The Mining Magazine

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

PUBLISHED on the 15th of each month by MINING PUBLICATIONS, LIMITED, AT SALISBURY HOUSE, LONDON, E.C. 2.

Telephone: *Metropolitan* 8938. Telegraphic Address: *Oligoclase.* Codes: *McNeill,* both Editions, *& Bentley.*

BRANCH OFFICES { New York: Amer. Inst. M. & M.E. Chicago: 360, N. Michigan Blvd. San Francisco: 681, Market.

SUBSCRIPTION { 12s. per annum, including postage. U.S.A., $3 per annum, including postage.

Vol. XLV. No. 2. LONDON, AUGUST, 1931. PRICE ONE SHILLING

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EDITORIAL

IN view of the generally adverse economic conditions throughout the world, the committee on organization of the 16th International Geological Congress has decided to postpone the meeting of the congress until June, 1933.

THE Summer General Meeting of the Institution of Mining Engineers, postponed from July 8, will now be held from September 23 to September 25, in Manchester, the programme originally outlined and circulated to members being adhered to.

IN his report[1] for 1930 the Director of the Geological Survey of Great Britain reveals that further experimental work has been carried out in geophysical prospecting. This includes surveys in Scotland and Leicestershire respectively with a vertical magnetometer and a new type of small Eötvos torsion balance, details of which are to be published later.

THE eighteenth volume of "The Mines Handbook"[2] makes its appearance this month, the previous volume having been published in 1926. This compendium of information of the mining industry of the American continent first appeared in 1900 as the "Copper Handbook" and it has now so grown in size as to be issued in two parts, the first and by far the larger covering all the companies operating in the United States and its dependencies and the second Canada, Mexico, and Central and South America.

DELEGATES from the United States, France, Belgium, and Germany attended the International Safety in Mines Conference held at the Buxton Research Station from July 11 to July 17. The meeting originated as the result of the visit to this country of Mr. G. S. Rice, the Chief Mining Engineer of the U.S. Bureau of Mines, in 1923. Discussions were confined to the subjects of explosives and explosions. As a result of the friendships and alliances formed, however, closer association in all matters affecting safety in coal mining may be expected to follow.

FIGURES which are now available show that the mineral output of British Columbia reached a new high level for 1930, although the value of the production at $55,391,993 was 18·8% less than for the previous year, consequent on the fall in silver and base-metal prices. Increased quantities of gold, silver, lead, and zinc and a decreased amount of copper were recovered. The gold output of the Dominion during 1930 at 2,102,068 fine ounces also established a record and definitely places Canada in the position of being the world's second largest producer of the precious metal.

ISSUED as a supplement to the F.M.S. Government Gazette of June 5, 1931, the report of the administration of the Mines Department and on the mining industries of Malaya for 1930 pays tribute to the stern fight put up and the philosophic spirit displayed by the Chinese mine owner and his employees in face of the fall in the price of tin to a level below which it was not generally believed he could continue to operate. The output from European-owned mines in 1929 and 1930 was greater than from the Chinese-owned properties. In this connexion interesting figures are published of the percentage output by different methods as follows:—By dredging, 38%; by gravel pumping, 43%; by hydraulicking, 7%; by open-cast working, 4%; by lode mining, 5%; by dulang washers, 2%, and by other methods, 1%.

THE recently-awarded bounty of one pound per ounce on all gold mined in Australia in excess of the average production of the past three years is to be reduced to ten shillings as part of the Commonwealth Government's scheme for economy in public expenditure and the right is reserved of

[1] Summary of Progress of the Geological Survey of Great Britain, 1930, Part I. Price 2s. London: H.M. Stationery Office.

[2] "The Mines Handbook," Volume XVIII. Parts I and II. Cloth, octavo, 2,870 pages. Price $25, or £5 5s. New York: Mines Information Bureau; London: The Technical Bookshop, 724, Salisbury House, E.C. 2.

again reducing the bounty if the exchange rate shows a further increase. This, it has been pointed out, is not such a hardship on the gold producers as it appears at first sight, in view of the advantage which they now possess in the rate of exchange. Thus the bounty as now fixed, allowing for the exchange, is practically the same as originally proposed and is equal to a reduction of one shilling on every rise of three per cent. in the exchange. The producers have been promised that any backward movement of the exchange will be met by a corresponding increase in the bounty, which would give them the full 20s. again should the exchange become normal. The gold producers will be further assisted as a result of an agreement which has been reached with the labour organizations whereby the miners will not, as heretofore, take their fortnight's leave together. In the past this custom of simultaneous holidays during Christmas and the New Year has necessitated the closing of the mines and the shutting down of plant.

