plate is mounted on top of the main shaft with a vertically adjustable feed spout above it. Special features of the construction include steel-cut gears, high-grade bronze bearings, manganese steel mantle and bowl liners and bowl thrust bearing to carry the weight of the eccentric. A feature of the latter is that the exceptionally long eccentric and large ball and socket ensure a low pressure per square inch on the only bearings that receive the crushing strain.

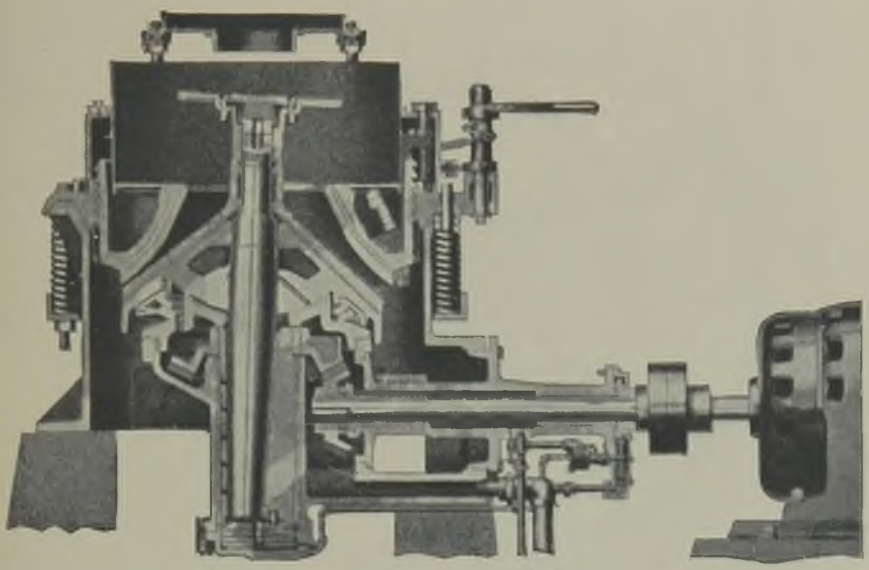
The size of the product may be varied, or adjustment made for wear. The bowl is screwed up or down with the aid of two ratchet lever windlasses, and when the desired setting is obtained the bowl is locked in place by dropping a pin or bolt through a lock link. Six cap screws are then tightened to prevent play in the bowl threads, these screws having first been loosened to effect the adjustment. It is

not necessary to stop the machine while making these adjustments to take up wear or to effect change of size.

The machine has a very complete oiling system whereby oil at the rate of several gallons per minute is pumped in at the bottom of the eccentric and must pass through all the bearings before being returned to the top of the tank.

The gyration of the crushing head in the cone crusher is similar to that of the ordinary gyratory crusher except that it moves about five times as great a distance and gyrates faster. The action, however, of the material being crushed is entirely different. The rapid gyration and long movement drops the head from under the stone after each crushing impact, and allows the stone to fall vertically away from the outer bowl, the number of gyrations of the head per minute regulating the distance the stone will travel between crushing impacts, the angle between the head and the outer bowl regulating the amount of reduction at each stroke.

It will be noted from the accompanying illustration that the lower part of the head and the lower part of the outer bowl are parallel for a sufficient distance to ensure the head making one complete gyration before the material will drop the entire width of the cone, which means that the closed side of the crusher regulates the size of the product. This long movement of the head creates the large opening on the discharged side, giving the crusher a high capacity. Less than one twentieth part of the head is actually crushing rock at any one time, which results in comparatively high pressure on the stone and low pressure on the bearings. The crushers are made in sizes of 2, 3, 4, 5½, and 7 feet, referring to the bottom diameter of the crushing head. The corresponding power consumptions for these sizes are as follows :—25 to 30, 50 to 60, 75 to 100, 125 to 150, and 150 to 200 h.p. The Symons cone crusher is built in America by the Nordberg Manufacturing Co., of Milwaukee, and in Great Britain by Fraser & Chalmers Eng. Wks. for the Nordberg Co., which has a direct branch office at Bush House, Strand, W.C. 2, established to give advice and service and to control manufacture and sales throughout Europe and the British Empire.



Symons Cone Crusher.

A NEW MAGNETOMETER

At a recent meeting of the Institution of Mining and Metallurgy the instrument here described was exhibited. It is manufactured by the Cambridge Instrument Co., Ltd., and we are indebted to that firm for the information contained hereunder.

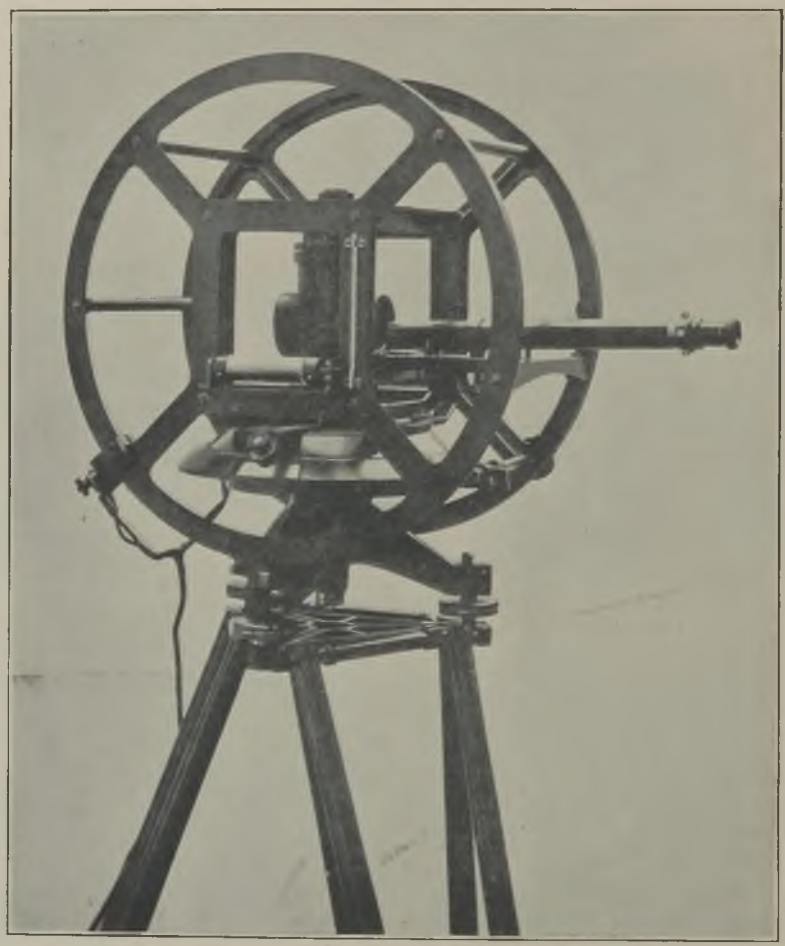
Prior to 1915, it was customary to measure the horizontal component of the earth's magnetic field in absolute units by the method devised by Gauss, and various instruments—such as the Kew magnetometer—were designed for this purpose. It is found, however, that these instruments are not suitable for rapid and accurate magnetic survey work because a determination cannot be made in much less than an hour, so that if the earth's field is changing rapidly during that period, only an average value is obtained which is not necessarily related to the ordinary average value of the magnetic force during that period. Changes in the values of the magnetic elements from place to place can be measured to a considerably higher degree of accuracy than the absolute values themselves, and, by comparing these with the absolute values obtained at a base station, the whole state of the region surveyed is known.

The instrument illustrated has recently been designed by Dr. F. E. Smith for the accurate comparison of the horizontal component of the

earth's magnetic force at two stations. Knowing the force in absolute units at one of the stations (the base station) and making corrections for any magnetic disturbances which may have arisen (and for which it is possible to correct by means of recording magnetographs) the horizontal force at the subsidiary station is determined in absolute values. The instrument is, to all intents and purposes, a sine galvanometer—an instrument described in text books but rarely used in the laboratory. In the new magnetometer a known current is used and the deflection of the magnet is inversely proportional to the cosine of the angle between meridian and the normal to the coil. The success of the instrument is primarily due to the accuracy with which an electric current can now be measured. A portable standard cell can be relied upon to give its normal voltage to within one part in twenty thousand and when the cell is used with a potentiometer and sensitive galvanometer the current can be measured to the same order of accuracy. Accordingly the value of H can be measured to the same accuracy.

The first instrument made on this principle was constructed at the request of Sir A. Schuster at the National Physical Laboratory and was designed for absolute measurements. In this case the coils were constructed in such a way that it was possible to determine by calculation the magnetic field given by the current and hence to measure directly the intensity of the earth's field.

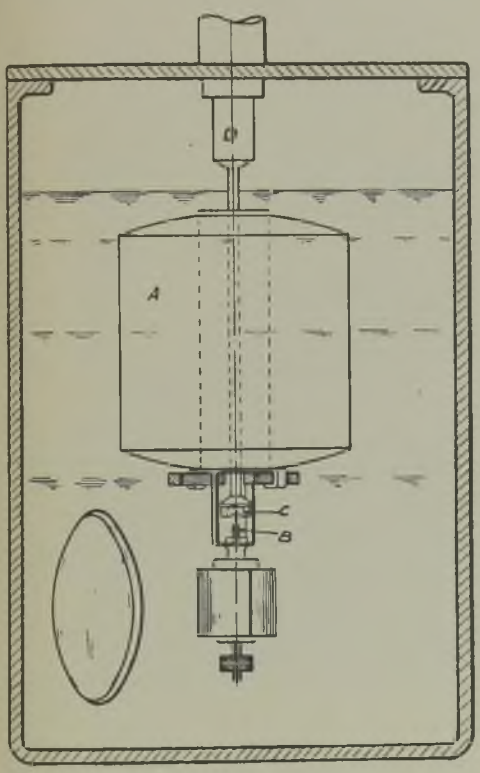
The new instrument is simpler in construction, its constant being determined by comparisons at a base station. A known current (usually about 0·1 ampere) is passed through the coils and the angle through which the magnet system is deflected is measured on an azimuth circle. The current through the coils is then reversed so the system is deflected through an equal angle in the opposite direction. The mean of the deflection is taken as the angular deflection corresponding to the particular value of the magnetizing current at the station where the observation is made.



The method of construction is as follows :—Two cobalt steel magnets (1·5 by 1·5 by 12 mm. in length) are mounted horizontally side by side on the underside of an annular float which floats in petrol contained in a gunmetal chamber. The float is centralized in position in the chamber by means of a jewel and sapphire pivot in the manner shown

in the diagram, in which *A* is the float, *B* the pivot, and *C* the jewel, the latter being mounted on the spindle *D* which projects through the centre of the float chamber.

The moving system carries an optically-plane mirror of platinized quartz 10 mm. in diameter (platinized on both sides) which is mounted with its surface vertical and in a plane parallel to the axes of the magnets. This mirror is viewed by a horizontal telescope mounted on the instrument and sighted through a worked glass window in the gunmetal chamber. The upper part of the field of the telescope is occupied by a cross line illuminated by light from the sky, reflected on to it by a prism. The image of the cross-wire is reflected by the mirror on to a micrometer scale (20 divisions per mm.) fixed in the focal plane



of the telescope and is viewed through a Ramsden eyepiece. A deflection of 10 seconds of arc can be measured in this way. The magnetic coils and the telescope are mounted on a casting which rotates over a lower casting on which is mounted the azimuth circle. This circle, which is of silver and 25 cms. in diameter, is divided into 15 minutes; by means of verniers and microscopes, readings may be taken to 10 seconds of arc. Levelling screws and a sensitive level are fitted. The magnetizing coils have a mean diameter of 40 cms. and are mounted 20 cms. apart. The windings on each coil consist of forty turns of 24 S.W.G. copper wire. The coils are connected in series so as to produce axial fields in the same direction. A current of approximately 0·1 ampere is generally employed, which can be measured to an accuracy of 5 microamperes by means of a potentiometer. All the parts of the apparatus are of non-magnetic material and the connections to the potentiometer are made by concentric cable. A complete determination—including the time taken to level the instrument, to determine the magnetic meridian, and to obtain the two sets of readings—can be made in about 10 minutes.

In the potentiometer used with the instrument a current of approximately 0·1 ampere through the windings on the field coils corresponds to a field intensity of 0·18 c.g.s. units. If a standard cell with an e.m.f. of 1·0183 volts is balanced across a 10-ohm coil in the potentiometer circuit, the current will be 0·1018 and the approximate field at the centre of the system will be 0·183. The potentiometer has been designed so that field intensities ranging from 0·16 to 0·19 may be measured to the degree of accuracy required (one part in 20,000).

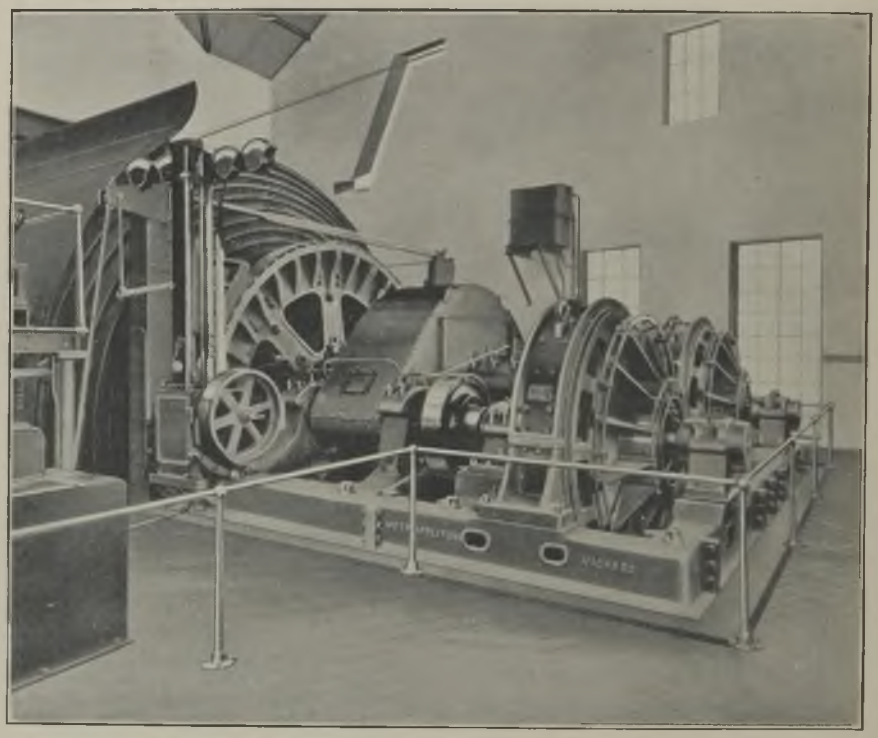
METROPOLITAN-VICKERS ELECTRIC WINDERS

The Metropolitan-Vickers Electrical Co., Ltd., report that five large electric winder sets are included among recent orders received for mining equipment. All five sets are to be arranged with Ward Leonard control, three with direct coupled motors and two with geared motors. The sets represent an interesting variety of applications, two being for a deep gold mine on the Rand, two for a new copper mine in Northern Rhodesia, and one for service involving exceptionally heavy output at a colliery in New South Wales, where one of the largest electric winding equipments in the world is already in service. New features of special interest are included in two of the equipments (those for Rhodesia), one development being a hydraulic slip regulator between the motor and the flywheel of the motor generator set and the other an improved system of automatic braking control. The two winders for the Rand are equipments of 2,150 r.m.s. rating and 4,310 h.p. working peak capacity ordered by the Union Corporation, Ltd., for East Geduld Mines, Ltd., a subsidiary company which was registered and commenced operations two years ago. The electric winders are to replace two steam engine equipments, one carrying men and the other hoisting ore, in an installation 5,600 ft. above sea level. The depth of the shaft is 3,350 ft., and the net load to be handled in the case of the ore hoist is 7 short tons (14,000 lb.), the output required being 230 tons per hour. The two equipments will be similar, the winder motor in each case having a normal speed of 58 r.p.m. and being coupled to two cylindrical drums 14 ft. in diameter and 5 ft. between flanges. The normal maximum winding speed will thus be 2,580 ft. per minute. The two motor generator sets will each consist of a 1,800 h.p., 2,000 volt induction motor direct coupled to a 1,550 k.w. 640 volt d.c. generator. The sets will not be equipped with flywheels as the power will be taken from the large capacity distribution system of the Victoria Falls and Transvaal Power Co. It is intended ultimately to increase the working peak capacity of the equipments to 4,570 h.p. by taking out part of the permanent resistance in the generator field circuit, thereby

increasing the winding speed by about 5% and the output capacity to 245 tons per hour. A sub-contract for the mechanical parts has been placed with Blane and Co., Ltd., of Johannesburg, who will supply parts manufactured by **Fullerton, Hodgart, and Barclay, Ltd.**

Caledonian Collieries, Ltd., of New South Wales, have ordered an electric winder of 1,900/4,000 h.p. to replace a steam engine equipment at a shaft of Aberdare Colliery, where it is required to increase the output to 557 tons per hour. The new equipment is to do this by a schedule of 133 trips per hour with a net load of 4¼ tons. The time for the load of 7½ tons from a depth of 1,260 ft. and maintains an output of 490 tons per hour.

The Roan Antelope Copper Mines, Ltd., in Northern Rhodesia, has ordered two geared d.c. winders of 1,290/2,580 h.p. with Ward Leonard control for a new shaft 1,100 ft. deep. In this installation also the two winders, one for men and one for ore, will be similar. The loads to be dealt with are 12 short tons and 10 short tons respectively, and the output of ore will be 500 tons per hour. The winding drums will be cylindrical of 16½ ft. diameter for the man hoist and 14½ ft. diameter for the ore hoist, with gear ratios to give the same



Metropolitan-Vickers Electrical Company's Winder at Harworth Colliery.

trip of 530 ft. is thus only 27 seconds, of which 7 seconds is allowed for decking. The acceleration is 5·53 ft. per second, and the maximum winding speed 2,555 ft. per minute. The motor is designed for operation at 70·5 r.p.m. and will be direct coupled to a cylindrical drum 12 ft. in diameter and 6½ ft. wide. The motor generator set will consist of a 680 h.p. induction motor coupled, with a flywheel, to a 1,170 k.w. d.c. generator, this equipment being housed in a separate building about 50 yards from the winder house. A sub-contract for the mechanical parts has been placed with **Vickers-Armstrongs, Ltd.** It is interesting to note that at another shaft of the Aberdare Colliery there is installed one of the largest colliery winders in the world, a Metrovick equipment rated at 4,500/11,250 h.p. This winder raises a net winding speed, 1,400 ft. per minute, in each case. Power will be supplied from the company's own system at 3,000 volts, three-phase, 50 cycles and converted by a motor generator set consisting of a 960 k.w. generator with a flywheel of 6½ tons. A novel feature of these two equipments will be the use of a new type of slip regulator consisting of a hydraulic coupling between the motor and the flywheel of the motor generator set. The device is a development of the well-known Vulcan coupling which has been extensively employed for marine propulsion and industrial drives. It consists essentially of two main elements, an impeller wheel mounted on the motor shaft and a runner wheel mounted on the flywheel shaft with a casing in which a controlled supply of oil provides the working medium. The oil circulates

under pressure and by varying the amount admitted to the coupling the slip can be regulated to any desired value from practically zero to 100%. The system is introduced as an important improvement upon the usual form of slip regulation by means of resistance in the secondary circuit of the driving motor of the flywheel set. Another notable feature to be incorporated in the equipments for Rhodesia is a new system of braking. In this system the braking effort is applied as a function of the speed change of the cages, compensation being made automatically for all variations of load, speed of travel, and other conditions. The use of this new principle gives the equipment the remarkable and highly desirable characteristics that any given position of the brake lever will give a definite rate of retardation under all conditions and that any desired rate of retardation can be obtained without shock. The retardation under emergency conditions is also capable of accurate setting, a definite rapid rate of retardation being set for operation if the cages are approaching the end of travel and a relatively slow rate of retardation selected for operation if the cages are in an intermediate position. The system thus ensures any required stoppage in a reasonably short distance of travel while eliminating the risk of sudden stoppages, which are a cause of grave danger to passengers and plant. Tests made in the works on experimental braking apparatus of this type have given remarkably successful results and arrangements are being made for tests in actual service on a large Metrovick winder in service at the Harworth Colliery. This installation, which is shown in the accompanying illustration, is of the same type and of about the same capacity as those for the Roan Antelope Copper Mines and is itself of interest as one of the largest electric winders in this country. The results of the tests at Great Harworth and the performance of the two winders for Rhodesia, on which both the new features will be incorporated, will be watched with considerable interest since the developments promise to have a far-reaching influence on future winder practice.