The Rand Gold

The functions of the geologist on a mining field are somewhat sharply defined and mining men are generally ready to admit that his work is both necessary and useful. Nevertheless it is often difficult for the practical man to appreciate the heated controversies which arise over questions which to him are of a purely academic character. It should be remembered, of course, that such disputes are merely the outcome of a search for truth and once the truth is discovered the quarrel dies and useful work is able to begin from a new position. From such a standpoint the detached observer is able to view the controversy with equanimity, for it is always possible to make use of new facts brought forward by the protagonists of opposing theories, and there is no doubt that many points of value to those responsible for the development of the Witwatersrand goldfield have been brought out by the arguments advanced by the supporters of the various theories which have been put forward to explain the origin of the gold on this field.

The publication in May, 1930, of a paper by Professor L. C. Graton, of Harvard University, on the origin of the Rand gold revived a controversy which has been in existence for many years. The subject was reviewed at some length in the MAGAZINE for July of last year, when the principles of the main theories which are at present held as to the origin of the gold in Rand " banket " were outlined. It was there stated that of the three main theories, so well summarized by de Launay in 1903 and which are known as the placer, the precipitation, and the infiltration theories, only the first and the last are now widely held, and, further, in South Africa at least, it is certain that the preponderance of opinion is in favour of what might be termed a modified placer theory. It was thus evident that the publication of Professor Graton's paper, which supported a hydrothermal origin for the gold and which therefore upheld the infiltrationists, was bound to create considerable interest and during the past year many well-known geologists have discussed his paper, either at meetings of or in written contributions to the Geological Society of South Africa. The excuse for further reference to the matter here is furnished by the publication of an important contribution to the discussion by Dr. E. T. Mellor, whose work on the Witwatersrand System is so well known and whose theory of some sort of deltaic site for the deposition of the system has been widely supported, especially after proving so useful in interpreting the peculiarities of distribution of the Main Reef Leader on the Far East Rand.

Professor Graton's paper contained numerous references to Dr. Mellor's work and his emphatic statements to the effect that he could see no reason to refute the dominant philosophy of ore-deposition—which, of course, involves a magmatic origin for all primary ore-bodies—and that he could only accept a hydrothermal hypothesis in the case of the Rand gold was bound to lead to an equally emphatic reply at some future period. Reviewing the contributions of both these authorities it must be admitted that there were many statements in Professor Graton's paper which seemed to indicate that he held a theory before examining the facts and that in consequence all facts were examined and correlated in the light of preconceived views, so that his conclusions could only be accepted after a careful examination of his reasoning. Such an examination leads one to feel that the new explanations are at least as difficult to accept as were the old, and it would seem that there is much yet to be explained before either theory can be held to be proved. Nevertheless, the weight

of the evidence appears to be in favour of a secondary origin for the gold and the enormous extent of the deposits undoubtedly supports Dr. Mellor's theory of a deltaic or similar origin. In addition, the almost general acceptance of the placer theory by those most familiar with the conglomerate reefs suggests that practical evidence is rather in favour of this theory than that of infiltration.

Trade and Finance

The feeling that something is drastically wrong with world affairs which has been generally experienced for some time is now being openly expressed and in many places it has been acknowledged that a state of emergency, if it does not already exist, is at least imminent. In consequence much thought is being given to necessary reconstructions of the world's financial edifice and a degree of clarity is given to the position, at any rate as far as it concerns this country, by the publication of the Report of the Committee on Finance and Industry,[1] of which Lord Macmillan was the chairman. The Macmillan Committee —to give it its short title—was set up in November, 1929, partly in response to criticisms of the monetary policy of this country and partly to meet allegations that adequate assistance to depressed industries had not been forthcoming from the banks. In addition, some explanation was required for the far-reaching effect of financial speculations in any one particular country. The committee's terms of reference were to inquire into banking, finance, and credit and to make recommendations calculated to enable these agents to promote the development of trade and commerce and the employment of labour. Its report is divided into two parts, the first being historical and descriptive and the second containing its conclusions and recommendations, while there are, in addition, various addenda and reservations. The principal conclusions arrived at are: (1) Adherence to an international gold standard should be continued; (2) a rise in commodity prices towards the 1928 level is to be recommended, central banks to work for stability of price level; (3) the currency of this country should be a managed system, the managing authority being the Bank of England; (4) the Bank of England should be empowered to increase its normal note circulation in order to give additional temporary elasticity and should by law not be permitted to allow its gold reserve to fall below £75,000,000, except temporarily by permission of the Treasury; (5) arrangements between the joint-stock banks and the central bank should be modified in such a way as will provide for the maintenance of cheap credit, and (6) further development of financial organization should be aided by the setting up of institutions to act as financial advisers to industrial companies.

The main conclusions of the report which principally concern us here are those which urge that a restoration of world price levels is urgently needed and wherein price stability on an international basis is suggested. It is proposed that the central banks of the world should adopt the objective of raising prices in order to prevent stabilization at present levels, which, the report submits, would be disastrous for all countries. When prices become appropriate to existing wages and salaries it is recommended that the monetary policy should endeavour to keep those prices stable, this being the principal reason for suggesting the placing of the monetary system of this country under control. It is recognized that, however desirable these objectives may be, they are not easy of achievement and can only be reached by international agreement.

Further attention should, perhaps, be given to the recommendation of the committee that adherence to an international gold standard at existing parity is to be desired, especially as it has been recognized that an insufficiency of gold will undoubtedly occur in the future, when a fall in prices is inevitable. Nevertheless, it is considered that, given international good will and understanding, dangers threatening price levels from this source are so remote that consideration of this side of the problem may be postponed. The insistence on the fact that the gold standard must be allowed to function freely is sufficient recognition of the part that maldistribution of the world's gold has played in creating the present depression and herein lies the cause of the restiveness manifested in many quarters by a demand either for a new standard of values or for the rehabilitation of silver by a return to

[1] Report of the Committee on Finance and Industry, June, 1931. Price 5s. London: H.M. Stationery Office.

a bi-metal standard. The main difficulty which lies in the way of fixing the gold-silver price ratio has recently been expressed as the impossibility of relating three movable and moving objects, for it is clear that, while goods may be quoted in terms of gold or of silver, the ratio of gold to silver will vary with the separate quotations. Nevertheless, it is the opinion of many people that this problem might well be evaded at the present juncture by the establishment of an international price ratio for the two metals.

Fifty Years of Chemical Engineering

The jubilee celebrations of the Society of Chemical Industry were held in London last month. While the field covered by the society is now all-embracing, it should not be forgotten that the branch of technology which has come to be known as chemical engineering has its roots deeply implanted in the ancient art of metallurgy. The metallurgist it was who first grappled with the problem of applying the processes of pure chemistry to industrial usage and from the industries of copper, lead, and zinc extraction—some of the oldest in this country—sprang a multitude of ancillary industries which formed a nucleus of the great chemical industry as we know it to-day. Important as are the great dye-stuffs, alkali, and other non-metallurgical industries in the world, the industrial chemist has a three-fold debt to the metallurgist, who developed first a technique, then a generation of chemical engineers, and finally produced metals and their alloys of a purity and strength which alone have made possible the implements and equipment at the disposal of the industry to-day.

Appropriately enough the celebrations opened in the Guildhall, where the society signified its appreciation of the valuable support its members had received from the Corporation and Livery Companies of the City of London by presenting suitable memorial plaques and addresses to each of the bodies concerned, particular attention being paid to the princely donations made to the City and Guilds Engineering College, the present immediate neighbour of the Royal School of Mines. This interesting function was followed by the presidential address of Sir Harry McGowan, than whom no one is better qualified to speak of the close association of chemistry and industry, holding as he does the position of chairman of the greatest chemical combine the world has ever known. Of the various sub-sections into which the general meeting subsequently broke that held under the auspices of the Fuel Committee is of chief interest to mining men. Here the discussions centred round the question of producing oil from coal, with a view to rendering this country independent of foreign supplies of a fuel which is displacing coal more and more every day. From these it appeared, as it has in previous discussions, that hydrogenation, in the light of present knowledge, provided the most promising future, especially in its application to the products of low-temperature carbonization. Dr. Dunstan, the chief chemist of the Anglo-Persian Oil Company, in dealing with another important subject, attributed over-production of oil to increased technical efficiency, which brings unemployment in its trail. This, unfortunately, is equally true of the metal industries, where reduction of mining costs, improvements in recovery, and similar advances have brought us a toll which is now hard to pay. This, however, may be regarded as but a limited view, for corresponding advances in other industrial spheres have been taking place which unfortunately have failed to maintain that level of consumption which might have helped to preserve the balance.

Any reference to this commemoration would be incomplete that omitted to mention the Chemical Plant Exhibition, which was held concurrently and which proved to be one of the most interesting of its kind that can be remembered. Some attention is paid to the individual exhibitors elsewhere in this issue, so that reference here will be confined to the research section. This was organized by the Chemical Engineering Group and consisted of a remarkably comprehensive display to illustrate the service rendered by the various research organizations, chief among which should be mentioned the National Physical Laboratory, the British Non-Ferrous Metals Research Association—of which more detailed mention was made here last month—and the Fuel Research Station. Specimens and apparatus testified visually and their guardians eloquently to the great benefit that persistent technical research confers on humanity.