METAL MARKETS

Copper.—Although there were indications that consumers were distinctly apathetic, the leading American producers maintained their export quotation for electrolytic metal in New York at 18 cents during June. Meanwhile, standard values in London, after exhibiting moderate firmness at one time, eased again and reflected, on the month, virtually no alteration. With stocks increasing, despite the recent curtailment of operations, the outlook for producers is a little precarious and it would not be surprising if they were forced eventually to modify their ideas of price. There is, of course, plenty of room for reductions, as ruling quotations return most copper producers an extremely handsome profit. It may turn out, however, that as a result of the recent hectic price-advances, a portion of the old clientele has definitely switched over to the use of alternative metals and is more or less permanently lost as far as the copper industry is concerned.

Average price of cash standard copper: June, 1929, £74 7s. 9d.; May, 1929, £75 2s. 6d.; June, 1928, £63 13s. 11d.; May, 1928, £62 11s. 9d.

Tin.—The tendency of values during June was slightly firmer, but this was due almost entirely to professional and speculative influences, as the industrial position of the metal was scarcely conducive to higher prices. Although consuming demand is still well maintained on the whole, there is really too much tin coming forward for all the supplies to be easily absorbed. It was anticipated that "visible supplies" during June might experience a decline, but even if this proved to be the case, it would not have demonstrated any excess of demand over supply as considerable "invisible stocks" are meanwhile still being accumulated. The position scarcely justifies any substantial advance in values over the near future, but this is not to say that professional operations will not carry them up all the same.

Average price of cash standard tin: June, 1929, £200 5s. 9d.; May, 1929, £197 12s. 8d.; June, 1928, £217 7s. 5d.; May, 1928, £230 19s. 3d.

Lead.—Price-changes were almost insignificant during June and the general position was indeed rather colourless. Demand was on the quiet side, but as arrivals of fresh metal tended to increase, the undertone towards the close of the month became rather less optimistic, despite the general view that the metal was really, everything considered, in a fairly sound position. Consumption in this country is running at a higher rate than twelve months ago. The meeting of lead producers fixed for early in July did not seem to have much sentimental effect on the market, buyers apparently believing that it would not result in anything very definite as regards market control.

Average mean price of soft foreign lead: June, 1929, £23 12s. 11d.; May, 1929, £23 16s. 11d.; June, 1928, £21 1s. 11d.; May, 1928, £20 12s. 11d.

Spelter.—The London spelter market last month exhibited a rather easy tendency. This was due to the quietude of demand and the fact that although producers had the position well under control thanks to their output-regulation measures, there was nevertheless rather more metal about than was actually needed. Even so, however, stocks cannot be described as excessive, and if only a moderate expansion in demand occurred, conditions might quickly become stringent. However, for the time being, unless buying does improve, prices are not likely to make a very firm showing.

Average mean price of spelter: June, 1929, £26 2s.; May, 1929, £26 13s. 4d.; June, 1928, £25 10s. 11d.; May, 1928, £25 18s. 6d.

Iron and Steel.—The Cleveland pig iron market was a nominal one throughout June owing to sheer lack of supplies. Works are booked up months ahead and have nothing to offer, and the quantities which merchants have available are meagre. No. 3 G.M.B. was nominally quoted around 72s. 6d. at the close of June. Production is being gradually increased, despite difficulties as regards fuel and ore, but it does not seem as if the position is being yet alleviated. Hematite was a firm and active market in June, and East Coast Mixed Nos. were advanced to 74s. 6d. In finished iron and steel, British material was in fair request, though demand seemed to slacken somewhat at the end of the month. Prices were firm. Continental material was rather irregular. The European Raw Steel Cartel increased the authorized rate of output of its members by 1,000,000 tons annually.

Antimony.—English regulus was steady during

LONDON DAILY METAL PRICES

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

	COPPER.				TIN.		ZINC (Spelter).	LEAD.		SILVER.		GOLD.
	Standard.		Electrolytic.	Best Selected				Soft Foreign.	English.			
	Cash.	3 Months.			Cash.	3 Months.				Cash.	Forward.	
June	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	d.	d.	s. d.
11	75 17 6	75 0 0	84 10 0	79 2 6	201 0 0	204 0 0	26 3 9	23 11 9	25 0 0	24½	24⅛	84 11½
12	74 15 0	74 0 0	84 7 6	—	200 10 0	203 10 0	26 2 6	23 9 6	25 0 0	24⅜	24⅛	84 11½
13	76 0 0	74 12 6	84 7 6	—	198 0 0	201 0 0	26 1 3	23 10 9	25 0 0	24 5/16	24⅛	84 11½
14	75 15 0	74 12 6	84 7 6	78 7 6	197 15 0	200 17 6	26 2 6	23 12 0	25 0 0	24 3/16	24⅛	84 11½
17	75 1 3	74 11 3	84 7 6	—	201 10 0	204 10 0	26 1 3	23 13 9	25 0 0	24 3/16	24⅛	84 11½
18	74 7 6	74 2 6	84 5 0	78 2 6	201 10 0	205 0 0	26 1 9	23 17 6	25 5 0	24⅜	24 5/16	84 11½
19	73 5 0	73 8 9	84 5 0	—	201 17 6	205 5 0	26 0 0	23 17 6	25 5 0	24 5/16	24 5/16	84 11½
20	72 15 0	73 1 3	84 5 0	—	202 0 0	205 7 6	26 0 9	23 17 6	25 5 0	24 5/16	24 5/16	84 11½
21	73 3 9	73 5 0	84 5 0	76 12 6	202 0 0	205 10 0	26 0 0	23 14 3	25 5 0	24⅜	24 5/16	84 11½
24	73 13 9	73 7 6	84 5 0	—	201 10 0	205 2 6	25 19 3	23 15 0	25 5 0	24⅜	24 5/16	84 11½
25	74 0 0	73 10 0	84 5 0	77 2 6	200 7 6	203 15 0	25 18 9	23 15 0	25 5 0	24⅜	24 5/16	84 11½
26	73 16 3	73 7 6	84 5 0	—	201 5 0	204 12 6	25 17 9	23 12 6	25 5 0	24 5/16	24⅛	84 11½
27	73 11 3	73 5 0	84 5 0	—	201 2 6	204 10 0	25 17 6	23 11 3	25 0 0	24⅜	24 5/16	84 11½
28	73 0 0	72 17 6	84 5 0	76 2 6	201 10 0	204 15 0	25 11 9	23 6 3	25 0 0	24⅜	24 5/16	84 11½
July												
1	73 10 0	73 5 0	84 5 0	—	202 5 0	205 10 0	25 6 9	23 6 9	24 15 0	24 7/16	24⅛	84 11½
2	73 7 6	73 0 0	84 5 0	76 2 6	201 15 0	205 0 0	25 8 9	23 6 9	24 15 0	24	24⅛	84 11⅜
3	72 17 6	72 18 9	84 5 0	—	204 0 0	207 0 0	25 8 9	23 1 9	24 10 0	23 15/16	24	84 11½
4	72 10 0	72 12 6	84 0 0	—	204 0 0	207 2 6	25 8 0	22 14 3	24 5 0	24 1/16	24⅛	84 11½
5	71 17 6	72 8 9	84 0 0	75 7 6	204 5 0	207 12 6	25 8 0	22 16 3	24 5 0	24 1/16	24⅛	84 11½
8	72 8 9	73 0 0	84 0 0	—	204 10 0	207 12 6	25 9 3	22 16 9	24 5 0	24 1/16	24⅛	84 11½
9	72 3 9	72 13 9	84 0 0	75 0 0	204 10 0	207 15 0	25 17 6	23 1 9	24 10 0	24 3/16	24⅛	84 10½

June, the value remaining around £48 to £52 10s. per ton. In Chinese there was a small business moving at £33 15s. to £34 ex warehouse and £31 c.i.f. for shipment from China.

Iron Ore.—Further buying has been done in this country, and on the Continent, both for this year and 1930, and there is now very little good ore offering for some months ahead. Prices are very firm but rather nominal, with best Bilbao rubio at 23s. 6d. per ton c.i.f.

Arsenic.—This market is quiet, but prices are steady at £16 to £16 2s. 6d. per ton f.o.r. mines for 99% Cornish white.

Bismuth.—The official price remains at 7s. 6d. per lb. for good parcels, and demand is steady.

Cadmium.—Some revival of inquiry was seen towards the end of June, but prices are fractionally lower than in our last report, about 4s. to 4s. 2d. per lb., being the current quotation, according to quantity and delivery.

Cobalt Metal.—Business continues on a fair scale, with the official price unaltered at 10s. per lb.

Cobalt Oxides.—A moderate turnover is reported at 8s. per lb. for black and 8s. 10d. for grey.

Platinum.—Demand improved slightly during the past month but the volume of business passing is not large. Quotations remain at £13 10s. to £13 15s. per oz. for merchant parcels.

Palladium.—This is a poor market and prices tend to sag. It is doubtful whether buyers would pay more than £7 to £7 10s. per oz., although sellers are nominally asking higher prices.

Iridium.—Quiet conditions continue here, with sponge and powder about £50 to £52 per oz.

Tellurium.—Quotations can only be called nominal at 12s. 6d. to 15s. per lb.

Selenium.—A very fair demand continues at 7s. 8d. to 7s. 9d. per lb. ex warehouse for 99%.

Manganese Ore.—The feature of the past month has been some forward sales of Russian ore at very low prices, down to 1s. 1d. per unit c.i.f. having been accepted for washed Caucasian and 1s. for unwashed. Best Indian is nominally held for about 1s. 2d. per unit c.i.f.

Aluminium.—A good demand has been maintained recently and there is still some talk of higher prices, although for the present quotations of ingots and bars are unaltered at £95, less 2%, delivered.

Sulphate of Copper.—A further downward movement has been seen in prices, English material now being offered at £28 5s. to £28 15s. per ton. less the usual discount of 5%.

Nickel.—Business has been on a very good scale, and producers can only just about keep pace with demand. Prices, however, are unchanged at £175 per ton.

Chrome Ore.—Despite the fact that world production is increasing most of the material coming forward is absorbed. Prices are still pegged at about £4 5s. to £4 6s. c.i.f. for good 48% ores.

Quicksilver.—Sales have been restricted to small parcels for prompt delivery, but spot quotations are upheld at £22 2s. 6d. to £22 5s. per bottle.

Tungsten Ore.—The difficulty experienced by Chinese shippers of getting ore down to the ports has kept the market short of supplies. Demand has not been particularly brisk, but prices are firm in the region of 33s. per unit c.i.f. for shipment material. Spot seems unobtainable at the moment.

Molybdenum Ore.—There has been some slackening in enquiry, and 37s. 6d. to 40s. per unit c.i.f. represents the current value of 85% concentrates.

Graphite.—A fair inquiry is reported for Madagascar flake at about £27 to £29 per ton c.i.f. for 85 to 90% material, but 90% Ceylon lumps are not very active at £25 to £26 c.i.f.

Silver.—On June 1 spot bars stood at 24⅜d., but the market had an easy appearance, general selling being in evidence. About the middle of the month China took a little more interest, and some bear covering was seen from India. On June 14 spot bars had arisen to 24 7/16d., after having touched 24d. early in the month. The latter half of the month, however, was one of extreme quietness accompanied by some sagging in prices, spot bars closing at 24⅛d. on June 29.

STATISTICS

PRODUCTION OF GOLD IN THE TRANSVAAL.

	Rand.	Elsewhere.	Total.
	Oz.	Oz.	Oz.
June, 1928	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
January, 1929	840,344	36,108	876,452
February	778,559	36,725	815,284
March	830,829	35,700	866,529
April	836,474	35,649	872,123
May	858,991	38,607	897,598
June	821,352	34,677	856,029

TRANSVAAL GOLD OUTPUTS.

	May.		June.	
	Treated Tons.	Yield Oz.	Treated Tons.	Yield Oz.
Brakpan	92,500	£152,301	87,500	£145,025
City Deep	98,000	27,268	93,000	26,345
Cons. Main Reef	59,100	21,968	60,200	21,811
Crown Mines	223,000	72,749	229,000	73,714
D'rb'n Roodepoort Deep	41,300	14,050	40,300	13,608
East Rand P.M.	145,500	39,098	142,000	37,788
Ferreira Deep	21,000	4,400	—	—
Geduld	85,000	26,736	82,500	26,038
Geldenhuis Deep	65,500	15,023	63,000	14,476
Glynn's Lydenburg	6,500	2,215	6,300	2,142
Government G.M. Areas	210,000	£399,021	194,000	£373,834
Kleinfontein	52,300	11,688	49,200	11,191
Langlaagte Estate	85,000	£114,422	79,000	£109,152
Luipaard's Vlei	23,500	5,941	22,400	5,705
Meyer and Charlton	16,300	£19,225	16,800	£18,507
Modderfontein New	152,000	74,248	146,000	73,062
Modderfontein B	71,500	25,520	69,500	24,780
Modderfontein Deep	45,900	24,180	43,000	22,730
Modderfontein East	70,000	21,304	68,000	19,881
New State Areas	81,000	£142,216	75,000	£135,199
Nourse	65,000	18,632	62,500	17,624
Randfontein	216,000	£213,707	210,000	£208,873
Robinson Deep	79,000	22,108	75,500	19,877
Rose Deep	59,000	12,248	57,000	11,816
Simmer and Jack	75,900	18,962	72,100	18,485
Springs	72,000	£145,468	65,500	£136,985
Sub Nigel	24,800	21,772	24,300	19,521
Transvaal G.M. Estates	15,110	5,127	14,650	4,943
Van Ryn	39,000	£37,383	38,600	£36,905
Van Ryn Deep	67,000	£108,699	58,000	£101,094
Village Deep	59,500	15,760	56,800	15,078
West Rand Consolidated	90,000	£93,828	87,000	£92,599
West Springs	65,100	£80,833	60,100	£74,375
Witw'tersr'nd (Knights)	55,000	£48,648	53,000	£46,332
Witwatersrand Deep	45,305	13,626	41,800	12,662
Wolhuter	22,100	5,241	—	—

COST AND PROFIT ON THE RAND, Etc.

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

	Tons milled.	Yield per ton.	Work'g cost per ton.	Work'g profit per ton.	Total working profit.
		s. d.	s. d.	s. d.	£
April, 1928	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
November	2,539,700	27 9	19 7	8 2	1,041,713
December	2,505,500	27 10	19 8	8 2	1,024,654
January, 1929	2,627,320	28 1	19 9	8 4	1,095,070
February	2,403,720	28 6	20 3	8 3	990,942
March	2,581,600	28 3	20 0	8 3	1,062,331
April	2,606,420	28 1	19 11	8 2	1,068,103
May	—	—	—	—	1,100,461

NATIVES EMPLOYED IN THE TRANSVAAL MINES.

	Gold Mines.	Coal Mines.	Diamond Mines.	Total.
June 30, 1928	197,186	16,870	5,650	222,340
July 31	194,584	16,695	5,189	220,345
August 31	194,788	16,553	4,839	218,578
September 30	194,936	16,724	4,535	215,843
October 31	193,147	16,767	4,807	216,362
November 30	190,870	16,803	4,889	216,628
December 31	187,970	16,059	4,444	208,473
January 31, 1929	192,526	15,845	50,56	213,427
February 28	196,150	15,940	5,635	217,725
March 30	197,616	16,065	5,787	219,498
April 30	197,412	15,900	5,554	218,866
May 31	195,733	15,852	5,473	217,058
June 30	192,595	15,928	5,029	213,552

PRODUCTION OF GOLD IN RHODESIA.

	1926	1927	1928	1929
	oz.	oz.	oz.	oz.
January	48,967	48,731	51,356	46,231
February	46,026	46,461	46,286	44,551
March	46,902	50,407	48,017	47,388
April	51,928	48,290	48,549	48,210
May	49,392	48,992	47,323	48,189
June	52,381	52,910	51,762	—
July	50,460	49,116	48,960	—
August	49,735	47,288	50,611	—
September	48,350	45,838	47,716	—
October	50,132	46,752	43,056	—
November	51,090	47,435	47,705	—
December	48,063	49,208	44,772	—

RHODESIAN GOLD OUTPUTS.

	May.		June.	
	Tons.	Oz.	Tons.	Oz.
Cam and Motor	24,600	12,506	25,000	12,680
Globe and Phœnix	6,048	5,134	6,015	5,435
Lonely Reef	5,100	4,063	4,900	3,969
Rezende	6,400	2,913	6,400	2,949
Shamva	47,000	£24,283	—	—
Sherwood Starr	4,800	£8,515	5,000	£8,675

WEST AFRICAN GOLD OUTPUTS.

	May.		June.	
	Tons.	Oz.	Tons.	Oz.
Ariston Gold Mines	6,090	£11,341	—	—
Ashanti Goldfields	9,324	10,367	9,302	10,362
Taquah and Abusso	7,435	£12,734	7,740	£13,288

AUSTRALIAN GOLD OUTPUTS BY STATES.

	Western Australia.	Victoria.	Queensland.	New South Wales
	Oz.	Oz.	Oz.	Oz.
June, 1928	30,449	3,932	498	487
July	29,399	3,208	772	154
August	37,991	2,637	690	3,447
September	32,397	3,366	644	364
October	36,565	2,632	820	256
November	21,466	3,111	865	550
December	36,097	—	493	208
January, 1929	27,384	—	260	445
February	28,177	—	117	474
March	25,848	—	816	—
April	39,166	—	—	—
May	28,026	—	—	—
June	33,139	—	—	—

AUSTRALASIAN GOLD OUTPUTS.

	May.		June.	
	Tons	Value £	Tons	Value £
Associated G.M. (W.A.)	5,151	9,902	4,902	7,517
Blackwater (N.Z.)	3,350	5,455	3,200	5,121
Boulder Persev'ce (W.A.)	6,329	13,685	5,785	13,572
Grt. Boulder Pro. (W.A.)	9,451	26,049	9,635	26,005
Lake View & Star (W.A.)	7,975	12,070	—	—
Sons of Gwalia (W.A.)	14,358	12,152	13,696	11,892
South Kalgurli (W.A.)	9,090	17,142	8,686	16,488
Waihi (N.Z.)	16,712	{ 5,823* 39,233†	—	—

* Oz. gold. † Oz. silver.

GOLD OUTPUTS, KOLAR DISTRICT, INDIA.

	May.		June.	
	Tons Ore	Total Oz.	Tons Ore	Total Oz.
Balaghat	4,850	3,015	4,050	2,400
Champion Reef	8,475	5,124	8,055	4,967
Mysore	18,490	8,370	18,302	8,296
Nundydroog	10,528	6,646	10,495	6,642
Ooregum	14,000	7,294	14,000	7,285

MISCELLANEOUS GOLD, SILVER, AND PLATINUM OUTPUTS.

	May.		June.	
	Tons	Value £	Tons	Value £
Chosen Synd. (Korea)	8,050	11,295	8,900	13,558
Frontino & Bolivia (Colombia)	1,650	5,073	1,480	6,139
Lena (Siberia)	—	29,652	—	—
Lydenburg Plat. (Trans.)	3,580	791*p*	3,320	664*p*
Marmajito (Colombia)	640	4,058	720	7,653
Mexican Corp. Fresnillo	89,726	146,049*d*	—	—
Onverwacht Platinum	2,514	400*p*	2,320	400*p*
Oriental Cons. (Korea)	—	75,700*d*	—	71,000*d*
St. John del Rey (Brazil)	—	36,600	—	31,200
Santa Gertrudis (Mexico)	49,495	129,885*d*	—	—

d dollars. *p* Oz. platinoids.

PRODUCTION OF TIN IN FEDERATED MALAY STATES.

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

July, 1928	5,488	January, 1929	5,840
August	5,499	February	4,896
September	5,071	March	5,236
October	5,161	April	5,433
November	5,483	May	5,405
December	5,249	June	5,523

OUTPUTS OF MALAYAN TIN COMPANIES.

In Long Tons of Concentrate.

	April	May	June
Ampang	21	16	—
Batu Caves	32	48	36
Changkat	53	54	—
Chenderiang	35	28½	24
Gopeng	83½	83	83
Idris Hydraulic	38⅜	41⅜	—
Ipoh	42½	35½	25½
Jelapang	23	33	—
Kamunting	81	102	103
Kent (F.M.S.)	58	54	48
Kepong	28	25	34
Kinta	30	28¼	—
Kinta Kellas	59½	25½	26⅜
Kramat Pulai	19½	18⅜	19
Kuala Kampar	115	115	—
Kundang	35	37	—
Lahat	17⅜	17¼	13⅜
Larut Tinfields	84½	80	—
Malaya Consolidated	73½	83	55
Malayan Tin	133	131	125
Meru	16	14¾	—
Pahang	226⅜	220	222
Pengkalen	77½	74½	77½
Petaling	226	220	46
Rahman	59⅜	71½	71⅜
Rambutan	12	10⅜	13⅛
Rantau	44	26	38
Rawang	70	70	—
Renong	50	37	60½
Selayang	26½	27	29
Southern Malayan	125	154⅜	190½
Southern Perak	86¼	91¼	95½
Southern Tronoh	—	18	30
Sungei Besi	43	46	—
Sungei Kinta	20	26	39½
Sungei Way	89½	89½	89½
Taiping	53	47	45
Tanjong	24½	30	—
Teja Malaya	12	17¼	14
Tekka	43	45	45
Tekka-Taiping	54	48	48
Temoh	35	34½	37
Tronoh	96	106	113½

OUTPUTS OF NIGERIAN TIN MINING COMPANIES.

In Long Tons of Concentrate.

	April.	May.	June.
Amari	6	6½	—
Anglo-Nigerian	55	56	50
Associated Tin Mines	250	250	—
Baba River	3¼	4	4¼
Batura Monguna	2	2½	2
Bisichi	61	66	70
Daffo	4	5	—
Ex-Lands	50	50	50
Filani	1½	1¾	2½
Jantar	35	43	45
Jos	18½	22¼	17¾
Juga Valley	9	12	—
Junction	6	8	—
Kaduna	27½	32	—
Kaduna Prospectors	19	24½	—
Kassa	17	17	18
Lower Bisichi	5½	5	6
Mongu	35	35	—
Naraguta	11½	—	27¼
Naraguta Durumi	14	—	15½*
Naraguta Extended	9	10	20
Naraguta Karama	19½	—	16½
Naraguta Korot	15	15	—
Nigerian Base Metals	49	54	47
Nigerian Consolidated	20	20	20
N.N. Bauchi	160	160	—
Offin River	6	8	6½
Ribon Valley	14	14½	13
Ropp	74	80	81
Rukuba	4	4	—
South Bukeru	14½	14	13½
Tin Fields	6	5	5
Tin Properties	19	15	—
United Tin Areas	4⅛	12⅛	17⅛
Yarde Kerri	15	10	9

* May and June.

OUTPUTS OF OTHER TIN MINING COMPANIES.

In Long Tons of Concentrate.

	April	May	June
Anglo-Burma (Burma)	3	6¾	—
Aramayo Mines (Bolivia)	415	425	338
Bangrin (Siam)	66½	65⅛	67¼
Berenguela (Bolivia)	27	45	—
Consolidated Tin Mines (Burma)	81*	72*	82
Eastern Siam (Siam)	—	—	—
East Pool (Cornwall)	84	84⅜	—
Fabulosa (Bolivia)	145	128	105
Geevor (Cornwall)	70	70	70
Jantar (Cornwall)	19	23	—
Kagera (Uganda)	25	23	23
Polhigey (Cornwall)	20	31	—
San Finx (Spain)	401*	411¼*	401*
Siamese Tin (Siam)	120⅜	131½	154¼
South Crofty (Cornwall)	65	65½	62⅜
Tavoy Tin (Burma)	54	51	—
Theindaw (Burma)	3½	3½	—
Tongkah Harbour (Siam)	64	95	110
Toyo (Japan)	—	—	—
Wheal Kitty (Cornwall)	50	50	—

* Tin and Wolfram.

COPPER, LEAD, AND ZINC OUTPUTS.

		May	June
Broken Hill Prop.	Tons lead conc.	1,719	—
Broken Hill South	Tons lead conc.	4,359	5,627
	Tons zinc conc.	3,954	5,165
Burma Corporation	Tons refined lead	6,567	6,545
	Oz. refined silver	623,222	590,620
Bwana M'Kuhwa	Tons copper oxide	354	609
Electrolytic Zinc	Tons zinc	3,982	—
Indian Copper	Tons copper	—	151
Messina	Tons copper	582	584
Mount Lyell	Tons concentrates	2,628	2,744
Namaqua	Tons copper	200	201
North Broken Hill	Tons lead conc.	8,020	—
	Tons zinc conc.	5,870	—
Poderosa	Tons copper ore	1,040	1,215
Rhodesia Broken Hill	Tons lead	145	155
	Tons slab zinc	985	930
San Francisco Mexico	Tons lead conc.	3,056	3,132
	Tons zinc conc.	4,036	3,545
Sulphide Corporation	Tons lead conc.	1,955	—
	Tons zinc conc.	3,055	—
Tetiuhe	Tons lead conc.	433	—
	Tons zinc conc.	1,101	—
Union Minière	Tons copper	12,000	—
Zinc Corporation	Tons lead conc.	5,485	5,512
	Tons zinc conc.	4,212	4,132

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

		April.	May.
Iron Ore	Tons	466,645	489,481
Manganese Ore	Tons	26,442	29,268
Iron and Steel	Tons	261,932	257,256
Copper and Iron Pyrites	Tons	7,305	43,760
Copper Ore, Matte, and Prec.	Tons	4,218	2,536
Copper Metal	Tons	13,514	16,789
Tin Concentrate	Tons	8,135	10,538
Tin Metal	Tons	1,249	770
Lead Pig and Sheet	Tons	25,415	26,483
Zinc (Spelter)	Tons	17,261	13,358
Zinc Sheets, etc.	Tons	1,681	1,787
Aluminium	Tons	1,396	1,430
Quicksilver	Lb.	27,781	12,040
Zinc Oxide	Tons	932	1,120
White Lead	Cwt.	14,238	13,463
Red and Orange Lead	Cwt.	2,545	3,459
Barytes, ground	Cwt.	117,657	54,189
Asbestos	Tons	2,286	2,892
Boron Minerals	Tons	1,266	1,199
Borax	Cwt.	29,700	14,770
Basic Slag	Tons	8,275	5,169
Superphosphates	Tons	29,912	18,775
Phosphate of Lime	Tons	29,973	17,939
Mica	Tons	182	243
Sulphur	Tons	10,667	4,500
Nitrate of Soda	Cwt.	145,893	74,984
Potash Salts	Cwt.	584,308	244,323
Petroleum: Crude	Gallons	23,868,489	30,911,994
Lamp Oil	Gallons	31,789,070	28,976,661
Motor Spirit	Gallons	64,189,086	77,033,505
Lubricating Oil	Gallons	8,542,667	8,838,337
Gas Oil	Gallons	5,300,465	9,099,016
Fuel Oil	Gallons	46,965,001	35,531,443
Asphalt and Bitumen	Tons	17,795	17,689
Paraffin Wax	Cwt.	129,225	102,184
Turpentine	Cwt.	15,203	20,544

OUTPUTS REPORTED BY OIL-PRODUCING COMPANIES.

In Tons.

	April.	May.	June.
Anglo-Ecuadorian	13,204	13,683	15,630
Apex Trinidad	35,820	37,060	38,290
Attock	5,241	4,688	4,653
British Burmah	5,222	5,652	5,415
British Controlled	31,520	31,922	—
Kern Mex	789	809	—
Kern River (Cal.)	3,827	4,377	—
Kern Romana	2,707	2,637	—
Kern Trinidad	3,086	3,644	—
Lobitos	26,899	27,362	26,147
Phœnix	34,048	36,029	38,178
St. Helen's Petroleum	5,198	22,627	—
Steaua Romana	61,850	68,940	68,040
Tampico	—	2,877	—
Trinidad Leaseholds	32,500	32,100	30,400
Venezuelan Consolidated	2,157	1,864	2,190

QUOTATIONS OF OIL COMPANIES SHARES.

Denomination of Shares £1 unless otherwise noted.

	June 7, 1929	July 8, 1929
	£ s. d.	£ s. d.
Anglo-American	3 2 6	3 3 9
Anglo-Ecuadorian	1 1 10½	1 3 9
Anglo-Egyptian B	2 15 0	2 13 9
Anglo-Persian 1st Pref.	1 7 0	1 7 6
" " Ord.	4 10 0	4 6 3
Apex Trinidad (5s.)	1 11 3	1 11 3
Attock	3 0 0	2 15 0
British Burmah (8s.)	7 0	6 9
British Controlled ($5)	6 6	5 9
Burmah Oil	4 9 6	4 6 3
Kern River, Cal. (10s.)	8 0	7 9
Lobitos, Peru	2 3 9	2 6 3
Mexican Eagle, Ord. (4 pesos)	17 0	16 6
" " 8% Pref. (4 pesos)	16 6	15 0
Phœnix, Roumania	13 0	13 0
Royal Dutch (100 fl.)	33 17 6	33 5 0
Shell Transport, Ord.	4 18 0	4 16 3
" 5% Pref. (£10)	10 0 0	9 17 6
Steaua Romana	11 9	11 0
Trinidad Leaseholds	4 9 6	4 6 3
United British of Trinidad (6s. 8d.)	10 0	9 0
V.O.C. Holding	3 16 3	3 12 6

PRICES OF CHEMICALS. July 8.

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

		£ s. d.
Acetic Acid, 40%	per cwt	16 6
" 80%	"	1 16 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	15 10 0
" Carbonate	"	27 10 0
" Nitrate	"	24 0 0
" Phosphate	"	40 0 0
" Sulphate, 20·6% N.	"	10 13 0
Antimony, Tartar Emetic	per lb.	10½
" Sulphide, Golden	"	7
Arsenic, White	per ton	16 0 0
Barium Carbonate, 94%	"	5 10 0
" Chloride	per ton	12 0 0
" Sulphate, 94%	"	6 0 0
Benzol, standard motor	per gal.	1 9½
Bleaching Powder, 35% Cl.	per ton	7 0 0
" Liquor, 7%	"	3 5 0
Borax	"	20 0 0
Boric Acid	"	30 0 0
Calcium Chloride	"	5 10 0
Carbolic Acid, crude 60%	per gal.	1 11
" " crystallized, 40°	per lb.	6½
Carbon Disulphide	per ton	24 0 0
Citric Acid	per lb.	2 1
Copper Sulphate	per ton	27 10 0
Cyanide of Sodium, 100% KCN	per lb.	7
Hydrofluoric Acid	"	6
Iodine	per oz.	1 0
Iron, Nitrate	per ton	6 10 0
" Sulphate	"	1 17 6
Lead, Acetate, white	"	40 0 0
" Nitrate	"	34 0 0
" Oxide, Litharge	"	37 10 0
" White	"	38 0 0
Lime, Acetate, brown	"	8 0 0
" " grey, 80%	"	16 10 0
Magnesite, Calcined	"	9 0 0
Magnesium, Chloride	"	6 15 0
" Sulphate	"	3 0 0
Methylated Spirit 64° Industrial	per gal.	1 5
Nitric Acid, 80° Tw.	per ton	21 0 0
Oxalic Acid	per cwt.	1 13 0
Phosphoric Acid	per ton	29 15 0
Potassium Bichromate	per lb.	4½
" Carbonate	per ton	26 2 6
" Chlorate	per lb.	2½
" Chloride 80%	per ton	9 0 0
" Hydrate (Caustic) 90%	"	31 10 0
" Nitrate, refined	"	20 10 0
" Permanganate	per lb.	5½
" Prussiate, Yellow	"	6½
" Red	"	1 9
" Sulphate, 90%	per ton	11 5 0
Sodium Acetate	per ton	21 5 0
" Arsenate, 45%	"	26 0 0
" Bicarbonate	"	10 10 0
" Bichromate	per lb.	3½
" Carbonate (Soda Ash)	per ton	6 0 0
" " (Crystals)	"	5 5 0
" Chlorate	per lb.	2½
" Hydrate, 76%	per ton	14 10 0
" Hyposulphite	"	9 0 0
" Nitrate, 96%	"	10 12 0
" Phosphate	"	11 10 0
" Prussiate	per lb.	4½
" Silicate	per ton	9 10 0
" Sulphate (Salt-cake)	"	2 10 0
" " (Glauber's Salt)	"	2 5 0
" Sulphide	"	9 0 0
Sulphur, Roll	"	10 10 0
" Flowers	"	11 10 0
Sulphuric Acid, 168°	"	6 5 0
" " free from Arsenic, 144°	"	4 0 0
Superphosphate of Lime, 35%	"	3 0 0
Tartaric Acid	per lb.	1 4½
Turpentine	per ton	47 0 0
Tin Crystals	per lb.	1 6½
Titanous Chloride	"	10
Zinc Chloride	per ton	12 0 0
Zinc Dust	"	32 0 0
Zinc Oxide	"	42 0 0
Zinc Sulphate	"	9 0 0

SHARE QUOTATIONS

Shares are £1 par value except where otherwise noted.

GOLD AND SILVER:	June 7, 1929. £ s. d.	July 8, 1929. £ s. d.
SOUTH AFRICA:		
Brakpan	4 7 6	4 10 0
City Deep	10 6	12 0
Consolidated Main Reef	16 6	19 9
Crown Mines (10s.)	3 4 6	3 7 0
Daggafontein	1 1 3	1 1 3
Durban Roodepoort Deep	10 0	10 0
East Geduld	1 17 0	1 17 0
East Rand Proprietary (10s.)	10 6	12 9
Ferreira Deep	6 0	6 3
Geduld	3 10 6	3 10 0
Geldenhuis Deep	4 6	4 9
Glynn's Lydenburg	5 0	2 6
Government Gold Mining Areas (5s.)	2 1 3	2 0 0
Langlaagte Estate	1 1 0	1 1 3
Meyer & Charlton	10 0	9 6
Modderfontein New (10s.)	5 7 6	5 8 9
Modderfontein B (5s.)	16 6	17 3
Modderfontein Deep (5s.)	1 11 3	1 10 6
Modderfontein East	1 8 9	1 11 3
New State Areas	1 13 0	1 12 6
Nourse	8 9	9 3
Randfontein	6 3	6 0
Robinson Deep A (1s.)	15 0	13 9
" " B	9 6	8 9
Rose Deep	5 0	5 0
Simmer & Jack (2s. 6d.)	3 3	3 3
Springs	3 6 3	3 4 6
Sub Nigel (10s.)	1 16 3	1 17 6
Van Ryn	9 0	7 6
Van Ryn Deep	2 0 0	1 19 6
Village Deep	4 0	4 9
West Rand Consolidated (10s.)	8 0	7 0
West Springs	18 3	18 6
Witwatersrand (Knight's)	7 0	7 0
Witwatersrand Deep	4 6	4 9
RHODESIA:		
Cam and Motor	1 16 3	1 16 3
Gaika	6 0	5 0
Globe and Phœnix (5s.)	11 6	9 0
Lonely Reef	1 5 0	1 3 9
Mayfair	1 1 3	1 0 0
Rezende	17 6	17 6
Shamva	5 6	7 6
Sherwood Starr	10 6	15 0
GOLD COAST:		
Ashanti (4s.)	1 4 0	1 4 3
Taquah and Abosso (5s.)	2 3	2 3
AUSTRALASIA:		
Golden Horseshoe (Pref., 5s.), W.A.	12 6	13 6
Great Boulder Proprietary (2s.), W.A.	2 6	2 3
Lake View and Star (4s.), W.A.	13 9	13 6
Sons of Gwalia, W.A.	2 9	2 6
South Kalgurli (10s.), W.A.	16 0	15 6
Waihi (5s.), N.Z.	13 6	11 9
Wiluna Gold, W.A.	1 2 0	1 1 3
INDIA:		
Balaghat (10s.)	5 3	5 0
Champion Reef (10s.)	8 7	8 6
Mysore (10s.)	13 6	13 0
Nundydroog (10s.)	15 6	15 3
Ooregum (10s.)	10 6	10 6
AMERICA:		
Camp Bird (2s.), Colorado	2 6	2 6
Exploration (10s.)	9 0	9 0
Frontino and Bolivia, Colombia	8 9	7 6
Mexican Corporation, Mexico	11 3	16 0
Mexico Mines of El Oro, Mexico	7 0	3 3
Panama Corporation	19 0	19 0
St. John del Rey, Brazil	17 6	17 0
Santa Gertrudis, Mexico	10 3	11 0
Selukwe (2s. 6d.), British Columbia	5 9	5 9
MISCELLANEOUS:		
Chosen, Korea	1 2 6	1 3 0
Ellyou (5s.), New Guinea	1 7 6	1 7 0
Lena Goldfields, Russia	4 6	4 3
COPPER:		
Bwana M'Kubwa (5s.) Rhodesia	19 3	1 2 0
Esperanza Copper, Spain	19 6	19 6
Indian (2s.)	2 9	2 6
Loangwa (5s.), Rhodesia	9 6	9 0
Luiri (5s.), Rhodesia	6 6	6 6
Messina (5s.), Transvaal	18 3	18 6
Mount Lyell, Tasmania	2 1 6	2 0 3
Namaqua (£2), Cape Province	1 3 9	1 0 0
N'Changa, Rhodesia	4 5 0	3 16 3
Rhodesia-Katanga	2 1 3	2 0 6
Rio Tinto (£5), Spain	57 0 0	54 12 6
Roan Antelope (5s.), Rhodesia	1 15 6	2 7 6
Tanganyika, Congo and Rhodesia	3 0 0	2 18 0
Tharsis (£2), Spain	5 11 3	5 12 6