REVIEW OF MINING

Introduction.—Conditions during the past month can hardly be said to have improved, a lack of confidence being evident in nearly all commodity markets. Prices of metals have been generally disappointing. Whilst the position of tin may be regarded as better than a month ago, copper has shown marked weakness, the price on August 11 of £32 6s. 3d. being the lowest recorded. As to zinc, the position has been somewhat strengthened by the renewal of the cartel, as stated in the Metal Markets report.

Transvaal.—The output of gold on the Rand for July was 872,198 oz. and in outside districts 44,645 oz., making a total of 916,843 oz., as compared with 897,750 oz. in June. The number of natives employed in the gold mines at the end of the month totalled 208,155, as compared with 207,209 at the end of June.

Reference was made here last month to the striking of the Randfontein leader in the No. 2 north shaft of Randfontein Estates. Further advice has now been received to the effect that the West Reef was intersected in the same shaft at a depth of 4,536 ft., assays at this point showing 6 dwt. of gold over a width of 41 in., the reef dip being 27°. At the other extreme of the Rand field the Daggafontein company announce that the reef has been encountered in No. 3 shaft at a depth of 3,880 ft., the average value at this point being 26·48 dwt. over 10·17 in.

At a special meeting of the Marievale Nigel Gold Mines and Estate, to be held in September, a resolution will be moved to confirm a provisional agreement which has been concluded with the Union Corporation in connexion with the disposal of the company's property. The Marievale Nigel ground adjoins the farm Vlakfontein No. 21, in the Heidelberg district, which is already being examined by the Union Corporation, and the proposed agreement gives them the right to prospect the area and the option, until June 30, 1935, to purchase it.

Towards the middle of last month it was announced by the Minister of Mines in the Union Government that it was not proposed to act on the interim report of the Low Grade Ore Commission, the intention being to await the final report.

The departure of Mr. Alfred James for South Africa was mentioned in the MAGAZINE for October last and it has now been announced that he is instituting legal action against various Rand companies in connexion with the use of certain patent processes of gold extraction, the rights of which are stated to be held by him.

Shareholders of the Wolhuter Gold Mines have been advised that the balance of that company's assets has now been realized and it is expected that the first and final liquidation distribution will amount to about 1s. 11d. per share.

Diamonds.—The head office of the Premier mine is being transferred to Kimberley and it is stated that this town will become the centre of a group system of diamond houses similarly organized to the gold mine groups in Johannesburg. The controlling board is to be increased from 12 to 16 members in consequence of the De Beers' larger interests.

Southern Rhodesia.—The output of gold from Southern Rhodesia during June was 44,118 oz., as compared with 43,731 oz. for the previous month and 45,208 oz. in June, 1930. Other outputs for June were : Silver, 5,647 oz. ; copper, 59 tons ; coal, 51,954 tons ; chrome ore, 3,305 tons ; asbestos, 1,317 tons, and mica, 3 tons.

Northern Rhodesia.—The accounts of Tanganyika Concessions for 1930 show a decrease in profits of £249,289 to £232,866, which, with the balance of £475,951 brought in, gave an available total of £708,817. Of this amount £179,000 was taken for income-tax provision, £50,000 written off share values, and £100,000 transferred to reserve, leaving a balance of £379,817 to be carried forward. The report shows that the output of copper during 1930 by the Union Minière du Haut Katanga was increased to a record total of 138,949 tons, the proved reserves of the metal being estimated at 5,000,000 tons. Other important interests of the company are in the Benguela Railway, just completed, and in the Rhodesia-Katanga company, which is developing the Kansanshi mine, for which a treatment plant capable of producing 50,000 tons of copper per annum is being designed.

The report of the Zambesia Exploration Company, which is a large shareholder in Tanganyika Concessions, shows that during 1930 a profit of £39,167 was made, as compared with £106,502 the previous year.

During 1930 Loangwa Concessions carried on prospecting and geological mapping, diamond drilling being employed when indications warranted, but so far no mineral

deposits of material value have been discovered. Reference is made to good gold assays of quartz float found in the concessions, but the value of the find is not yet known. The British South Africa Company have been appointed consultants to the company, in place of Rhodesian Anglo American.

The third unit of the plant at the Roan Antelope mine was started up on July 25.

Gold Coast.—An interesting feature in the development report of the Ashanti Goldfields for July is the cutting of the Ashanti reef by extension No. 12 cross-cut N.E. from No. 16 level, a width of 5 ft. being revealed, the ore having an average assay value of 5·5 dwt.

Nigeria.—Operations of Juga Valley Tin Areas during the year ended February 28 last were on a very restricted scale, the output having decreased to 153½ tons of tin concentrates. As it was found uneconomical to work the plants they have been closed down, the tin produced being won by tributors. The accounts show a loss of £6,872, increasing the debit balance to £19,143.