LEAD-ZINC:	June 7, 1929. £ s. d.	July 8, 1929. £ s. d.
Amalgamated Zinc (8s.), N.S.W.	14 0	14 0
Broken Hill Proprietary, N.S.W.	1 5 9	1 5 9
Broken Hill North, N.S.W.	5 11 3	5 7 6
Broken Hill South, N.S.W.	3 6 3	3 5 0
Burma Corporation (10 rupees)	18 9	18 9
Electrolytic Zinc Pref., Tasmania	1 16 6	1 15 0
Mount Isa, Queensland	2 5 0	2 3 9
Rhodesia Broken Hill (5s.)	4 0	3 9
San Francisco (10s.), Mexico	1 17 6	1 16 9
Sulphide Corporation (15s.), N.S.W.	18 6	17 0
ditto, Pref.	1 4 0	1 3 9
Zinc Corporation (10s.), N.S.W.	2 11 6	2 8 9
ditto, Pref.	4 12 6	4 11 3
TIN:		
Aramayo Mines (25 fr.), Bolivia	3 0 0	3 0 0
Associated Tin (5s.), Nigeria	10 0	10 0
Bangrin, Siam	1 16 3	1 17 0
Bisichi (10s.), Nigeria	9 0	9 0
Chenderiang, Malay	8 9	8 9
Consolidated Tin Mines of Burma	10 6	10 6
East Pool (5s.), Cornwall	1 6	1 6
Ex-Lands Nigeria (2s.), Nigeria	2 6	2 9
Geevor (10s.), Cornwall	8 0	8 0
Gopeng, Malaya	2 5 0	2 5 0
Idris (5s.), Malaya	15 6	15 0
Ipoh Dredging (16s.), Malay	1 7 0	1 8 3
Kaduna Prospectors (5s.), Nigeria	11 3	10 0
Kaduna Syndicate (5s.), Nigeria	18 9	17 6
Kamunting (5s.), Malay	15 6	15 6
Kepong, Malay	1 10 0	1 10 0
Kinta, Malay	11 6	12 6
Kinta Kellas, Malay	1 10 0	1 11 3
Kramat Pulai, Malay	1 8 9	1 8 9
Lahat, Malay	14 0	14 0
Malayan Tin Dredging (5s.)	1 6 6	1 7 0
Mongu (10s.), Nigeria	9 9	8 3
Naraguta, Nigeria	17 6	17 6
Nigerian Base Metals (5s.)	4 6	4 3
N.N. Bauchi, Nigeria (10s.), Ord.	1 1 6	1 3 3
ditto (10s.), Pref.	1 9 0	1 9 6
Pahang Consolidated (5s.), Malay	9 9	10 3
Penawat ($1), Malay	2 3	2 6
Pengkalen (5s.), Malay	19 0	19 3
Petaling (2s. 4d.), Malay	13 0	13 3
Rambutan, Malay	15 0	16 9
Renong Dredging, Malay	1 10 0	1 10 6
Ropp (4s.), Nigeria	8 0	9 0
Siamese Tin (5s.), Siam	15 3	14 3
South Crofty (5s.), Cornwall	4 6	4 9
Southern Malayan	14 9	16 0
Southern Perak, Malay	2 11 10	2 13 0
Southern Tronoh (5s.), Malay	11 3	11 9
Sungei Besi (5s.), Malay	14 0	13 9
Sungei Kinta, Malay	1 1 0	1 1 0
Tanjong (5s.), Malay	15 0	15 9
Tavoy (4s.), Burma	12 0	10 9
Tekka, Malay	1 0 0	1 0 6
Tekka Taiping, Malay	1 0 9	1 1 0
Temengor, Malay	1 14 6	1 14 6
Toyo (10s.), Japan	11 6	11 3
Tronoh (5s.), Malay	1 1 0	1 2 6
DIAMONDS:		
Consol. African Selection Trust (5s.)	1 10 0	1 10 0
Consolidated of S.W.A.	1 5 6	1 4 3
De Beers Deferred (£2 10s.)	13 10 0	13 7 6
Jagersfontein	2 9 6	2 7 6
Premier Preferred (5s.)	5 16 3	5 7 6
FINANCE, ETC.:		
Anglo-American Corporation	2 4 6	2 2 6
Anglo-French Exploration	1 2 9	1 3 0
Anglo-Continental (10s.)	10 3	10 3
Anglo-Oriental (Ord., 5s.)	11 9	11 6
ditto, Pref.	19 9	19 6
British South Africa (15s.)	2 2 3	2 1 3
Central Mining (£8)	19 0 0	18 5 0
Consolidated Gold Fields	2 17 0	2 13 9
Consolidated Mines Selection (10s.)	18 6	17 6
Fanti Consols (8s.)	14 9	14 9
General Mining and Finance	19 6	1 2 6
Gold Fields Rhodesian (10s.)	10 6	11 0
Johannesburg Consolidated	2 7 6	2 9 0
London Malayan	16 0	16 0
London Tin Syndicate	3 9 0	3 6 3
Minerals Separation	7 10 0	7 7 6
National Mining (8s.)	3 6	3 9
Rand Mines (5s.)	3 3 0	3 2 6
Rand Selection (5s.)	17 6	17 9
Rhodesian Anglo-American (10s.)	1 12 6	1 15 0
Rhodesian Congo Border	10 0 0	10 0 0
Rhodesian Selection Trust (5s.)	3 10 0	3 16 0
South African Gold Trust	1 10	1 10 0
Southern Rhodesia Base Metals	13 9	1 1 3
Tigon (5s.)	1 15 0	1 11 3
Tin Selection Trust	1 7 6	1 6 0
Union Corporation (12s. 6d.)	4 7 6	4 6 3
Venture Trust (10s.)	8 6	8 0

THE MINING DIGEST

A RECORD OF PROGRESS IN MINING, METALLURGY, AND GEOLOGY

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

THE SULMAN-PICARD TIN EXTRACTION PROCESS

In the MAGAZINE for November, 1927, particulars were given of a patent taken out by Messrs. H. L. Sulman and H. F. K. Picard covering a new process for the extraction of tin from rough concentrates and we publish below extensive extracts from British Patent 310,639 covering developments in this process effected by these co-workers.

"This invention comprises improvements in or relating to the recovery of tin from ores and the like. The term "ores and the like" is intended to include ores, concentrates, tailings and by-products which contain tin. The invention is specially applicable to the treatment of low-grade concentrates containing substantial amounts of iron, arsenic and other metals or minerals which would be deleterious when smelting in the ordinary manner.

"The present invention relates to the type of process in which tin is recovered as oxide fume from a heated charge which is subjected to the action of an air current while in admixture with carbonaceous material.

"The present invention is characterized by the fact that the charge in an open porous condition is so disposed (for example, in a layer of suitable thickness on a grate) and air is passed therethrough in such quantity that oxidizing conditions are maintained throughout the charge. It is found that by operating in this way at a suitable temperature a good recovery of tin is possible. To this end, moreover, the contents of the charge and temperature conditions should be maintained such that the production of molten slag is avoided. By this we mean that although clinkering of the ash is not necessarily wholly avoided no molten flowing slag is produced, as in a blast-furnace.

"At ordinary temperatures (such as may readily be attained in a grate provided with a current of air at low pressure) it is possible to eliminate a considerable amount of tin in the practical absence of sulphur. If this temperature range be exceeded, a larger amount of tin can be eliminated; but in order to avoid this higher temperature and to increase the elimination of the tin, the charge should contain a proportion of a sulphur in such form as to assist the recovery of the tin as oxide.

"The sulphur may be present in the form of pyrites or other sulphur-bearing mineral or substance admixed with the charge. The sulphur-containing substance must be such as is capable of bringing about the elimination of the tin as oxide fume under the conditions described herein. In some instances we have even obtained good results by using calcium sulphate as the sulphur-containing addition; on the other hand sulphur dioxide passed through the charge did not produce the desired elimination of the tin. A simple preliminary test would suffice in any particular case to determine the suitability or otherwise of a proposed sulphur-containing reagent.

"In our previous British Patent Application No. 301,553[1] we have described a process in which the tin content of the ore is heat-treated with a sulphidizing agent with the object of sulphidizing the tin mineral and rendering it amenable to recovery by solvents. In that process it was essential to sulphidize the whole of the tin mineral present, and to this end a considerable amount of sulphur was requisite sufficient to sulphidize not only the tin but also any iron or other minerals which might be present and which would absorb sulphur during the heat treatment.

"According to our present invention, also, instead of adding sulphur-yielding materials separate from the tin to the charge, the sulphur may be brought into combination with the tin as sulphide. To this end the ore may be first heat-treated with sulphur-yielding substances (under the conditions hereinafter described) to sulphidize the tin mineral present and thereafter the product may be subjected to the air-current, as already described.

"If the whole of the tin is to be brought first into combination with the sulphur before the blowing stage, a sufficient proportion of the sulphur-containing agent must be added to satisfy the sulphidization of other metals present such as iron, arsenic, zinc, lead and the like. Moreover if pyrites be the sulphur-bearing agent employed a moiety of its sulphur will be retained as sesqui-sulphide of iron or as ferrous sulphide. It is, however, not necessary according to this invention that the whole of the tin should be so converted. When conversion is effected before blowing, a portion only of the tin may be converted to stannous sulphide and the quantity of pyrites or the like correspondingly reduced.

"When pyrites or other sulphur-bearing substance is present admixed with the charge during the blowing operation, it is also unnecessary to add the sulphur agent in chemical equivalence to the sulphide forming metals present in the charge as well as to the tin content; in some cases we have found that the total sulphur present in the charge, either added or carried by the ore itself, may even be less than that theoretically equivalent (as stannous sulphide) to the tin alone. We do not seek to explain the complex reactions which take place nor to account for the part played by the relatively small proportions of sulphur in the charge admixture which attend the effective transformation of tin, as cassiterite, etc., into tin oxide fume.

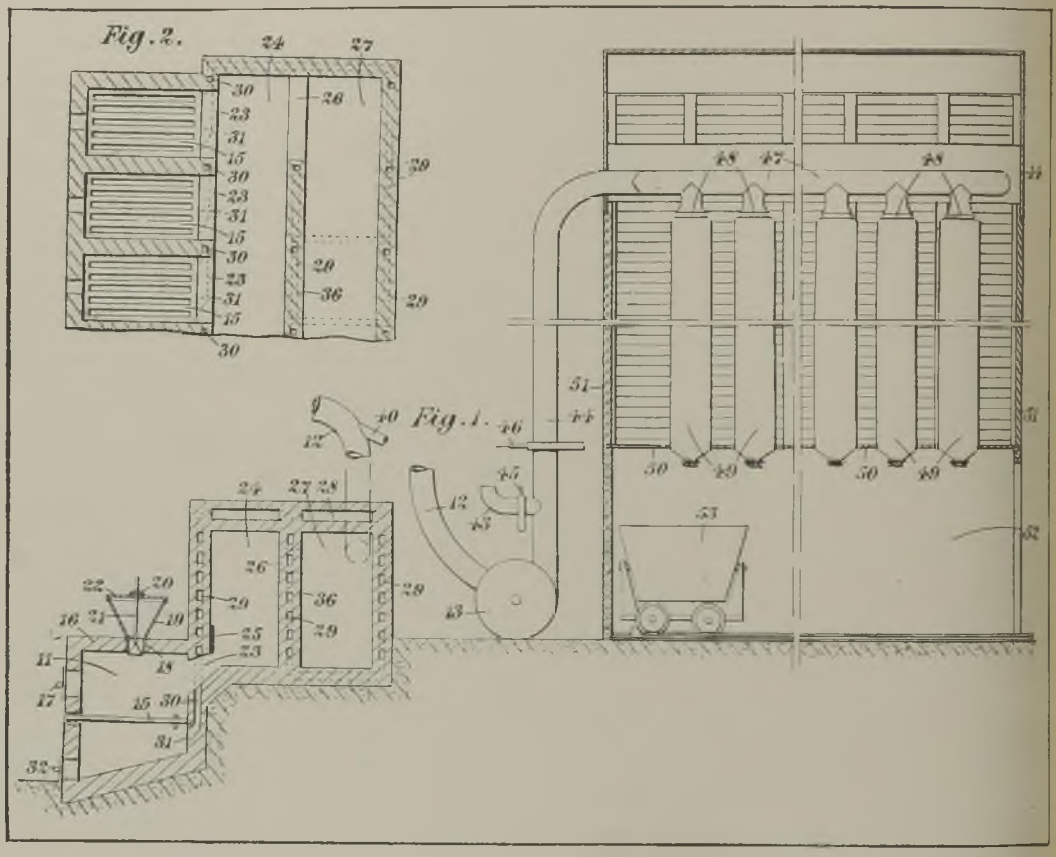
"Comparative tests are hereinafter set forth which indicate the nature of the reduction in the consumption of pyrites thus effected. It is, therefore, a feature of this invention that the sulphur present in the charge may be less than that which is chemically equivalent to the production of proto-

[1] *The Mining Magazine*, February, 1929, p. 130.

sulphides of tin and other metals which may be present (e.g. ferrous or stannous sulphides).

"One convenient method of carrying the invention into effect will now be described by way of example with reference to the accompanying drawing in which:—Figure 1 is a diagrammatic vertical sectional view of the plant, and Figure 2 is a part sectional plan of the furnace portion of the apparatus.

"The plant which comprises a furnace (11) set in brickwork and a long iron flue (12) (only part of which appears in the drawing) extending in the open air from the furnace to a fan (13) and a bag-house (14) adjacent to the fan, in which the product is collected.



"The furnace grate comprises a plurality of grates (15) side by side with brick arches (16) over them. A rabbling door (17) is provided in front and a charging opening (18) in the middle of the arch. In the charging opening is set a hopper (19) with a cross-bar (20) which carries a valve (21). A lid (22) (free to be lifted off without disturbing the valve) is provided on the hopper. From the back of the grate (15) there is an opening (23) into a large brick combustion-chamber (24), which is common to all the grates (15), whose function is primarily to complete the oxidation of oxidizable substances such as carbon issuing from the grates. Dampers (25) control each of the outlets (23) separately. The combustion-chamber is divided by a partition (36), the two parts being connected by an opening (26).

"The combustion-chamber also serves as a settling-chamber wherein any ash or coarse dust accidentally carried over tends to settle and from this chamber the gases go to the flue (12).

"The roof of the chamber (27) is made hollow at (28) with an inlet for air (not shown). From this hollow space air goes to sets of air-heating passages (29) in the walls of chambers (27) and (24), terminating in a down-passage (30) to a discharge (31) below the grate. There is a separate heating flue to each grate. The ash-pits are closed by a door (32) in front. This is a desirable arrangement for conserving the waste heat from the furnaces by preheating the air.

"The iron cooling flue (12) is provided with one or more air-inlets (one shown at 40) in the course of its length, through which cold air may be admitted to assist in cooling the gases. It is made of metal to radiate heat and is of sufficient length to reduce the gas-temperature within it to one suitable for the fan (13) and bag-house (14). The delivery side of the fan (13) is provided with a branch (43) to discharge to the atmosphere, when desired, or, alternatively, to discharge to the bag-house through

pipe (44). The two pipes (43), (44) are each provided with dampers (45), (46).

" In the bag-house the flue is branched into two or more sides (47) and each branch (47) carries a sufficient number of depending bag-holders (48) in the shape of inverted funnels, the mouths of which may be about 16 inches in diameter. To these are secured flannel or other fabric bags (49) about two feet in diameter. The bags are gathered together around the mouth of the funnel and attached by a hoop. The bags depend as far as an internal horizontal floor (50) and holes cut in the floor to fit the bags encircle their lower ends. The bag-house walls (51) above the floor are louvred to allow of the escape of the sulphur gases or, alternatively, they may be removed by fan or otherwise placed conveniently near the peak of the bag-house roof whence they may be discharged into a stack. With this arrangement louvres are unnecessary. Below the floor is a chamber (52) for collecting the products.

" The process, in this example, is as follows :— Finely-divided cassiterite concentrates taken from a preliminary concentration on vanners or the like and carrying, say, from 15 to 30% of tin as cassiterite, are mixed with pyrites, a binder and sufficient coal to support the temperature of the furnace by its combustion, and are made into briquettes on an Ovoid roll machine. These briquettes may, if desired, be coked at a low temperature to eliminate volatile hydrocarbons, as hereinafter referred to, or they may be charged direct. In either case the elimination of the hydrocarbons renders the briquettes open and porous, during the first stages of the heating operation. After the furnace has been preliminarily heated by means of a fire, the briquettes are charged in batches of say 30 to 40 lb. every 4 or 5 minutes into each grate of the furnace through the hopper (19) ; this we have found to be a convenient rate of feed for a grate unit of about 12 sq. ft. in area. They are quickly spread over the charge area by the furnace-man, care being taken to avoid undue cooling of the furnace by air entering during such charging. The fire is kept about 10–15 in. deep on the grate, and no other fuel beyond that contained in the briquette is needed once the operation has begun. A bright fire is kept, of a temperature of say 1,000° C. or above.

" Alternatively, instead of putting all the fuel into the briquettes, some of it may be separately charged into the furnace, say, in layers alternating with layers of briquettes.

" Fumes of tin oxide are evolved and carried upwards in the draught in admixture with a small amount of ash together with arsenic and the oxides or oxidized compounds of other volatilizable metals which may be present. In the combustion-chamber (24) any combustible dust is as far as possible burnt and the coarser dust is settled therein. No appreciable amount of tin oxide collects here as the fume is so finely divided ; but if, after long operation, it is found that there is a useful quantity of tin oxide in the combustion chamber this is easily recoverable for retreatment.

" The fumes are drawn by the fan (13) through the iron flue (12) in the open air and in the course of their progress to the bag-house are cooled to a temperature of 100° C. to 145° C. or to such higher temperature as will not be detrimental to the bag filters. A thermometric indicator fitted with electrical connections to the furnace-room, is advantageous to enable the temperature to be kept approximately constant, and to prevent accidental over-heating of the bags.

" In the bag-house the tin oxide dust is collected. As the bags are blown out fully by the draught they seal the openings in the floor (50) at the bottom of the bags and prevent notable access of the SO_2 contained in the waste gases into the discharging chamber (52). The waste gases escape through the louvres (51).

" From time to time any series of the bags may be shut off by suitable dampers for the purpose of collecting their accumulated oxide, into a receptacle (53) below, as usual in bag-house practice.

" The collected tin oxide is of a light grey colour, or white, depending on the efficient working of the combustion chamber and may contain as impurities, arsenic, some carbon, ash and other oxidized compounds. By heating the product in a suitable furnace such as a muffle-furnace any arsenic present may be sublimed separately from other products and thereafter any oxidizable material may be burnt off in an air current ; or if air is admitted from the commencement of these operations they may both be carried out simultaneously.

" The calcined tin oxide may further be treated with hydrochloric acid to remove remaining impurities such as oxides of iron, zinc, lead, antimony, any residual arsenic, etc. By following this procedure a purity of 99% SnO_2 has been obtained.

The following points may be noted as to the carrying out of the various steps :—If the tin is to be converted to sulphide before admission to the blowing furnace, it is, of course, possible to do this in a separate sulphiding operation by treatment with a reducing agent and sulphidizing agent. It is possible to use hydrogen sulphide whereby the sulphidizing and reducing agent is constituted by one and the same gas. The tin oxide or cassiterite is converted to sulphide with commercial completeness at a temperature of about 750° C. If pyrites be employed with carbonaceous material, and briquettes are made, as hereinbefore described, sulphidization can be effected in the coking apparatus if the temperature be raised to about 750°—800° C. This preliminary sulphidization step is not usually necessary but if circumstances render it advantageous the sequence of the operation is as follows :—The main carbonization of coal and binder takes place at about 300—400° C. Thereafter at a higher temperature, in the presence of a sufficiency of sulphur, arsenic is eliminated as arsenious sulphide ; finally the sulphidization of the tin is completed, and the charge (cooled out of access of air) is ready for the blowing furnace.

" The proportion of the coal and the sulphidizing agent will necessarily vary with the nature of the ore, its tin-content and the general conditions of the process, it being necessary to maintain the furnace sufficiently hot by the aid of the fuel and to afford sufficient porosity to the charge to permit of the ready escape of the tin-fume. One function of the excess of carbon present is to prevent sintering or slagging of the charge, which would tend to prevent the extraction of the tin.

" The size of the briquettes should not be too great ; it may be about that of ordinary fuel ' ovoids ' or somewhat smaller."

A number of examples illustrative of the operation of the process are then quoted. These comprise examples of tests carried out at the Geevor Mine, Cornwall.

PLATINUM EXTRACTION BY CHLORINE

In a paper before the Chemical, Metallurgical, and Mining Society of South Africa, published in the *Journal* for April, R. A. Cooper and F. W. Watson described the methods evolved, as a result of prolonged research at the laboratories of the Rand Mines Metallurgical Department, for the extraction of platinum, and we append considerable extracts therefrom :—

In June, 1923, samples of platinum ore were first received from the Waterberg District of the Transvaal, and attempts were almost immediately commenced to find a method of recovery of the platinum. A small consignment of ore was submitted to gravity concentration, and although this ore was amazingly rich, the recovery in the form of concentrate was very poor.

A characteristic gravity test is as follows :—

Material.	Proportion by weight.	Assay Value per ton.	Proportion of Value.
		dwt.	
Original Ore .	—	84·0	—
Concentrate .	1·05%	1560·0	21·0%
Tailings (sand)	55·50%	48·3	34·3%
Tailings (slime)	43·45%	80·5	44·7%

The proportion of the value which existed in the elutriated slime made it clear that gravity concentration was unlikely to be successful, and it was not suspected at that time that ore with entirely different characteristics would be found within a few hundred yards of the source of the above. The ore is principally quartzite with a considerable amount of iron oxide, and on attempting to dissolve this oxide from the above slime, in order to be able to inspect the actual grains of platinum, the remarkable fact was observed that much of the platinum was dissolved in hot strong hydrochloric acid, and no metal could be detected in the residue except by fire assay. In spite of repeated attempts by every known chemical, mechanical, and electrical means, it was never found possible to isolate the finely divided portion of the platinum group metals from the Waterberg ores, and its nature remains a secret. It is so finely dispersed that it is almost colloidal, but whether in the form of metal or of some oxide is unknown.

Unsuccessful methods of concentration of the platinum included retarded settlement of gangue in viscous liquids and in liquids of high specific gravity, accelerated settlement of platinum in centrifuges, accurately controlled elutriation, oil-froth flotation, magnetism, hysteresis, dielectric attraction and a variety of applications of electrolytic amalgamation. At a later date it was found that one section of the ore deposit consisted of material from which a relatively high recovery could be obtained by gravity concentration, but nevertheless, a considerable amount of irrecoverable platinum and palladium remained in the tailings. The solubility of much platinum and palladium in hot strong hydrochloric acid aroused the hope that recovery of the metals by a simple solvent would be practicable, and tests were made with dilute hydrochloric acid, ferric chloride and chlorine gas applied as in gold metallurgy. Results were disappointing, although each reagent extracted a certain proportion of the values ; in the latter case 17%. Brine (13% NaCl) saturated with chlorine, extracted almost 40%, but could not be improved beyond this point, even in heated solutions. Nascent chlorine solution produced by electrolysing a brine-ore pulp was no more successful.

A sample of ore containing 42 dwt. of platinum metals per ton was obtained, and a gravity concentrate removed, leaving the tailings with a value of 33 dwt. per ton. These tailings were treated with cyanide (0·2% KCN) with intermittent agitation for four days, new solutions being used each day. The extraction was 29% of the gravity tailings value, and further tests with 5% cyanide gave similar results, as also did bromo-cyanide solutions. From elutriated slimes an extraction of some 50% was obtained by 0·2% cyanide in four days. When the tailings were treated with 5% cyanide, heated to 100° C. for a few hours daily and cooled overnight, for several days, an extraction of 73% was obtained, but this is hardly a practical treatment and the cyanide consumption is very high. Preliminary roastings or treatment with acids does not improve the cyanide extraction. Other unsuccessful solvents tried were : hot 10% hydrochloric acid, cold solutions of zinc chloride, cupric chloride, cuprous chloride, sodium hyposulphite, cyanogen chloride, ethyl cyanide, hydrocyanic acid, bromine, iodine, and acid hydrogen peroxide ; alkaline peroxides, permanganates and sulphides ; dilute aqua-regia, hydrobromic acid and caustic soda ; heated solutions of mixed common salt, sodium nitrate, and sulphuric acid with and without permanganate.

A peculiar point noticed with these Waterberg ores, was a slight but distinct solubility of platinum in caustic soda solution, pointing to the possible presence of hydrated platinum oxygen compounds.

Treatment of Original Ore and Gravity Tailings with Chlorine.—In November, 1923, it was decided that cyanides and chlorine had given the only encouraging extractions. The best results obtainable with cyanides left much to be desired, and so attention was focussed on to the possibilities of chlorine. Nascent and normal solutions of chlorine and applications of cold chlorine gas, as in gold extraction, were unsatisfactory, so attack by the gas at high temperatures was investigated. Chloridizing roasts with common salt, both with and without pyrites, gave negative results, but roasts with salt and certain suiphates, such as copper sulphate, rendered up to 25% of the platinum metals soluble in water.

Attempts were then made to produce nascent chlorine in contact with heated ore by roasting with salt, manganese dioxide and sodium bisulphate. Again negative results were obtained when roasting took place, either in the open or in a closed space. Numerous tests proved that the idea of obtaining soluble platinum compounds by generating chlorine and hydrochloric acid in contact with the ore, was impracticable, and therefore ore was heated to 550° C. in a glass combustion tube and moist chlorine from a generator was passed slowly through it. After treatment, the ore was leached with acidified water and an extraction of 80% of the values was obtained. It was previously known that chlorine at moderate heats would convert platinum group metals into chlorides, but it by no means followed that quantities of gangue containing relatively minute proportions of platinum, in unknown forms of combination, could be successfully treated. The reactions of chlorine with basic

gangue minerals were unknown, and might have either prevented reaction with platinum or absorbed so much chlorine that the method would become impossible commercially. Very shortly after the attainment of this first good extraction, a curvilinear concentration table was installed at the laboratory and large scale tests confirmed the previous poor recoveries from the same type of ore as had been tested earlier. The possibilities of chlorine treatment were explored further, and it was found that the addition of 1% of sodium chloride in the form of solution, to the ore, increased the extraction to almost 90% and rendered very accurate temperature control less necessary. A remarkable feature of the treatment was the selectivity of the chlorine attack as the oxides of iron were practically unaffected, while the platinum metals were rendered water soluble by a few minutes' treatment. Only the largest grains of platinum were left incompletely attacked, and these were easily recovered by gravity.

In February, 1924, a revolving steel tube 24 in. by 4 in., electrically heated, was made to test the possibility of continuous ore treatment. Current was supplied through brushes to insulated copper bands at the end of the tube, and passed from them through a nichrome winding. The temperature was controlled by placing two copper plates in a cell of acidified water in the circuit, and varying the space between the plates to give what was empirically determined to be the correct amperage. The inlet and exit ends of the tube were reduced to 1 in. diameter and the interior was lined with a quartz-sodium-silicate cement. The ends were trapped to retain chlorine, and the whole apparatus was inclined, to cause downward travel of the ore during rotation. The object of this apparatus was to determine whether ore could be treated in a continuous stream instead of in separate lots in a stationary furnace, and the very promising extraction of 79% was obtained, from 22 dwt. ore, but extraction soon fell as the chlorine began to attack the tube. An entirely non-metallic tube, made of asbestos and silicate, was next tried and gave improved extractions, but it was then found that the sodium-silicate was mainly responsible for the consumption of chlorine. Finally a neutral material was obtained, and it was proved that 90% extraction was given by a 12 to 15 minute treatment of ore from which the coarser metallic grains had been removed. Steps were now taken to design and construct a large rotary furnace capable of treating a ton of ore in 24 hours. This furnace consisted of a steel tube approximately 8 ft. by 12 in. lined with rings of fire brick set in a fireclay-asbestos mixture; the ends entered stationary inlet and discharge sections through gas-tight asbestos-lined unions. The tube was supported by revolving discs at each end and was driven through a worm and gear. A motor car gear box was attached to the driving motor and gave choice of four primary speeds which were further reduced by gears attached to the worm. The tube passed through a fire-box 5 ft. in length, in which gas was burnt to give the necessary temperature. The whole furnace and carrier frame could be inclined to obtain any required speed of flow of the ore. Ore was fed through a small cup and cone hopper to the upper end of the tube and was periodically removed from a receiver at the discharge end, while chlorine gas was passed up through the descending ore. Numerous mechanical difficulties had to be overcome in the operation of this furnace, but eventually a satisfactory result was attained with a 15 minute treatment; extraction of 85% being got from 9·3 dwt. gravity tailings over a 30-hour run, with a chlorine consumption of approximately 40 lb. per ton. It was realized that, to operate this process on ore or gravity tailings, a high grade ore was necessary to meet the cost, but when mining was conducted on a large scale, it was found that the average grade of the deposit was much too low to hold out any hope of success.

Treatment of Gravity Concentrates from Oxide Ores.—Attention was next directed to the recovery of platinum from the gravity concentrates. Chlorine treatment of concentrates, mixed with 15 to 20% of salt, in a glass combustion tube, was found to convert the platinum metals into soluble form quite satisfactorily, again with little action on the gangue, though this was almost purely iron oxide. The time required for treatment was found to be much longer than for tailings. A rotary steel tube lined with fireclay tube 2 ft by 4 in. and gas heated, was arranged for the treatment of concentrate in batches. This furnace unexpectedly gave very poor and erratic results, although no fault could be found with its construction, and it was known that the concentrate was amenable to treatment. No variation of time, temperature or chlorine consumption appeared to improve matters. Generally, small charges gave worse results than large ones. The charge tended to " ball " with the rotation, and the centre of each ball was insufficiently treated, but the use of firebrick slabs in the furnace to keep the charge broken up and exposed gave results worse than anything so far experienced. On reverting to the glass tube to study the action, excellent extractions were consistently obtained. It was not possible to cause the charge to move freely, on rotation of the glass tube, on account of caking, and that point appeared to be the only difference between the tests in the two forms of apparatus. The larger furnace was again used and it was found that extractions varied in inverse ratio to the number of revolutions given during treatment. When the tube was kept stationary throughout a test, the subsequent extraction was very satisfactory. This discovery made furnace construction a much simpler matter, as moving joints were eliminated and a rectangular furnace, with large hearth capacity, could be used. To prove this, a Swedish oil-fired annealing furnace was obtained and fitted with a rectangular muffle constructed of 2 in firebrick slabs. A door was made by clamping a ¼ in. asbestos sheet, with a thin steel backing, across the front. Chlorine was admitted to the back of the muffle through a fireclay tube, and exit gases passed through a small observation hole in the door. This furnace proved to be most convenient for a much more detailed examination of the reactions of the process than anything that had preceded it. Chlorine could be used in exact quantities with practically no loss, and its rate of flow was measured by by-passing into an inverted measuring cylinder, filled with chlorine-saturated brine, for a given number of seconds at intervals during treatment. Exit gases were drawn through absorption apparatus and carefully examined for any traces of volatilised precious metals. No trace of these was found to be volatile, but a small quantity of cuprous chloride condensed in crystals from cooled gas when norites were being treated. These crystals are white when first deposited, but rapidly turn first golden and then green as they absorb moisture and oxygen. Charges of concentrate up to 6 in. thickness were treated

with chlorine equivalent to 150 lb. per ton, and extractions of 88% obtained from the Waterberg concentrates.

As these concentrates contained no appreciable quantity of base metals which are precipitated by zinc, the precious metals were easily recovered in a very pure form from the leach liquors. At this time gravity concentration tests on dunite were being carried out, and in view of the comparatively coarse and compact nature of the platinum crystals in these, the electrolytic amalgamation method, described in Messrs. Prentice and Murdoch's recent paper before this Society, was tried. The amalgamation proved successful, and as technique was improved it was applied to the Waterberg concentrates. Amalgamation had previously proved very inefficient when applied to the original ore in the early part of 1925, for reasons which later became obvious, but accumulated experience on dunites made its use on concentrate appear more hopeful. A new type of ore had been discovered on the Transvaal Platinum property which was much more amenable to gravity concentration than that first discovered. This ore, from the farm Welgevonden, contained only a small proportion of palladium and gave recoveries of over 70% in gravity concentrates. It was felt that it would be desirable to leave as little platinum as possilbe in these concentrates for chlorine treatment, as the cheap removal of much metal by amalgamation would also cheapen the chlorine treatment by reducing the time and gas required. It was soon found that at least 90% of the value could be recovered by amalgamation, and a plant was erected on the mine to deal with the Welgevonden ore by concentration and amalgamation, leaving the non-concentratable ore from the farm Rietfontein, to be dealt with later, if large scale mining operations developed ore of sufficient value.

Treatment of Norite Concentrates.—As development of these Waterberg ores showed very disappointing values, it became doubtful whether any application of the chlorine process of primary importance would be found, but within a short time, platinum in encouraging quantities was discovered in the norites. Again, a long series of tests was made to determine whether solvents would remove the precious metals from the ore, and whether any of the previously mentioned concentration methods, or direct matte smelting, were practicable. It was found that a certain proportion of the platinum is present in the form of sperrylite, and at a later date that a greater amount exists as the new mineral, platinum disulphide. Even boiling aqua-regia will only dissolve sperrylite with the greatest difficulty, and the sulphide is entirely unaffected by it. Gravity concentration tests did not recover more than about 20% of the value, but it was soon found that a good recovery into a small bulk could be obtained by the froth flotation process. By the use of a mixture of frothing and non-frothing oils, which was first worked out in the laboratory by the authors, a concentrate weighing about 5% of the ore, and containing some 87% of the values, was obtained. Similar concentrations were also obtained later in tests made in America. A normal value of these concentrates from the sulphide ore is from 150 to 200 dwt. per ton. There was a distinct tendency at one time to call these concentrations "recovery," but it was soon realized by all concerned that there was a considerable hiatus between concentrate and cash. Amalgamation methods applied to these sulphide concentrates towards the end of 1925 were unsatisfactory. One cause of trouble is the presence of much pyrrhotite which decomposes rapidly in mineral acid circuits, and even in solutions of heavy metal compounds, evolving sulphuretted hydrogen. This rapidly "sickens" the mercury and precipitates "activating" metals from solution. In addition, the basic nature of the gangue, which consists largely of easily decomposed magnesian-iron-silicates with free carbonates of lime and magnesia, causes an excessive consumption of acid reagents.

The principal reason for the non-success of any amalgamation process, however, is the fact which has now been established by Dr. Schneiderhohn, that much of the platinum-group-metal content of the ore is actually in either solid solution or sub-microscopic dispersion within certain of the base metal sulphides and cannot be liberated by any mechanical means. This fact entirely precludes any possibility of recovery of much of the platinum by any mechanical process, or even by chemical processes which do not entirely decompose these sulphides, and it also accounts for the greater difficulty of obtaining high concentration recoveries from oxidised ores, where the natural decomposition of sulphides by weathering must have left some of the precious metal so finely dispersed as to be in almost molecular condition. It is usual in oxidised ores to find that, in a crushed sample, the finest elutriated slimes are of similar value per ton to the original ore. Even this fine material, however, comes within the range of treatment by the flotation process to a considerable extent. In these norite concentrates we had, therefore, a new and important problem for the chlorine process. At first only gravity concentrates were available in sufficient quantity for testing, but work was done on these to accumulate information, as it was feared that the basic gangue would absorb large quantities of chlorine, and the only possibility of success was that action might be selective at the temperature employed. Another difficulty was that the chloridizing action would certainly form soluble salts of the copper and nickel present in these concentrates, and the subsequent separation of these from the platinum appeared to be a serious obstacle. An attempt to overcome both of these difficulties was made by first submitting the ore to a chloridising roast with salt, and then leaching to remove all soluble chlorides. This treatment—using 4% of salt during roasting—gave the following results :—

	Original Concentrate.	After Roasting and Leaching.
Sulphur . .	12·97%	0·13%
Copper . . .	0·76%	0·08%
Nickel . . .	3·50%	0·81%

Up to 22% of the concentrate became water soluble after the chloridising roast. The leached concentrate was dried, mixed with salt, and chlorine treated. This treatment at the first attempt rendered 80% of the precious metal content soluble, but also extracted almost all the remaining copper and nickel. As even 0·08% copper, when co-precipitated with the platinum metals by zinc, will give a final product containing over 70% of copper, which would be unsatisfactory to the refiners, it was clear that one object of the chloridising roasting was not attained. Direct chlorine

treatment of roasted sulphide concentrate was attempted, and, after a number of trials, a satisfactory procedure was worked out, and extractions of 85 to 90% were obtained. It was some time before quantities of flotation concentrate were available, but during 1926 sufficiently encouraging values were found in the norites to justify the erection of a small experimental flotation plant, and early in 1927 this plant commenced operations. Again chloridising roasting, with 4% of salt, was tried, and by this means the copper was reduced from 2·0% to 0·25%, but chlorine treatment of the leached roast failed to render more than 77½% of the platinum metals soluble, and again the solutions contained too much copper to allow of direct precipitation of a clean platinum metal product. It appeared that the preliminary chloridising roast was not only unsatisfactory as a method of removing copper, but also left the material in a condition unsuitable for chlorine treatment, while the leaching and re-drying of the concentrate would be expensive. This, and other tests, clearly showed that the action of the chlorine is not by any means the normal text book direct combination of platinum and chlorine. It is possible by incorrect heat treatment of concentrates to render the subsequent chlorine treatment entirely unsatisfactory and leave a large proportion of the platinum content unattacked.

Fortunately, the correct treatment is simple and easily controlled. It was feared that penetration of a reasonably thick layer of the powdery flotation concentrate by the chlorine would be slow and inefficient, but direct tests on material which had been only normally roasted to decompose the sulphides soon dispelled this fear, and showed that layers exceeding 4 in. thickness could be successfully treated by the application of some 150 lb. of chlorine per ton, at a temperature of 500-600° C. over a period of four hours. Leaching tests on the treated material gave extractions of 85 to 89% of the platinum metals. A curious feature of the method appeared at this stage, when the selective action of chlorine on the individual precious metals was discovered. In the first place it was found that gold was unaffected owing to the fact that the temperature employed is above the decomposition temperature of gold chloride. All of the platiniferous norites so far tested contain a small amount of gold, and this, together with some palladium and a little platinum, can be extracted by cyanide from the chlorine residues. The most important selective action of the chlorine is shown in its preference for platinum rather than for palladium and the other metals of the group. The precious metals present in chlorine residues always contain a distinctly lower percentage of platinum than those in the original concentrate, so that the actual recovery of platinum is always higher than the overall percentage recovery of total metals. If the total extraction of precious metals by chlorine is 87%, then approximately 92% of the platinum itself will have been extracted. Some of the coarser grains of platinum are incompletely attacked by chlorine in the time allowed ; these are recovered by gravity concentration and amalgamation from the residues. Usually the cyanide and gravity treatment of chlorine residues together give an additional recovery of some 5% which is to be added to the chlorine recovery.

Mixtures of flotation concentrates from oxidised and sulphide norites were tested in the small oil-fired muffle, the sulphide being previously roasted, and were found to give better extractions than sulphides alone ; residues, after leaching and without further treatment, having a value of 13 to 16 dwt. per ton, were obtained from original concentrates containing 160 to 180 dwt. per ton. Much research work was done on the platinum solutions produced during the above tests with the object of separating a platinum metal product of sufficiently good grade for direct refining. Complete precipitation of the copper and precious metals by means of iron or zinc was possible, but this entailed the smelting of a rich product with risk of loss and subsequent electrolytic separation. Many methods of separation, such as fractional electrolysis of the solution and fractional precipitation by reducing agents and bases were tried without success. A slow method for the precipitation of copper alone was sought for and was eventually found in the action of pulverised limestone. The action of limestone on copper solutions is known, but the separation of copper from precious metals by this means is new. When limestone is agitated with the chloride solutions for several hours, the copper is removed from solutions as the insoluble green basic carbonate in a dense granular form. Almost every trace of copper is precipitated and carries with it only a very small proportion of the platinum group metals present. This action is also selective, and of the metals carried by the copper carbonate only approximately one-third is platinum. The carbonate generally contains from 15 to 22% copper and can be smelted to metal from which the platinum metals, now present in very small quantities, can be recovered. As copper is the only base metal present which interferes appreciably, it is possible after its removal to produce a high grade platinum product by simple precipitation with zinc dust.