The report of the Nigerian Electricity Supply Corporation for the year ended February 28 last shows that electric power was first supplied in June, 1930, the company being in a position to offer a permanent supply of current to the tin mines at the end of October, and the power house has since continued to function satisfactorily. The accounts for the year show a profit of £17,524, a balance of £16,625 being carried forward.

Australia.—The report of the Broken Hill Proprietary Block 14 for the six months ended March 31 last shows that operations at the mine were at a standstill for the period, the price of metals being too low to warrant resumption of operations. The working loss for the six months amounted to £2,821, other expenses making the total net loss £8,244. The credit balance now stands at £11,189. The plant is being kept in good condition with a small staff.

Cabled advices from Melbourne give the profit of the Broken Hill Proprietary company for the year ended May 31 last as £83,257, after providing £232,752 for depreciation and £64,659 for debenture interest. This figure compares with £161,890 in the previous year.

Contract miners employed at Broken Hill by the Zinc Corporation ceased work last month owing to a reduction in prices offered, the management being forced to suspend other underground operations. Up to the time of going to press no news had been received of the settlement of the dispute.

Shareholders of the Boulder Perseverance have been informed that the company proposes to issue £50,000 of 10-year profit-sharing notes in denominations of £5, £50, and £100. Interest will be at the rate of 10% and, in addition, the notes will carry the right to 50% of the profits of the company as from January 1 next. The notes will be repayable on June 30, 1941, at the rate of £120%, but may be redeemed at any time after June, 1936. The proceeds of the issue are to be utilized for the installation of new treatment plant.

A Wiluna Gold Corporation circular states that during July 25,952 tons of ore was treated for bullion valued, with exchange allowance, at £36,700, working costs being £26,241. While the power plant is running more steadily, a restriction of output to 30,000 tons monthly is anticipated to meet a lack of capacity in the grinding section. Mr. C. O. Lindberg has been asked to make a further report on the property.

New Zealand.—Interesting developments on the No. 5 level of the Junction Eastern area of the Waihi Gold Mining Company provide yet another instance of a mine dying hard. A reef averaging 3½ft. in width intersected south of the Martha lode has been driven on for 14 ft., the ore assaying £4 1s. per ton. In addition, driving has been commenced in a north-easterly direction on quartz intersected south of the main shaft. This averages 1 ft. in width and the first 7 ft. was in high-grade sulphide ore.

India.—Working places in the Nundydroog mine had been generally freed from the poisonous gases resulting from the serious fire by the middle of last month and stoping and development have been resumed. Milling was expected to restart by the end of the month.

On the Mysore a serious rockburst occurred on July 22 in the Edgar shaft, three men being reported as missing. Damage to the brickwork of the shaft was reported to be quite extensive and it was estimated that at least three weeks would be required for the completion of repairs.

Malaya.—During the year ended March 31 last Malaysiam Tin treated 539,030 cu. yd. of ground, recovering 262½ tons of tin concentrates, which realized £18,730. The

profit for the year was £2,789 and, after writing off the debit balance brought in, there remained a sum of £32 to be carried forward. At the annual meeting held last month it was agreed that 100,000 of the unissued shares should be called preferred ordinary shares and that the 595,504 issued and the remaining 304,496 unissued shares should be called ordinary shares, the preferred shares to have the right to a fixed preferential dividend of 7% and to participate in any balance of profits. It is proposed shortly to issue the preferred ordinary shares in order to finance the purchase of the Glami property.

At a meeting of shareholders of Siput Tin, held last month, it was decided that the company should go into voluntary liquidation, efforts to raise additional working capital having proved unsuccessful.

The accounts of Teja Malaya Tin Dredging for 1930 show a loss of £8,977, increasing the debit balance to £34,461. The company's claim against the dredgebuilders was settled during the year, the company receiving cash and spare parts to the value of £12,072. The output of the two dredges was 337·47 tons. In a circular accompanying the report shareholders are invited to subscribe to an issue of loan notes carrying interest at 10% per annum and repayable at 105% on or before July 31, 1936, the amount raised to be limited to £30,000, which it is estimated will enable the company to carry on operations and provide for debenture interest.

Korea.—Conflicts between Koreans and Chinese have caused so much damage to the property and stores of the Chosen Corporation that it has been thought prudent to postpone the payment of dividend No. 2 pending further advices. This dividend, 3¾d. per share, was declared in May last and was due to be paid last month.

Panama.—Shareholders of Panama Corporation were informed last month of progress on the various properties. At the Remance broken ore awaiting treatment was restricting work in the mine, but it was expected the complete mill would be running at an early date. Up to July 13, when the statement was issued, the mill had treated 800 tons of ore of an average value of 36s. per ton, the extraction being 92·3%. Cyaniding commenced on June 12 and the precipitation plant on June 17, this running at a reduced capacity pending the installation of a cone-crusher. No proper clean-up had been made at El Mineral, where the work was still in its initial stage. On the Sabalo section 14,000 cu. yd. of ground had been treated in opening up the paddocks, in addition to about 10,000 cu. yd. of overburden, but no clean-up had been made.

Spain.—Shareholders of Tigon Mining and Finance were informed last month that the operations of the treatment plant to date had not proved wholly satisfactory and that further work on the extension had been suspended for the time being. Four furnaces of an improved Gill type have been installed and these have proved so satisfactory that a second four are under construction. On the Chile properties production has been curtailed, stocks having accumulated to an extent which makes this step advisable.

Unrest among miners in the Huelva district, owing to the Rio Tinto company reducing the working week to five days, is giving cause for some anxiety.

Cyprus.—The report of the Cyprus Asbestos Company for 1930 shows a profit of £2·15. After transferring £10,000 to Stock Depreciation Reserve the balance carried forward was reduced to £29,072. During the year 177,161 tons of ore was milled and 7,256 tons of fibre produced, the recovery being 4·1%, as compared with 3·4% the previous year. At a meeting to be held in Cyprus next month it will be proposed that the undertaking should be sold to a new company, called the Cyprus and General Asbestos Company, having a capital of £750,000, divided into 150,000 6% redeemable preference shares of £1 each and 600,000 ordinary shares of £1 each. Shareholders are to be invited to apply for shares in the new company credited as 18s. paid, the balance of 2s. being payable 1s. on allotment and 1s. in December next. It is considered that the alternative to acceptance of reconstruction will be the winding-up of the company.

Consolidated Tin Smelters.—For the nine months to June 30 last the accounts of Consolidated Tin Smelters show a profit of £177,698. A dividend of 5% has been declared, the balance carried forward being £81,513. Curtailment of smelting operations has been met by centralizing operations at certain plants and this procedure will be continued if necessary.

Tin.—After the meeting of the International Tin Committee on July 21 last the following annual quotas for the four participating countries were issued, covering the period June to September: Netherlands East Indies, 25,167 tons; Nigeria, 6,733 tons; Bolivia, 26,827 tons; Malaya, 45,369 tons. With regard to the excess output of Malaya, arrangements have been made to take this off the market for the time being.

THE RUHUHU COALFIELDS, TANGANYIKA TERRITORY

By G. M. STOCKLEY, A.R.C.S., D.I.C., F.G.S., and F. OATES, A.R.S.M., B.Sc.

The authors, both officers of the Tanganyika Geological Survey, give the results of a survey over the coal areas in the Ruhuhu basin and of preliminary tests in outcrop samples.

INTRODUCTION.—Search for coal in East Africa commenced as far back as 1860, when Sultan Seyid Bargash of Zanzibar had the Makaa-Ituli outcrop on the Middle Ruvuma (on the Portuguese border) examined. Loads of coal were brought to Zanzibar by dhows and test experiments were carried out on several of the Sultan's steamers. Hasslacher, a mining engineer who carried out a number of surveys of prospects for the German Government, says that even the erection of a gasworks was under consideration. Since then search for reasonably thick seams of coal has gone on intermittently, now by Government, now by private companies. Both in Kenya and in Tanganyika (then German East Africa) the respective Governments have endeavoured to find a coalfield which would supply their railways, but, so far, without success. All the coal at present used by the Kenya and Uganda railway and the Tanganyika railways is shipped from Natal.

With the exception of the coalfields in Portuguese East Africa and Nyasaland (chiefly the Sumbu and Mt. Waller Coalfields) recent discoveries have all been made in Tanganyika. Coal has been known near Manda as far back as 1890 and Bornhardt carried out an examination in 1895–7 of a small coalfield in that locality, condemning it. He also examined another field to the north of Lake Nyasa, not far from Tukuyu near the Kivira-Songwe Rivers and this proved to be more promising, as seams of economic thickness were found, some 8 metres of coal occurring in several seams, slightly separated from each other by thin shale intercalations. Rumours of coal also came from near Songea, but were not actively followed up. Coal was reported to the German Government from the Lumecha River by John Booth; in German file No. G.2408 [1] a letter from Booth shows that the outcrop is about a day's march north-west of Songea in the Lumecha and Nyaka Rivers. He says he could not give an estimate of the thickness, but "the coal lies so high and free, under a yellowish clay surface soil that considerable quantities could be obtained without great working costs". That was in 1902 and nothing has been done since on that area, which, if any deposit of value had been discovered, would surely have attracted the attention of those locally interested in mining. Attached to that file is a memorandum in which it is stated that a sample of the coal gave an ash percentage of 27·06.