After having solved this difficulty, the authors were in a position to design a plant which would, in three stages, produce a satisfactory product from raw flotation concentrate, and it was decided to try out the whole procedure on a small working scale. A crushing flotation and gravity concentration plant, with a capacity of approximately 2 tons of ore per 8 hours, was built. At the same time a small recovery plant was also constructed to treat the concentrates produced. The latter plant consisted of a coal-fired roasting furnace of muffle type with a capacity of 200 lb. of concentrate per charge, a chlorine treatment furnace also of muffle type, and a series of wooden tanks for leaching the treated concentrate and subsequent operations with the solutions. The chlorine treatment furnace is essentially an external rectangular casing of firebrick with an inner shell or muffle. The muffle has its floor and roof arched laterally and is supported on a series of small longitudinal arches within the casing. Side thrust of the muffle floor and roof is supported by horizontal checker work of bricks between the edges of the arches and the external casing walls. The muffle walls are of special 4½ in. tongued and grooved firebricks to prevent loss of chlorine. The inner hearth area is 18 sq. ft. (6 ft. by 3 ft.) and the interior height 13 in. A cast-iron door, lined with asbestos and having a ½ in. hole for exit gases and observation of the interior, closes the front of the muffle, while chlorine is admitted to the back end through a ¾ in. porcelain "lead-in" tube. For the sake of simplicity and easy control, the furnace is heated by four small fuel-oil jets which operate through

diagonally placed tuyeres pierced horizontally through the external furnace walls below the muffle floor. These produce a remarkably uniform temperature throughout the interior of the furnace ; the exact degree of heat being recorded by electric pyrometer. The optimum charge of this furnace proved to be 20 lb. of concentrate per square foot of muffle area, and the time of treatment 6 hours. After roasting, the concentrate is mixed with 15 to 20% of its weight of salt and spread evenly over the hearth of the chlorine furnace to a depth of 4 to 5 inches. The requisite chlorine is admitted at such a rate that only a slight smell can be detected at the exit hole in the door. Some 130 to 150 lb. of chlorine per ton is used, and this is almost entirely absorbed by the concentrate, which is maintained at a temperature near 550° C. After treatment the charge is slightly caked and appears to be moist ; this latter condition is peculiar and indicates correct conditions. When withdrawn from the furnace, the material rapidly assumes a dry appearance and any lumps disintegrate on handling. Instead of the original powdery consistency, the concentrate now appears to be slightly granular and leaches well. It is dumped, while still hot, into water acidified with hydrochloric acid and leaching is immediately commenced ; when surface dry, an acid wash is given and is followed by two water washes. The total ratio of solution to solid is approximately 3 to 1, and leaching and washing is complete in 12 to 24 hours through a cocoanut matting calico filter by gravity. The dark green solution containing the platinum group metals with copper, nickel, calcium, magnesium and sodium chlorides, is agitated with pulverised limestone until copper can no longer be detected on the addition of potassium ferrocyanide to a small quantity of solution. Usually, about 20 lb. of limestone are required per ton of solution, and four to six hours' agitation. These factors depend, to some extent, on the acidity, temperature and copper content of the solution. The necessary agitation is produced by a wooden impeller suspended in the tank from overhead vertical bearings with a slow speed drive. When precipitation of the copper is sufficiently complete, the liquor is pumped to a second overhead filter tank and the filtrate graviated to a second agitator. This filtrate is still green in colour owing to the dissolved nickel, and it is neutral in reaction ; zinc dust (1 lb. per ton) is added during agitation and is followed by sufficient hydrochloric acid to dissolve the zinc. Precipitation of platinum metals is completed in 5 to 6 hours, and they are recovered by passing the liquor through a small calico filter bag, from which they are later removed and dried. A few minutes calcination at red heat converts the metals to a grey coherent sponge of high grade. As a final safeguard, the solution after filtration is passed through filiform zinc in an extractor box. Normal flotation concentrates from sulphide norite give solutions containing 25 to 30 dwt. of platinum metals per ton, after zinc dust precipitation the value is 0·08 dwt, and the extractor box effluent is 0·02 dwt. per ton. Copper carbonate precipitate carries values of about 40 dwt. per ton, but as a comparatively small quantity of this material is produced, its incidence on direct recovery is very slight ; this value is recoverable, as explained above. Experience has proved that the amount of precious metal carried by the copper carbonate can be maintained at a low point by careful attention to details of the precipitation procedure. Nickel remains in solution after removal of the platinum metals, and can be precipitated as hydrated oxide by the addition of alkalies and bleaching powder. The recovery of nickel and copper from the concentrates is approximately 80% of each, in the form of oxides and carbonates, when the original concentrate contains some 5% of nickel plus copper.

The following is an analysis of the final product recovered from 600 lb. of concentrate during the last tests made :—

Platinum	51·88%
Palladium	15·36%
Silica	11·32%
Iron Oxide	4·06%
Calcium Oxide	0·76%
Lead	Trace
Zinc	2·40%
Copper	6·84%
Nickel	2·00%
Silver	1·96%
Sulphur trioxide	0·12%
Oxygen (by difference)	3·30%

The silica is largely due to contamination by dust in the open tanks. The copper present indicates that there was approximately 0·0003% Cu, or 1·7 dwt. per ton, in the de-coppered solution, and clearly demonstrates the efficiency of the de-coppering process.

GEOLOGY AND COPPER-ZINC DEPOSITS OF COLD LAKE AREA, MANITOBA

In the *Canadian Mining and Metallurgical Bulletin* for April, J. F. Wright describes the geology of this newly-discovered mineralized area, and the following is abstracted therefrom. Within the past 18 months, a village of several dozen cabins and with a population of 100 or more persons, has sprung up on the shore of Cold Lake, just west of the Sherritt-Gordon mine. The present paper summarizes the author's observations and conclusions regarding the geology and mineral deposits of this new mining camp. The mineral deposits are within an ancient series of sedimentary gneisses, formerly regarded as for the most part of igneous origin, and by some not considered favourable prospecting ground.

General Geology.—The bedrock of Cold Lake area is pre-Cambrian, and the formations recognized may be tabulated as below.

Amisk-Wekusko Lavas and Sediments.—The lavas of this group outcrop over only a small area south and east of Kisseynew lake and north from Nokomis lake. The volcanic rocks south of Kisseynew lake are the northward continuation of the Amisk series of the Athapapuskow area [1]. The area of volcanic rocks north of Nokomis lake, so far as examined, is surrounded by granite, and therefore their correlation is uncertain. These lavas and

[1] Bruce, E. L., "Amisk-Athapapuskow Lake District"; Geol. Surv. Can., Mem. 105, pp. 23-25, 1918.

sediments however, lithologically resemble closely the members of the Wekusko group[1], and are tentatively correlated with this series. The lavas of these groups are dark grey to black, fine-grained, massive and schistose rocks, with only a few outcrops showing pillow structure or other evidence of their volcanic origin. In the thin sections examined, secondary minerals are fairly abundant, but originally the rocks were of medium basicity, probably dacite or andesite. Associated with the massive and schistose lavas are beds of laminated rock, probably representing water-sorted volcanic ash. Some beds of these dark banded rocks carry abundant red garnets. Locally, the lavas form only a minor proportion of the group, fine to medium-grained, grey arkosic sediments being much more abundant. At some localities, a variety of quartz-mica, quartz-hornblende, and quartz-chlorite, schists have been developed through the regional metamorphism of the members of this complex of lavas and sediments.

TABLE OF FORMATIONS

GROUP	COMPONENT ROCKS
Granitic Intrusives	Pegmatite Aplite Kaminis granite Pink and grey granite and granite-gneiss
INTRUSIVE CONTACT	
Basic Intrusives	Picrite, gabbro, and diorite
INTRUSIVE CONTACT	
Kisseynew Sedimentary Gneisses	Granitized sediments (Injection and impregnation gneisses) Hornblende-plagioclase-quartz-garnet gneiss Quartz-biotite-garnet gneiss Quartzite gneiss
CONFORMABLE CONTACT	
Amisk-Wekusko Lavas and Sediments	Andesite and dacite with beds of tuff, greywacké, quartz-hornblende schist, quartz-biotite-garnet schist, and chlorite schist.

Kisseynew Gneisses.—The quartzose gneisses and intimately intermixed intrusives outcropping in the vicinity of Kisseynew lake were described by Bruce as the *Kisseynew gneisses*. The field work of last summer has shown that these gneisses are widespread from north of Kisseynew lake to a few miles north of Cold lake, where the gneiss gradually disappears and is replaced by granite. The field evidence is clear that these gneisses were originally sandstone and impure sandstone, with some beds of clayey arkose. There has been extensive granitic intrusion into these sediments, accompanied by digestion and partial replacement of the original clastic materials by granite, so that many outcrops show an intimate mixture of granite and sediment. A great number of rock types has been developed by the regional and contact metamorphism of this sedimentary series, and locally a great range in the appearance and mineral make-up of the gneiss takes place within a very short distance. In other parts of the area, however, the gneisses show only minor textural and mineralogical variations and present a monotonous succession of grey quartz-mica-garnet gneiss and schist, cut by sills of granite and dykes of pegmatite. Black medium to coarse-grained hornblende-bearing garnet-gneiss is locally an abundant member of the Kisseynew group. Some outcrops of this gneiss have the appearance of an intrusive quartz-diorite gneiss, but many outcrops show relics of bedding which is convincing evidence that these rocks represent recrystallized sediments. Also, the black gneiss alternates with quartz-mica-garnet gneiss of undoubted sedimentary origin. The contacts between the two types, wherever observed, are gradational rather than sharp igneous contacts. These facts, combined with the presence of abundant garnet and a texture characteristic of recrystallized rocks, proves that the black igneous-appearing gneisses were originally sediments, probably beds of clayey arkose. The detailed structure of the Kisseynew gneisses is difficult to work out because of the absence of characteristic horizon markers. The major structure of the gneisses is interpreted as a broad synclinorium, trending north to northwest through Cold lake. The axial plane of a number of the minor folds on the limbs of this major fold are locally overturned. The Sherritt-Gordon deposit is located along the southwest limb of an isoclinal fold, apparently overturned from the northeast.

Basic Intrusives.—A few outcrops of basic rock, ranging in mineral composition from peridotite to diorite, were noted in the area examined. These basic rocks cut the Kisseynew gneiss as sills, dykes, and bosses, and are older than the granite and pegmatite. The basic intrusives are much older than the mineral deposits, hence the magma from which these rocks originated cannot be considered as the source of the copper-zinc mineralization.

Granite.—The Amisk-Wekusko volcanics and the Kisseynew gneisses are cut by batholith-like bodies and sills of granite and granite-gneiss. The longer axis of the granite bodies north of Cold lake trends east and west, whereas the granite bodies in the southeast and southwest corners of the area trend approximately north and south. The typical granite is grey to slightly pinkish, and it is uniform in appearance over wide areas. Some outcrops are gneissic and others are slightly porphyritic. At many points, inclusions of sedimentary gneiss are abundant within the granite. Apparently, the granite magma had little competence in absorbing the quartzose sedimentary gneiss, but did send out a great quantity of invading substances, which penetrated and worked over the Kisseynew sediments to form a complex of *lit-par-lit* and injection gneisses.

The Kaminis granite extends northward from the Athapapuskow area into the southeast corner of the Cold Lake area. Associated with this granite are numerous small bodies of massive, pink aplitic and pegmatitic granite. The copper-zinc deposits are believed to be related in origin to an end-phase of magma that formed these bodies of aplite, pegmatitic granite, and pegmatite.

The pegmatite dykes and sills cut the Kisseynew gneiss with sharp contacts, and they effected little or no contact action in the country rock. Many of the dykes vary greatly in width along their strike,

[1] Alcock, F. J., "The Reed-Wekusko Map-Area Northern Manitoba"; Geol. Surv. Can., Mem. 119, pp. 14–24, 1920.

in many places forming a series of lenses connected by narrow necks. Other dykes are straight and uniform in width throughout their length. Many parallel the bedding and foliation of the gneiss, whereas others cut the foliation at an angle, and some cut across both the dip and strike of the bedding of the gneiss. The pegmatites clearly were intruded after the foliation was developed, and after the sedimentary gneisses were folded into their present position. They have not yet been examined closely. Small pegmatite dykes are developed along many of the sulphide-bearing shear zones, and in these pegmatites copper and iron sulphides occur sparingly.

Distribution of Copper-Zinc Deposits.—Copper and zinc sulphides and associated iron sulphides are of widespread occurrence in northwestern Manitoba. At present, the largest known commercial deposits of these minerals are the Flin Flon and Sherritt-Gordon, in the Athapapuskow and Cold Lake areas, respectively. In these areas, and also in the Wekusko area to the east, some development has been completed on a dozen or more additional prospects, but this work has not been extensive enough to prove large tonnages of commercial copper or copper-zinc ore on the individual deposits explored. In the Cold Lake area, the Sherritt-Gordon deposit is just east of the southeast bay of Cold lake, and the majority of the copper-zinc prospects of the area examined are in a rectangular area 10 miles wide and extending northwest some 25 miles from just southeast of the Sherrit-Gordon. During 1928, prospects with showings of copper-zinc sulphides were discovered to the east of this area, in the vicinity of Elkan and Walton lakes, but here little surface work has yet been completed, and this section, though largely staked, has been only partially prospected. In the northwest corner of the map-area, some prospecting was done near Kipahigan lake, and here copper-zinc sulphides also occur sparingly.

General Character.—The copper-zinc deposits of Cold Lake area are massive and disseminated replacements of fractured and sheared zones in the Kisseynew sedimentary gneisses. Many of the deposits are along a contact zone between grey quartzite and black hornblende-plagioclase-garnet gneiss. The Sherritt-Gordon ore is for the most part within quartzite, adjacent to the black gneiss, which forms the hanging-wall. During folding, the contacts between thick massive sandstone and clayey beds would be naturally a zone of weakness, where adjustments between the beds could take place causing brecciation and shearing of the rock. Although the hornblende- and mica-bearing garnet-gneisses were sheared across fairly wide areas, these zones were apparently not so favourable for sulphide deposition as were the fractured and sheared zones within the more acid gneiss. The Flin Flon, Mandy, Baker-Patton, and other sulphide deposits to the south of Cold lake are replacements of sheared zones in the Amisk volcanics. The abundant sulphides in the Cold Lake deposits are pyrrhotite, sphalerite, chalcopyrite, and chalmersite. Assays of the ore show that gold and silver are present in small quantities. The gold is apparently associated with the chalcopyrite. Galena occurs only sparingly, and at the Sherritt-Gordon has been noted at only a few points in the black hanging-wall rock. Many sheared zones carry only pyrrhotite, and the proportion of sphalerite and chalcopyrite present varies greatly in different deposits, and also from point to point within the same deposit. The deposits in the Kisseynew gneisses differ from those to the south in the Amisk lavas in that pyrrhotite instead of pyrite is the abundant iron sulphide.

Barren or practically barren pyrrhotite bodies, or the so-called "pyrrhotite dykes" are widespread in northern Manitoba. They generally outcrop as prominent yellowish or brownish rusty zones. Some of these barren deposits have been trenched, and the fine grain of the pyrrhotite is the only apparent difference between the barren deposits and the deposits carrying the copper and zinc sulphides. So far as can be determined, the wall-rock shearing and alteration are identical in the barren deposits and in those that are copper- and zinc-bearing. The sulphides of the Sherritt-Gordon ore are coarsely crystalline, and must have been formed under conditions that allowed slow deposition. The fine grain of the pyrrhotite of the barren deposits indicates that here the metal-bearing materials cooled quickly, probably due to their original general character rather than to wall-rock or structural conditions, for it is not unusual to find barren pyrrhotite bodies close to the copper-zinc deposits. The barren deposits were noted throughout most parts of the district examined, whereas the copper-zinc mineralization is confined for the most part to the area north and northwest of the tongue-shaped bodies of granite extending north from the Kaminis batholith.

Wall-rock Alteration.—At the Sherritt-Gordon, the wall-rock alteration caused by the sulphide-bearing materials was very slight. There is locally an abundance of sericite and chlorite along the ore zone, but these minerals were formed by the shearing of the rocks before the sulphides were introduced. Where the wall-rock is black hornblende-gneiss, some of the hornblende has been altered to a green nearly opaque chlorite, and the green or brown biotite bleached to a colourless mica. This alteration, however, extends for only a fraction of an inch from the sulphide veinlets. In thin sections of the ore in the acid gneiss, the felspar is seen to be in part altered to zoisite and calcite, and the biotite to chlorite. The small amount of wall-rock alteration caused by the sulphides is an interesting feature of the deposits of the area. In this respect the deposits resemble pegmatite dykes, which generally are formed with comparatively slight wall-rock alteration.

Origin of the Deposits.—The copper-zinc deposits are believed to be genetically related to the granitic intrusives of the area. The sills and dykes of granite, pegmatite, and aplite occurring along or near the mineralized shear-zones represent a phase of a granite magma, and indicate that undoubtedly granite extends beneath much of the area. Although pegmatitic magma penetrated almost every plane of weakness in the Kisseynew sediments, a few of the larger fractured and sheared zones were not completely filled. Some of the partly filled fractured zones were reopened after the consolidation of the pegmatitic magma, and these fractures, and all open spaces not occupied by pegmatite, were filled by the ore materials, which, in addition, were able to penetrate and replace some beds of the quartzite gneiss, and, at a few points, the hornblende-garnet gneiss and pegmatite. There is a close genetic relation between the pegmatite dykes and the copper-zinc deposits. At many places, a few grains of pyrrhotite and chalcopyrite are present in massive pegmatite, and here the sulphides must have crystallized with the silicate minerals of the rock. This suggests a common source for the pegmatitic magma and the metallic sulphides. Along the

Sherritt-Gordon deposit, however, fractured pegmatite is cut by veinlets of pyrrhotite, chalcopyrite, and quartz, which were introduced after the rock had consolidated. Some of the Sherritt-Gordon ore appears to be sheared pegmatite replaced by sulphides. Sphalerite is generally the abundant sulphide present in association with the dark grey, more basic varieties of pegmatite. Some lenses of massive pyrrhotite are cut by narrow stringers of vitreous pegmatitic quartz, and chalcopyrite, replacing the pyrrhotite, is abundant adjacent the quartz. Veins of pegmatitic quartz, carrying sulphides and gold are also developed along graphite-bearing shear-zones in the footwall quartzite gneiss of the Sherritt-Gordon deposit. It would seem that the pegmatitic magma, carrying small quantities of the sulphides, first entered the fractured and sheared zones, to be followed by the ore materials, the end phase of which was also siliceous and pegmatitic in character.

The Sherritt-Gordon Deposit.—The Sherritt-Gordon ore-body is a long narrow zone of fractured and sheared rock that has been impregnated by pyrrhotite, sphalerite, chalmersite, and chalcopyrite. These sulphides were deposited in all the open spaces available, and also have replaced the schistose and gneissic rock along bedding and foliation planes. In places, bodies of massive sulphide, two feet or more in width, were formed, but most of the ore consists of quartzite gneiss intimately intermixed with veinlets, small lenses, and specks of sulphides. The outer limits of the sulphide mineralization are not sharp, as pyrrhotite is distributed in small grains in the hanging-wall rock from 50 to 100 feet from the centre of the shear zone. The outline of the ore-bodies will also be irregular, for the proportion of pyrrhotite, chalcopyrite, and sphalerite present varies along the strike. Locally, bodies of pegmatite completely fill the fractured zone. The ore-bodies follow closely the dip and strike of the beds of the sedimentary gneiss. From the northwest end of the deposit, the dip gradually steepens from 45 degrees northeast to vertical near the southeast end, and at the east end the dip of the gneiss and ore-body is steep and in the reverse direction from the dip farther west. In hand specimens of the ore, the sulphides appear intimately intermixed, but in polished specimens the pyrrhotite is seen to be cut by sphalerite and chalcopyrite. In some specimens, chalcopyrite contains inclusions of sphalerite. In specimens carrying abundant chalcopyrite, the pyrrhotite, chalmersite, and chalcopyrite appear to have crystallized together. In specimens with only a small amount of pyrrhotite, the chalcopyrite and sphalerite are intimately intergrown. There is no evidence of a long time-interval between the deposition of the sulphides, and apparently their order of formation was governed, to some extent at least, by the relative abundance of the various metals present. The metallic sulphides are clearly later than the silicate gangue minerals, the more abundant of which are quartz, felspar, hornblende, biotite, and garnet. In addition to these minerals, some thin sections of the sulphide-bearing rock were found to contain actinolite, tremolite, augite, epidote, zoisite, titanite, magnetite, sericite and chlorite. The sulphides penetrate the felspar and other silicate minerals as veinlets along fracture and cleavage planes, and inclusions of silicate minerals, including chlorite and sericite, are abundant in the sulphides. Many specimens of massive sulphides contain elliptical-outlined blebs of quartz, which are interpreted as remnants of the original siliceous rock that was replaced to make room for the bodies of massive sulphides. Surface exploration of this deposit has been done at five points, where the outcrop was near the surface, and this trenching proved the presence of a mineralized zone for approximately 5,300 feet of the 13,600 feet along which the mineralization may extend. The remaining distance of 8,300 feet between and beyond where the surface work has been done, is drift covered, and here it is more economical to drill shallow pilot holes than to attempt to trench; for the upper part of the deposit is generally weathered, and the hanging-wall rock caved so that it is impossible to determine the grade and the width of the ore without sinking at least 50 feet. To the middle of September, 1928, some 88 holes had been drilled to intersect the ore-zone at from 125 feet to 400 feet below the surface. Only a few holes were drilled to the 700 and 1,000 feet horizons. The holes are spaced at intervals of about 250 feet along a distance of 4,400 feet from the east end of the deposit and 6,200 feet from the northwest end. The intervening length of 3,000 feet has not yet been explored by diamond drilling.