Then, in 1907, the District Officer Songea, while journeying along the Portuguese border, three days' march from Songea, made another discovery of coal, which proved to have an ash content of 25·12% and a calorific value of 4,778 small calories per gram (equivalent to 8,600 B.T.U. per lb.).

Other rumours of coal came from near the Central Railway at Kilosa, but Scholz, the German government geologist, failed to find any. After the war this area was again examined and one of our colleagues, F. B. Wade, found an impure coal seam with a maximum thickness of 42 in. An analysis however, proved it to be more of the nature of a carbonaceous shale than true coal, the ash content being 63%. This area was referred to by Mennell in a paper read last year before the International Geological Congress at Pretoria. Mennell had carried out several examinations for private companies looking for coal in the coastal area, in the hinterland of Mombasa, near Tanga, and along the Rufiji close to the Pangani falls, but apparently without success. In 1921, just prior to Mennell's visit, Dr. E. O. Teale and Mr. F. B. Wade were engaged examining for the Tanganyika Government the various areas of known Karroo rocks within the coastal lowlands with a view to finding workable seams of coal. In the Tanga area promising black carbonaceous shale was found, but no coal. In the Rufiji region a thin streak of coal was found in black shale, but nothing of promising thickness was discovered.

The best known coalfield in Tanganyika occurs on the Ufipa Plateau and was discovered in 1914 by Father Poultier de Montechov of the Chala Mission in the Namwele valley. The German Government

[1] Secretariat. Dar es Salaam.