During the winter of 1928, two surface plants, capable of developing the property to the 1,000-foot level, were installed. Early in the summer, the east shaft had reached a depth of 260 feet, and lateral work was commenced on the 125-foot and 250-foot levels. On the 125-foot level, 1,600 feet of drifting has been completed, and widths of ore from 14 to 50 feet are reported to average from $18 to $20 per ton gross metal content. The average metal-content of this ore is 3·25 per cent copper, 7 per cent zinc, and approximately $1·00 in gold and silver. At the present west shaft, approximately 7,000 feet northwest of the east shaft, exploration was commenced on the 375-foot level, and cross-cuts south to the ore-zone at this horizon are reported to show widths of from 22 to 30 feet averaging 2·3 per cent copper and 3 per cent zinc. No underground work has been done at the northwest end, but here the diamond-drill intersections showed, on the average, higher copper than elsewhere. Several estimates of tonnage and grade of ore of this deposit have been published, and these estimates give a general idea of the large size of the deposit and of the general grade of the ore to the depths explored. It is to be expected that underground exploration will prove the deposit to be much larger and higher in grade at some points than has been indicated by the few drill intersections. Late in 1929, the railway will be completed to the mine, and then large-scale developments can be undertaken more economically. It has recently been announced that a 1,500-ton unit of a concentrator will be built. Electric power will probably be developed at one of the large falls on the Churchill river, approximately 50 miles northwest of the deposit.

Future of the District.—The successful results of the development work at the Sherritt-Gordon assure a long mining history for the area, provided the market price of copper and zinc keeps near the present level. Although little deep exploration has yet been undertaken, the length of the mineralized zone, combined with the general character and the deep-seated origin of the deposit, would seem to indicate a continuation of ore much below the present level of exploration. The coarse grain and general siliceous character of the ore should make it a comparatively easy sulphide-ore to concentrate. Up to the present, no additional ore-bodies have been discovered in the area examined.

COPPER MOUNTAIN ORES

In the *Canadian Mining and Metallurgical Bulletin* V. Dolmage describes the origin of the Copper Mountain ores in British Columbia. Copper Mountain is a low-grade deposit of the contact-metamorphic type with refractory ores consisting of chalcopyrite and bornite in a gangue of altered andesitic and basaltic breccia, situated 12 miles south of Princeton, 150 miles east of Vancouver and 40 miles north of the International Boundary line, and is connected to Princeton by a good motor road.

Geologically, the ore bodies are situated along the contact of a stock composed of gabbro, diorite, and other related rocks, thrust up through a series of steeply folded andesitic and basaltic breccias. The only other rocks of importance are some large white felsite and quartz porphyry dykes, which cut both the stock and the breccias as well as the ore-bodies. The metallic content of the ore is believed to have originated in the magma of the stock and to have been deposited some time prior to the injection of the large white dykes. The breccias occupy a large area in this general region, and prior to this replacement by the stock and other similar intrusions and to their being buried under more recent lavas, they occupied the entire region. The total thickness of the series is not known, but it must measure several thousands of feet. The breccias vary in texture from fine to very coarse, with fragments up to a foot or more in length, and in composition they range from andesite to basalt. Fragments and matrix alike consist almost entirely of plagioclase and augite, usually in nearly equal proportions. The breccias are steeply folded, and in the vicinity of the mine strike north-west and dip 50°–70° to the south-west. In the vicinity of the stock they are in places intensely biotitized, and where the ore has been deposited they are severely fractured. They probably belong to Dawson's Nicola series of Triassic age.

The stock is elliptical in plan, having a major axis five miles long extending in a north-west direction, and a minor axis of about three miles. The Similkameen valley, with its steep sides and deep rock canyon, cuts fairly through the centre of the stock from north to south, clearly exposing it, not only in a horizontal section, but over a vertical range of nearly 2,000 feet. The stock varies markedly in composition from periphery to core. The outer zone consists of a fine to medium grained syeno-gabbro made up of approximately 57% labradorite, 20% augite, 10% orthoclase, and 2% magnetite. In a few places portions of the plagioclase and augite are replaced by considerable amounts of biotite. Inside this zone is a coarser and more salic one, ranging in composition from a syeno-diorite through a monzonite to almost a syenite, and in the centre of the stock is a core nearly one mile in diameter of syenitic pegmatite of medium-coarse grain and consisting of orthoclase, microcline, albite, and albite-oligoclase, with small amounts of biotite, chalcopyrite, and bornite. The sulphides, though present in only minute quantities, are almost as evenly and as widely distributed through this core as are the other constituents. The same copper-iron sulphides occur in minute particles also in tiny veinlets which cut the rocks adjoining the pegmatitic core. Little or no pyrite is present.

Quartz is absent from all phases of the stock, as well as from numerous related pegmatites and also from the ore. No felspathoids were observed. A noteworthy feature of the stock, as well as its pegmatites and related ore veins, is the conspicuous amount of apatite, usually in large crystals from $\frac{1}{8}$ to $\frac{1}{4}$ in. diameter. Still another important peculiarity of the stock is the large amount of orthoclase present in its outer basic phases. The boundary separating the pegmatitic core from the next zone is sharply defined and resembles an intrusive contact. The boundary, however, between the central and outer zones is much more gradual and is clearly not an intrusive contact. At a number of localities in the outer zones of the stock, as well as in the surrounding breccias, are irregular bodies of extremely coarse syenitic pegmatite, some of which also contain chalcopyrite and bornite. Some of these dykes have felspar crystals one foot in length, as well as leaves of biotite with similar dimensions.

The large white dykes, though a conspicuous feature of the geology, are of little consequence and need not be described at length. They follow a northerly trend and vary in width from 10 to 200 ft. In composition they range from dense felsites to medium grained quartz porphyry. Their principal influence has been to replace a quantity of good ore and also to complicate mining and milling operations, as it has been found necessary to mine the great bulk of them and to eliminate the fragments from the ore by hand sorting. Besides these large white dykes there are also a few much smaller dark green andesitic dykes, which tend generally to strike in a direction normal to the white dykes.

The Ore.—The ore consists of basaltic and andesitic breccia which has been intensely biotitized, then foliated and fractured, and later the fractures and adjoining rock impregnated by augite, orthoclase, albite, epidote, zoisite, bornite, chalcopyrite, pyrite, and magnetite. Notwithstanding all these impregnations, the original fragmental character of the rock can usually be recognized, and under the microscope the bulk of the original felspar and augite is easily visible, except in the zone of most intense biotitization; and even here some of the original minerals can be seen. Comparatively little chemical change has been produced in the original basaltic breccia by the mineralization process.

The amounts of pyrite and magnetite are exceedingly small, and they are both entirely absent from much of the ore. The magnetite appears to be more abundant in sections where the copper-iron sulphides are absent. The biotitized zone lies adjacent to the contact of the stock, but is extremely irregular in width and in the intensity of the alteration. The outer limit of the zone is so irregular and indefinite that it could not be satisfactorily mapped, even in the underground workings. In some areas there appears to have been almost complete conversion to biotite, and here the rocks have a dense black colour. Where the biotite crystals are large they show a tendency to lie in parallel planes, producing a schistose structure, but where they are small no such tendency can be detected and the rock has the appearance of rubber. A considerable amount of bornite is found as disseminated particles in this biotitized rock;

some of it may probably have been introduced with the biotite, though there is no doubt that the bulk of the bornite was introduced during the main period of metallization which came later. A few tiny fresh dykelets of diorite were observed cutting the biotitized rock, and both were affected by a later period of fracturing. These facts seem to indicate that the fluids which produced the biotite escaped prior to the solidification of the magma, and probably before it had finally come to rest. The biotitization may have advanced like a wave in front of the slowly rising magma.

Outside of the biotitized zone, and at a few places in it, the breccias are converted to a densely fine, greyish-green, chert-like material produced by the introduction of a vast number of crystallites of a pale green pyroxene, probably augite. This alteration affected the matrix of the breccia to a much greater extent than the coarser grained fragments, which are frequently found in a fairly fresh condition enclosed in this densely fine chert-like matrix. A large proportion of the ore mined occurs in this chert-like pyroxenite, which has the objectionable property of being exceedingly tough and difficult to grind. A small amount of scapolite was also observed in some of the altered rock. After this period of biotitization, or during its close, the breccias were subjected to stresses which caused the formation of vast numbers of minute, parallel fractures standing vertically and striking in a direction almost precisely normal to that of the contact of the stock. In places they are so numerous as to be only a small fraction of an inch apart, while in other places they are fewer but are longer and wider. They vary in width from microscopic to a quarter of an inch or more, but average less than one-twentieth of an inch. They are important in that they provided the openings by which the copper-bearing fluids entered the breccias, and a large proportion of the copper is now found in these fractures.

The grade of the ore varies with the number and size of the fractures. Besides the fractures, the rocks in the vicinity of the deposits have an indistinct foliation parallel to the stock-contact, and therefore perpendicular to the fractures. The foliation planes assisted in the formation of the ore by conducting some of the mineralizing fluids away from the fractures, causing the spread of copper minerals throughout the rock. The exact time of the fracturing is not known, but it is clearly later than the biotitization and earlier than the solidification of the stock-magma, or at least earlier than the solidification of more than a very thin shell of it, for the fractures do not occur in the stock itself except to a very slight extent close to the contact. Since, also, the fractures are not all filled with the same minerals, it is possible that the fracturing took place over an extended period of time. Many of the fractures, probably the majority of them, and particularly the larger ones, are filled with large amounts of orthoclase, albite, and green mica ; or, in other words, syenitic pegmatite. With the pegmatite are smaller but important amounts of bornite, chalcocite, and chalcopyrite, and still smaller amounts of epidote and zoisite. The copper minerals tend to segregate along a narrow line in the centre of the vein, but occur also in small amounts throughout the pegmatite. Some of the sulphides appear to have been deposited later than the feldspars, but the bulk of them have the appearance of having been deposited simultaneously. The orthoclase, besides filling these veins, is also to some extent disseminated as small isolated crystals in the adjoining rock, which seems to prove that it was deposited from solutions and not formed by the solidification of a magma.

Other fractures are filled mainly with augite, epidote, zoisite, albite, and the same three copper minerals. Along the margins of these fractures, bleached zones occur up to a quarter of an inch in width, which owe their lighter colour to the injection of crystallites of augite, zoisite, and sericite. Still other fractures, which are usually smaller, contain only bornite and chalcopyrite, with a few small crystals of albite. A very few fractures are filled with magnetite, and one or two were observed which contained only pyrite. As previously mentioned, much bornite and chalcopyrite is disseminated throughout the rock between the veinlets, in places bringing the copper content up to 3% or more.

Since the deposition of the ore, the only geological events by which it has been affected are the injection of the white dykes and the removal of a large amount of overlying material, as well as some of the ore itself, principally by erosion, but to a slight extent by glaciation also. Since glacial times, a small amount of oxidation has affected the ore, producing some malachite and probably some chalcocite, though undoubtedly much of the chalcocite is of hypogene origin.

Origin of the Ore.—In the Copper Mountain deposits the relations of the ore to the magma of the stock are extraordinarily well shown ; first, by their relative positions, and second, by certain striking similarities in the mineral content of each. The orebodies which compose the Copper Mountain mine lie adjacent to the contact of the stock, and several much smaller but exactly similar deposits occur at other places along the contact of the stock ; one lies adjacent to the contact of an inclusion enclosed within the stock. Bornite, the characteristic ore mineral, is present also in the pegmatitic core of the stock and in many pegmatite dykes obviously derived from the stock magma. A considerable amount of pegmatite is associated with the ore and is a quartzless, syenitic type of pegmatite identical in character to that which forms the stock-core and the other related pegmatite dykes. The absence from the ore of quartz as a gangue mineral is an unusual feature, but is in accord with its absence from all phases of the stock, including pegmatite dykes. Another notable feature is the absence from the ore of any appreciable amounts of pyrite, indicating that the mineralizing solutions were unusually low in iron. Pyrite is absent also from the many minute chalcopyrite veinlets occurring in that portion of the stock adjacent to the pegmatitic core, suggesting their deposition by similarly iron-poor mineralizing solutions. These striking similarities, together with the relative positions of the ore and stock, leave little doubt as to their common origin.

These features do not, however, prove that the ore-forming solutions came directly from the stock, moving more or less laterally away from it, but they admit of the possibility of the solutions having risen vertically along the contact from much deeper regions, probably from the main magma chamber, of which the stock is only an appendix. As the orebodies are explored to greater and greater depth, evidence bearing on this question will certainly be obtained, but at present the only

light on the problem must come from observations made on other contact-metamorphic deposits. Associated with the Coast Range batholith of British Columbia are many similar contact deposits, occurring either in limestone or porous tuff or, as in most cases, in sheared rocks of various composition. Many of these deposits are in inclusions lying within the batholith, while many others are in roof pendents which project far down into the batholith. In some of the smaller of these the base of the ore is exposed, and it invariably butts against fresh, unaltered and barren, or almost barren, granodiorite, thus proving that the solutions passed directly from the batholith into the soluble or porous rocks adjacent to the contact. In view of these facts, it seems probable that the solutions which formed the Copper Mountain ores also passed directly from the stock into the fractured breccia.

The above-mentioned facts—that many of the contact-metamorphic deposits of the Coast Range batholith occur in roof pendents and in inclusions and that they lie against fresh, unaltered, barren granodiorite—seem to indicate pretty clearly also that the solutions came from the magma prior to its solidification, though not necessarily prior to the commencement of crystallization. That solutions do escape from magmas prior to their solidification is believed by almost all students of petrology and metamorphism, who account for most contact-metamorphic phenomena in this way; and there is no apparent reason why some of these solutions should not transport some of the metals and sulphur contained in the magma and deposit them as metallic sulphides. The mechanism of the process by which these attenuated, probably highly aqueous, portions of the magma are separated from the more viscous portion has not been investigated, but it would appear to be a straining effect depending on the size of the openings penetrated. If the openings are large enough, the magma will rush in and form dykes or sills; but if they are less than a certain critical size which will permit this, then only the thin attenuated liquids or gases will escape. This process is really an early phase of magmatic differentiation and should so be regarded. Not all of the highly liquid portion of a magma escapes in this way, but much of it, probably the great bulk of it, remains in the magma to be slowly concentrated as a final residue by the ordinary methods of magmatic differentiation attendant on the crystallization of the anhydrous rock-forming minerals. There appear to be at least two main methods by which the volatile components of a magma may be separated from the more viscous portion; first, a very early one, by which the highly attenuated fluids escape from the molten magma through minute openings in the walls of the magma chamber; and a second one by which they are concentrated as a residual liquor and squeezed out by the crystallizing of the rock minerals, later to escape into the surrounding rocks through fissures. The former method produces contact-metamorphic ore deposits as well as other metamorphic phenomena, including, in some cases, what has been called "injection gneiss", while the latter process results in the formation of mineral veins and pegmatite veins or dykes.

The Copper Mountain deposits have not been proved to belong to either one or the other of these two periods of magmatic differentiation, but there are reasons for believing that they belong to the earlier period.

SHORT NOTICES

Gas Producer for Motor Vehicles. — In *Engineering* for May 24 appears an article on the Tulloch-Reading gas producer for motor vehicles. This portable gas producer in its early stages was described in THE MAGAZINE for May, 1924, and November, 1926, by S. Dawson Ware.

Powdered Fuel Firing.—In *Colliery Engineering* for May, 1929, a description is given of the "H and M" powdered-fuel burner, which has been developed by Gasified Pulverised Fuel, Ltd., together with results of recent tests conducted on a Lancashire boiler at Grimethorpe Colliery.

Gas Masks for Mine Rescue.—In *Miners Circular* 32 of U.S. Bureau of Mines, S. H. Katz and G. S. McCaa give a description of the use of type N miners' gas mask.

Mine-Fan Performance.—In *Technical Paper* 447 of the U.S. Bureau of Mines, G. E. McElroy and A. S. Richardson describe experiments on mine-fan performance at Butte mines during 1926 and 1927.

Blast-Roasting at Cerro de Pasco.—In *Technical Publication* No. 209 of the American Institute of Mining and Metallurgical Engineers, G. A. Keep describes the blast-roasting, in Peru, of the Cerro de Pasco copper-silver ores in Holt-Dern furnaces.

Loss of Cyanide in Clarifiers.—In *Bulletin* No. 25 of the Kolar Gold Field Mining and Metallurgical Society, January-March, 1929, W. E. Whitehead describes the loss of cyanide in the clarifiers at the Balaghat mine of the Kolar gold field.

Control of Atmospheric Conditions in Hot and Deep Mines.—At the general meeting of the Institution of Mining Engineers, July 10, 11, and 12, J. S. Haldane reviewed the work of the committee on "The Control of Atmospheric Conditions in Hot and Deep Mines."

Salts Lost by Sweating owing to High Air-Temperature.—In a paper before the General Meeting of the Institution of Mining Engineers on July 10, 11, and 12, W. Hancock, A. G. R. Whitehouse, and J. S. Haldane describe the work in which they have been engaged for some years with a view to the alleviation of the conditions under which men work in hot and deep mines.

Exploitation of the Dead Sea.—In *Discovery* for April and May, I. Melamede gives an account of the Dead Sea scheme together with the financial and transport aspects of the same.

Zinc-Lead Copper Mining in Nova Scotia.—In *Canadian Mining and Metallurgical Bulletin* for June, R. E. Legg gives a brief outline of the mining and milling methods which will be used at the Stirling Mine in Richmond County, Nova Scotia.

Cyanide Regeneration at Pachuca, Mexico.—In *Technical Publication* No. 208 of the American Institute of Mining and Metallurgical Engineers, C. W. Lawr describes the method of cyanide regeneration as practised at Pachuca, Mexico.

Differential Grinding in Tailing Retreatment.—In *Technical Publication* No. 217 of the American Institute of Mining and Metallurgical Engineers, L. M. Banks and G. A. Johnson describe the application of differential grinding to tailing retreatment.

Permeation of Solutions in Leaching.—In *Technical Paper* 441 of the U.S. Bureau of Mines, a description is given of the factors governing the entry of solutions into ores during leaching.

Working Iron Ore in South Australia.—In *Chemical Engineering and Mining Review* for April 5, a description is given of quarry operations and plant at Iron Knob and Whyalla, South Australia.

Copper in North Carolina.—In *Engineering and Mining Journal* for June 1, H. J. Bryson describes the copper deposits of North Carolina.

Wire-Rope Lubrication.—In *Engineering and Mining Journal* for June 8, C. D. Meals describes the importance of the proper lubrication of wire ropes.

Sulphur Recovery in Nevada.—In *Engineering and Mining Journal* for May 25, H. L. Hazen describes the recovery of sulphur from a Nevada surface deposit.

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.*

34,375 of 1927 (283,132). Chemische Fabrik Johannisthal G.m.b.H., Berlin-Rudow, and F. Trostler, Berlin-Grunewald. Method for the recovery of copper and nickel from copper-nickel alloys or intermediate metallurgical products.

2,183 of 1928 (311,839). Francois Cementation Company, Ltd., Doncaster, W. R. Degenhardt, London, A. F. de Fraine, Wembley, and others. Improvements in rock abraiding machines for tunnelling or shaft boring.

2,962 of 1928 (310,780). T. J. Taplin, Bwana M'Kubwa, Northern Rhodesia, and Metals Production, Ltd., London. Means for sealing the junction between a rotary kiln or furnace and stationary apparatus connected therewith for the exclusion of atmospheric air from the interior of the furnace or kiln.

3,666 of 1928 (284,976). A. A. Frey, Pittsburgh. Smelting process whereby iron may be produced of an unusual degree of purity comparable with that produced by electrolytic methods.

3,700 of 1928 (285,373). I. G. Farbenindustrie A.G., Frankfort-on-Main. Improvements in the manufacture of electrolytic zinc by the wet method.

3,932 of 1928 (311,304). Heenan and Froude Ltd., and G. H. Walker, Worcester. Improvements in the conditioning of air in mines, by dehydration and humidification.

10,325 of 1928 (288,319). Vereinigte Stahlwerke A.G., Düsseldorf. Improved process of obtaining iron from iron-containing ores with the formation of ferric chloride.

11,469 of 1928 (311,909). S. C. Smith, London. Process for treating ores, concentrates, residues, etc., in which the chief metal values are nickel and copper, whether or not associated with platinum or other precious metals.

21,496 of 1928 (311,991). Cayzer Tin Smelting Company, Johannesburg. Improved process of concentrating ores containing platinum and metals of the platinum group.

21,719 of 1928 (294,655). Hans Bardt, Berlin-Schöneberg, Germany. An improved process for extracting halogens and precious metals from sea water.

23,945 of 1928 (299,300). F. Krupp Grusonwerk A.G., Magdeburg-Buckau, Germany. Process for the recovery of volatilizable metals from iron-containing materials and particularly from pyrites waste or calamine containing iron.

24,598 of 1928 (312,007). H. A. Sloman, National Physical Laboratory, Teddington, A. C. Vivian, Dept. of Mines, Livingstone, Northern Rhodesia. Process for obtaining beryllium oxide from ores, residues, etc.

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.

Industrial Fuel and Power Statistics for Ontario, 1925. By E. S. Malloch and C. E. Baltzer. Paper covers, 23 pages, with 12 maps. Price 10 cents. Ottawa: Department of Mines.

Cadmium. Imperial Institute Report. Paper covers, 23 pages. Price 9d. London: H.M. Stationery Office.

Year Book of the American Bureau of Metal Statistics, 1928. Paper covers, 112 pages. Price $2. New York (33 Rector Street).

Report on Mining Operations in the Province of Quebec, 1927. Paper covers, 246 pages, illustrated. Quebec: Bureau of Mines.

Civil Engineers Reference-Book, 20th Edition, Third issue, 1929. Cloth, octavo, 1512 pages. Price 35s. U.S.A.: Trautwine Company. London: Chapman and Hall, Ltd.

French-English and English-French Dictionary of Financial and Business Terms, Phrases, and Practice. Second edition. By J. O. Kettridge. Cloth, octavo, 248 pages. Price 10s. 6d. London: George Routledge and Sons, Ltd. New York: E. P. Dutton and Co.

Preliminary Review and Summary of Mining Operations in British Columbia for 1928. By J. D. Galloway. Paper covers, 68 pages, illustrated. Victoria: Bureau of Mines.

Annual Report of the Minister of Mines, British Columbia, for the year 1928. Paper covers, 540 pages, illustrated, and with maps. Victoria: Bureau of Mines.

Methods of Compiling Statistics of Coal-Mining Accidents (International Labour office, League of Nations, Studies and Reports, Series N, No. 14). Paper covers, 90 pages. Price 2s. London: P. S. King and Son, Ltd.

Metallurgical Limestone, Problems in Production and Utilization. U.S. Bureau of Mines, Bulletin 299. Paper covers, 40 pages. Washington: Government Printing Office.

Summarized Data of Zinc Production. U.S. Bureau of Mines, Economic Paper 2. Paper covers, 47 pages, illustrated. Washington: Government Printing Office.

Kalgoorlie School of Mines, Metallurgical Investigations, 1929 (Bulletin 4 of the Department of Mines of Western Australia, Kalgoorlie). Paper covers, 49 pages. Perth: Mines Department.

A Review of the Trade of British Malaya in 1928. By L. B. Beale, of the Department of Overseas Trade. Paper covers, 90 pages, with 1 map. Price 3s. London: H.M. Stationery Office.

COMPANY REPORTS

Mount Isa Mines.—This Australian company, which owns lead-zinc-silver properties in Queensland, has been financed and managed by Russo-Asiatic Consolidated since 1927. According to the report for 1928 £500,000 has been subscribed by Russo-Asiatic Consolidated during the year and that company has undertaken to subscribe up to £1,000,000 against the issue of debentures. The estimated cost of development and erection of a mill and smelter of 1,500 to 2,000 tons daily capacity is £1,300,000. J. M. Callow has designed the mill and smelter and his representatives are in Australia supervising construction. C. A. Mitke has formulated a programme of mining development. A three-compartment ore shaft will be sunk on the eastern or foot-wall side of the ore-bodies and the ore raised will be dumped direct to the mill bins. A man and supply shaft will be sunk west of the ore shaft and between the Black Rock and Black Star mines. A first main haulage level will be at a depth of 350 ft. and will connect these shafts with the Black Star, Black Rock, Rio Grande, and other ore-bodies. Subsequent haulage levels will be arranged at intervals of 300 ft. in depth. There are at present three existing shafts; of these the Davidson, on the Black Star, has been deepened to the 350 ft. haulage level and the Black Rock and Rio Grande shafts will be sunk to the same level. Stoping will be carried out by a combination of glory-hole, shrinkage, and caving methods, which at other mines have proved to give the lowest mining costs. The estimate of ore reserves made by H. H. Knox has already been quoted in the MAGAZINE. By development and diamond drilling the sulphide ore to a depth of 750 ft. is figured at 17,700,000 tons, averaging 6·2% lead, 8% zinc, and 3·9 oz. silver per ton, and the drill holes continue to give favourable results. At the pilot concentration plant an 87% extraction of the lead content was obtained in concentrates averaging 47% lead, 6·5% zinc, and 36·3 oz. silver, and a 66% extraction of the zinc, in concentrates averaging 50% zinc and 2% lead.

Sons of Gwalia.—During recent years this once great Westralian gold mine has worked on a smaller scale and attention has been paid to the re-treatment of old tailings. Two years ago the directors negotiated a loan with the West Australian Government, whereby £78,000 was obtained, to be spent on plant and development during a period of 3½ years. During the year 1928 the 30-stamp mill treated 121,058 tons of ore and 37,388 tons of accumulated sand and slime, the total output being 30,712 oz. of gold, which realized £130,293. These figures show a considerable increase in the amount of ore treated as compared with the previous year, but a decrease in the accumulated tailings. The working expenditure in Australia was £132,493. The results of the new development campaign are reported to be satisfactory and encouraging. The company also has a holding in Cornish Kaolin, which unfortunately experienced a fall in the sales of products during the year under review, which neutralized the advantage of increased prices, but consumption now appears to be improving.

Tronoh Mines.—This is one of the pioneer companies to work alluvial tin deposits in the Federated Malay States, being formed in 1901, and it is now head of a group of similar companies. During the year 1928 Nos. 2 and 3 dredges were continuously working and Nos. 4 and 5 commenced operations during its course. The dredges yielded 574 tons of tin concentrate and other sources brought the total sales to 1,197 tons, as compared with 997 tons the year before. The profits, including dividends on investments, were £67,646, out of which £51,164 has been distributed as dividends, the rate being 20%. No. 8 dredge is in course of completion and a new steel pontoon is being provided for No. 3 dredge. The report also mentions that further funds are required for dealing with a property in Siam, in which it is interested jointly with the Waihi Gold Mining Co. For the purpose of increasing the working capital for these and other purposes the directors propose capitalizing £50,000 of the undivided profit, £109,338 of which was brought forward from the previous year's accounts, and they are offering 100,000 shares to shareholders, payable half in cash, the remainder being satisfied out of this capitalization.

Sungei Besi Mines.—This company belongs to the Tronoh group and has worked a tin property in Selangor, Federated Malay States, since 1909. The property used to be operated by underground methods, but is now being worked as an opencast. During last year 218,956 cu. yd. were mined, coming almost entirely from the northern end of the opencast, yielding 539 tons of tin concentrate, the yield per yard being 5½ lb. The profit for 1928 was £16,319 and £43,765 was brought forward from the previous year. Dividends absorbed £28,400, the rate being 20%. So far it has not been possible to work the Village Area, recently acquired, owing to the Government not yet having completed arrangements for the new village.

Idris Hydraulic Tin.—This company belongs to the Tronoh group and has worked alluvial tin property in Perak, Federated Malay States, since 1913. During the year 1928 the output of tin concentrate was 552 tons, as compared with 585 tons the year before. Owing to the drop in the price of tin the revenue fell from £93,766 to £69,286 and the profit from £66,584 to £47,584. Dividends absorbed £48,000, the rate being 40%, as compared with 45% the year before. The property is worked by hydraulicking methods. Dry seasons caused a shortness of water supply, so that the amount of ground treated was curtailed, but, on the other hand, ground of higher value was treated.

Lahat Mines.—This company, which belongs to the Tronoh group and operates alluvial tin property in Perak, Federated Malay States, reports an output of 195 tons of tin concentrate during 1928, as compared with 259 tons during 1927. The profit for the year was £9,206, out of which dividends at the rate of 5% have been paid, absorbing £6,000. The fall in the output was due to the closing of the South mine, the bulk of the present output now coming from the North mine. This latter mine is now worked on the gravel-pump system instead of as ordinary open-cast, as formerly.

Siamese Tin.—This company, which has worked alluvial tin ground at Ngow, in the Renong district of Siam, since 1906, reports a lower output for the year 1928 than that for 1927, due partly to a stoppage for repairs to No. 2 dredge and partly to the passage through comparatively barren ground of No. 3 dredge. The total output was 507 tons of tin concentrate, as compared with 661 tons the year before, and the average yield was 0·41 lb. per yard. The company more recently acquired property farther south at Kopah and started dredging at Plaiwah in 1926 and at Peek in 1927.

During 1928 these dredges produced 642 tons of concentrate, the yield per yard being virtually the same as that at Ngow. The company also has a large holding in the Bangrin Company. The revenue from the sale of concentrate from Ngow and Kopah was £180,402 and the working profit was £35,227. Dividends absorbed £30,000, as compared with £75,000 for 1927.

Bangrin Tin Dredging.—This company is a subsidiary of the Siamese Tin Syndicate and works alluvial tin ground near the latter's properties. One dredge is at work and two others have recently been completed. One of these dredges is ready to start operations, but the other, which was illustrated in the MAGAZINE for February of last year, still requires considerable adjustment of its dressing plant. During 1928 No. 1 dredge treated 1,612,500 cu. yd. for a yield of 498 tons of concentrate. The revenue was £77,695 and £30,000 has been distributed as dividend, the rate being 10%.

Naraguta Extended (Nigeria) Tin Mines.—Owing to the result of floods during July, 1928, when damage was done to the plant, the company was not able to record the increased output of tin concentrate for 1928 that was expected, and the figure was much the same as that for 1927, being 190 tons, as compared with 187 tons. The profit for the year was £6,548 and £7,637 was distributed as interim dividend before the floods occurred. The year 1928 commenced with a balance of £16,174 and ended with one of £15,085. It is expected that before long it will be possible to distribute an interim dividend for 1929.

Wheal Kitty Tin.—Since control of this group of mines at St. Agnes, Cornwall, was acquired by the Anglo-Oriental group in 1925 much development work has been done and additional plant has been erected. During the year ended January 31 last 33,075 tons of ore was milled, for a yield of 264½ tons of concentrate, having an average assay of 70·8% tin. The sales, including stock at January 31, realized £41,264 and there was a net loss for the year of £10,855. Important developments have occurred at the 880 ft. level in the Wheal Kitty workings, where 411 ft. was driven westerly averaging 84 lb. of tin oxide per ton over a lode width of 24 in. Two rises from this level exposed for 265 ft. a lode averaging 101 lb. of tin oxide per ton over a width of 28 in. It is now planned to sink to this ore-body in order to continue development and to extend operations into the Friendly workings.

Aramayo de Mines en Bolivie.—During the year 1928 the profit was £192,044, as compared with £277,295 the year before, the decrease being due almost entirely to the fall in the price of tin. The sale of tin concentrate during the year was 4,229 tons, as compared with 4,045 tons the year before, and the price realized per ton averaged £114, as compared with £143. The sale of silver was 1,705,091 oz. and of cement copper 349 tons. The sale of bismuth is, as usual, not stated, but it was practically the same as during the previous year. Dividends amounted to £184,800, being at the rate of 20% on the old capital and 10% on the additional capital created in February, 1928. As already recorded in the MAGAZINE, the technical management of the company's properties was taken over by Guggenheim Brothers in July, 1928, for a period of ten years. The new managers have installed improved plant, by means of which better results can be obtained. The company has become signatories to the British-American Metal Company, one of the objects of which is to test the possibility of regularizing the output of tin and of stabilizing the price.

Marmajito Mines.—In association with the Frontino and Bolivia Co., this company has worked a neighbouring gold mine in Colombia since 1919. During last year 8,340 tons of ore was treated, giving 10,550 oz. of gold, the yield being 25 dwt. per ton. The revenue was £44,745 and the net profit was £11,756. Out of this £6,000 has been distributed as preference dividend, the rate being 20%, and £800 on the ordinary shares, at the rate of 5%. The ore reserve is estimated at 19,000 tons, averaging 23·3 dwt. per ton. The number of stamps is being increased from 15 to 20 and two electrically-driven sinking pumps are being provided in order to deal with water below the 7th level.

Cyprus Asbestos.—Particulars of the operations of this company were given in an article in the MAGAZINE for September last. The report for 1928 shows that the profits are still increasing, but, owing to necessary expenditure on development and plant, no dividends have yet been declared. During last year 2,115,876 tons of rock were mined, 433,271 tons were milled, and 16,287 tons of asbestos fibre were produced. The net profit was £61,036, making a total available balance of £90,023. The reserve account is increased to £50,000 by the transfer of £46,299 from the profit and loss account, and £43,724 is carried forward. The power station is being extended and the capacity raised to 2,000 kw. Primary mills Nos. 7 and 8 are in course of construction and should be in operation by the end of the current month. During 1929 the output will be further increased and the working costs reduced.

Libiola Copper.—This company, which has worked a copper mine in northern Italy since 1867, reports a net profit of £69 for 1928, as compared with a loss of £1,488 for the previous year, the improvement being due to the sale of rich copper ore early in the year. The production of copper ore during 1928 was 2,042 tons and of pyrites 11,854 tons, as compared with 3,555 tons and 10,979 tons respectively in 1927. The ore reserve is estimated at 11,580 tons of copper ore and 37,830 tons of pyrites, falls of 230 tons and 6,190 tons respectively as compared with the figures a year ago. The sale of the company's mines and properties to the Italian company, the Societa per l'esercizio della Miniera di Libiola, which for some years worked the property under lease, was effected just prior to the close of the period under review.

San Finx Tin Mines.—During 1928 the company milled 39,177 tons of ore for a yield of 253 tons of tin concentrates and 139 tons of wolfram concentrates. The net profit was £3,537. Owing to the fall in the price of tin from £278 per ton in 1927 to £226 in 1928 it has not been possible to maintain the dividends, the payment of which started with the results for 1927. The ore reserves above the 5th level are calculated at 148,000 tons. Since the end of the year under review development on the 6th level has been started and already 54,000 tons have been added to the reserve from that source.

West African Diamond Syndicate.—This company, which was formed in 1923 to take over the alluvial diamond properties in Gold Coast Colony from Akim, Ltd., now issues its report for the eighteen months ended March 31. During this period 163,350 carats of diamonds were recovered at a profit of £34,330. Working costs have been

considerably reduced, and additions and improvements to plant are being introduced. Before dividends can be declared the directors consider it advisable to write off some of the expenditure on prospecting and development, which had previously been added to leases account. It is therefore proposed to write off 5s. on each £1 share on the capital of £403,000, and to divide each 15s. share thus formed into three of 5s. each. Sanction of the Court for this reduction of capital will be sought after the Long Vacation, and when this has been obtained it will be possible to distribute a dividend at the rate of 5%.

Minerals Separation.—The report for the year 1928 deals only with the results obtained by leading users of the flotation process and does not mention the company's investments in Rhodesian mining properties. The profit for the year was £58,599, as compared with £34,122 the year before. A final dividend of 20% is now paid, making 25% for the year, absorbing £50,000. In Spain 71,112 tons of mineral concentrates were produced by the company's flotation process, as against 49,152 tons the year before, and 245,927 tons of cleaned coal, as compared with 201,107 tons the year before. The large-scale plant installed by the Union Minière has been still further extended and 593,888 tons of ore was treated, as against 119,035 tons in 1927. The Andes Copper Co. treated 3,849,339 tons of ore, as against 1,728,541 tons the year before, and the Braden Copper Co. has renewed its contract for a further three years. The directors express their confidence that the copper ores now being developed in Northern Rhodesia will be amenable to their methods, the sulphide ores to the flotation process and the oxidized ores to the copper segregation process, which is owned by the subsidiary, Metals Production, Ltd.

DIVIDENDS DECLARED

Apex.—4½d., less tax, payable August 9.
Aramayo.—5%, less tax, payable August 1.
Broken Hill South.—1s. 6d., less tax, payable August 23.
Burma Corporation.—9 annas, free of tax, payable August 15.
Cam and Motor.—2s. 6d., less tax.
Consolidated African Selection Trust.—2s. 3d., less tax, payable August 3.
De Beers.—Deferred and Preference, 10s., less tax, payable August 1.
Frontino and Bolivia.—Pref., 1s., less tax, payable July 1.
Gopeng.—9d., less tax, payable July 6.
Idris.—3d., less tax, payable June 29.
Jelapang.—6d., less tax, payable June 29.
Johannesburg Consolidated Investment.—1s. 6d., free of tax, payable September 12.
Kramat Pulai.—6d., less tax, payable June 11.
Kundang.—6d., less tax, payable June 29.
Lahat.—6d., less tax, payable July 5.
Messina.—1s., less tax, payable July 4.
Minerals Separation.—4s., less tax, payable July 1.
New Consort.—1s. 6d., less tax.
New Era.—3d., less tax, payable August 8.
Onverwacht Platinum.—3d., less tax, payable August 1.
Pari.—3d., less tax, payable June 27.
Pengkalen.—Pref. and Ord., 3d., less tax, payable July 25.
Rand Mines.—2s. 6d., less tax, payable August 8.
Rand Selection Corporation.—9d., less tax, payable August 7.
Rezende.—2s. 6d., less tax.
San Francisco Mines of Mexico.—1s. 6d., less tax, payable July 10.
Santa Gertrudis.—1s. 6d., less tax, payable July 10.
Sherwood Starr.—6d., less tax.
South Kalgurli.—1s. 6d., less tax, payable July 31.
Sungei Besi.—1½d., less tax, payable June 26.
Sungei Way.—5%, less tax, payable June 28.
Tronoh.—4½d., less tax, payable June 28.
West End Diamonds.—6d., less tax.
Willoughby Consolidated.—6d., less tax, payable July 27.

NEW COMPANIES REGISTERED

Ancona Sulphur, Ltd.—Registered June 28. Capital: £100,000 in 5s. shares. Objects: To acquire mining or mineral properties; adopt agreements (1) with R. W. Sutton, W. E. Langton, and E. J. Lake and (2) with J. Thame. Offices: 639-643, Salisbury House, London Wall, E.C. 2.

British-American Tin Corporation, Ltd.—Registered June 14. Capital: £1,000,000 in £1 shares. Objects: To operate in metallic tin and other metals, metallic and other ores, minerals and mineral substances, to carry on any metallurgical business, to acquire any concessions, mining rights, or any lands containing tin, precious stones, gold, silver, lead, wolfram, copper, iron, oil, or other valuable products, and to carry on the business of explorers, financiers, promoters, etc. Subscribers: Sir Hugo Cunliffe-Owen, Lord Brabourne, O. V. G. Hoare, Sir John Mullens, Caracoles Tin Company of Bolivia, Senor Carlos V. Aramayo, Mr. Hugh Micklem, Mr. John Howeson. First directors to be appointed by subscribers. Office: 101, Salisbury House, London Wall, E.C. 2.

Janjevo Mines, Ltd.—Registered June 14. Capital: £100,000 in 5s. shares. Objects: To adopt an agreement with David Soskice and the Selection Trust, Ltd., etc. Directors: A. C. Beatty, Lieut.-Col. Ralph Micklem, D. Sokolow. Offices: Selection Trust Building, Mason's Avenue, E.C. 2.

Monarch (Rhodesia) Asbestos Co., Ltd.—Registered June 27. Capital: £150,000 in 5s. shares. Objects: To acquire certain mineral and other property and rights of working in respect thereof in the Mashaba District of Southern Rhodesia; adopt agreement with Colonial Properties Syndicate for the acquisition of the above-mentioned mineral properties, etc. Directors: H. D. Lorimer, Sir Charles Delme-Radcliffe, T. G. Trevor, T. W. Hanmer. Offices: 36, Basinghall Street, E.C. 2.

P. M. G. Metal Trust, Ltd.—Registered June 8. Capital: £10,000 in £1 shares. Objects: To enter into an agreement for the purchase of the exclusive foreign rights in connection with an invention relating to copper alloys and to carry on the business of ironmasters, engineers, etc. Directors: Udo de Berker, W. Machin, W. B. O. Goudielock, and Sir Frank Nelson.

Russo-Asiatic Consolidated, Ltd.—Registered June 28. Capital: £100 in 800 shares of 2s. 6d. each. Objects: To adopt agreement with Russo-Asiatic Consolidated and J. P. B. Webster, liquidator, for acquisition of the whole of the Russian undertaking of that company. Offices: Adelaide House, King William Street, E.C. 2.