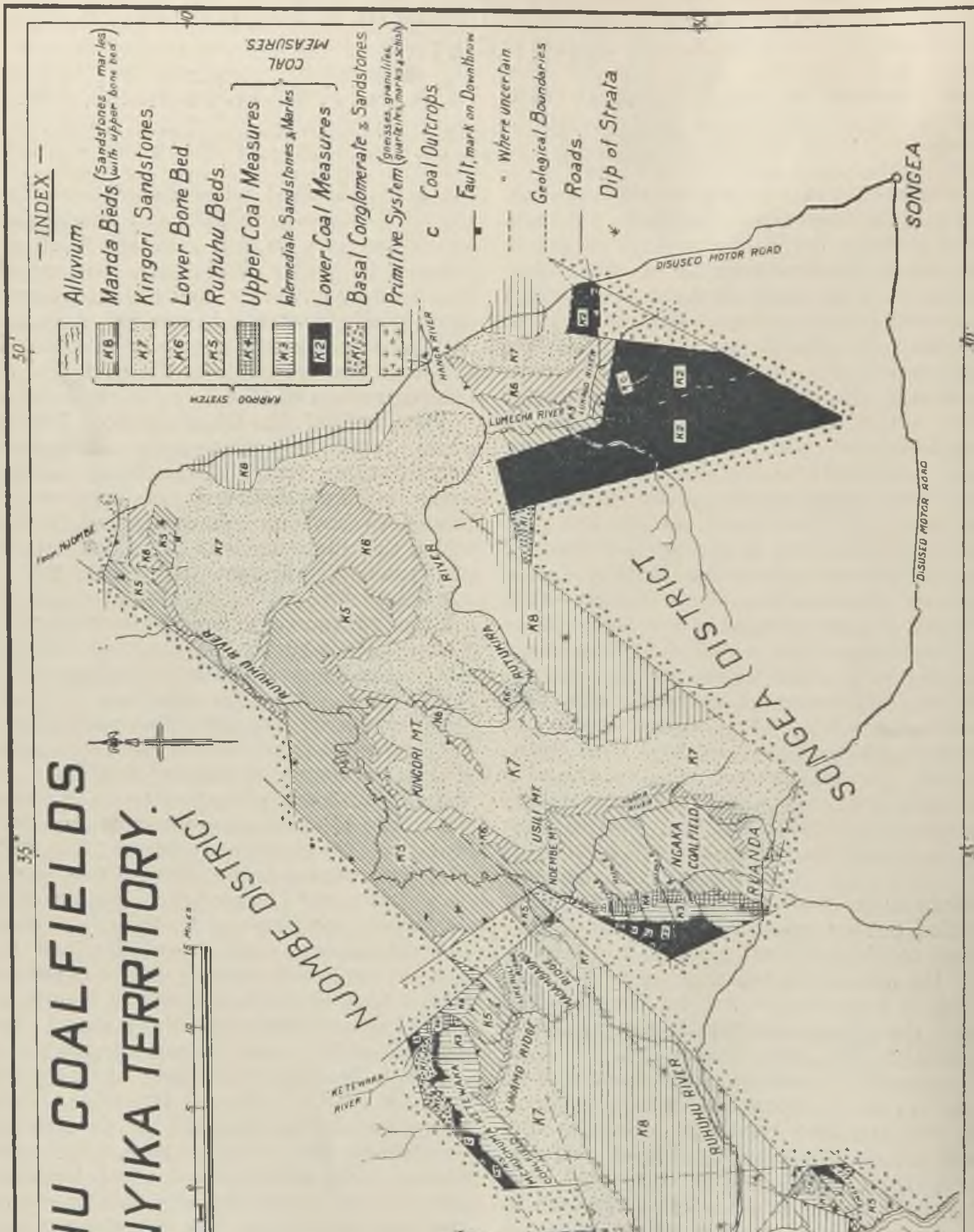

RUHUHU COALFIELDS
TANGANYIKA TERRITORY.
— INDEX —
Alluvium
Manda Beds (Sandstones, marles with upper bone bed)
Kingori Sandstones
Lower Bone Bed
Ruhuhu Beds
Upper Coal Measures
Intermediate Sandstones & Marles
Lower Coal Measures
Basal Conglomerate & Sandstones
Primitive System (gneisses, granulites, quartzites, marbles & schists)
COAL MEASURES
KARROO SYSTEM
c Coal Outcrops
Fault, mark on Downthrow
" Where uncertain
Geological Boundaries
Roads
Dip of Strata
NJOMBE DISTRICT
SONGEA DISTRICT
SONGEA
DISUSED MOTOR ROAD
RUHUHU RIVER
LUMECHA RIVER
RUTUKIRA
KINGORI MT.
USILI MT.
NGAKA COALFIELD
RUANDA
KETEWAKA RIVER
LIVINGSTONE MTS
N. MANDA COALFIELD
MANDA
LAKE NYASA
S. MANDA COALFIELD
MILES

FIG. 1.

sent Dr. Kirschstein to examine the area. It occurs 885 metres above and 80–110 kilometres from Lake Tanganyika and is close to, but above, Lake Rukwa. Several seams of coal are exposed in the Namwele valley and are as follows: (1) Upper seam, flaky and poor quality, 106 cm. thick containing 39 cm. of coal; (2) middle seam, pyritiferous, 262 cm. thick with 160 cm. of coal; (3) lower seams, more massive than the former, thickness 461 cm. with 97 cm. of coal. It was considered a good coking coal and the ash varied from 19 to 28%. Recently the Nyasaland Minerals examined the area extensively and proved the existence of workable coal seams by boring. Market and other conditions however delayed development and work has been suspended.

All these areas are confined to the Karroo formation which is, of course, the principal coal-bearing formation in Africa. Coal has also been found to the west of Kilwa and Lindi in the younger formations near to the coast, but no definite details of thickness or extent have yet been determined.

The latest discovery is that by the Tanganyika Geological Survey of the numerous coalfields in the Ruhuhu basin, south and south-east of the Livingstone Mountains. This region, situated to the east of Lake Nyasa, comprises 1,300 square miles and lies both in the Njombe and Songea districts. Between the lake and the old Njombe-Songea road is an area of Karroo rocks

Fig. 2.—Fault Scarp—Manda Beds faulted against Gneiss—Manda-Songea Road.

Fig. 3.—Part of the 17 ft. Seam, Mkapa River, Ngaka Coalfield.

which has been let down by normal faults between walls of gneiss. These boundary scarps are very imposing in some portions, although in much of the area the walls have been eroded, leaving broken remnants in the form of pyramidal hills. At one point at Ndembe Mountain, the scarp has a precipitous face of 1,500 ft. The country within the depression is not very mountainous, being in the nature of ridges and low erosion scarps, which very seldom attain 500 ft. above the surrounding country. Kingori Mountain, which is situated close to the Ruhuhu-Rutukira confluence and the Lihamo and Likenuli ridges are the chief features in the depression. From Kingori to the east and to the south-west a ridge extends and is fairly prominent and distinct. The general altitude of the country from Lake Nyasa to the Njombe-Songea road rises from about 1,700 ft. to about 2,500 ft. at the Hanga-Rutukira confluence. The country around this confluence rises to about 3,000 ft. at about seven miles both to the south and the north. Thus generally the country is gently rolling broken by a few low scarps. The drainage is towards the lake, the principal river being the Ruhuhu, which is the largest river in the south-western regions of Tanganyika and

may be compared with other better known rivers of the Territory, the Ruvuma and the Ruaha. The Rutukira, the largest tributary, drains the north-eastern portion of the area, while the Ruhuhu River drains the mountainous country to the east of the Livingstone Mountains. Three other large tributaries are the Lumecha River, draining the south-eastern portion, the Ngaka, the south-western mountain region, and the Ketewaka, the Livingstone Mountains to the north of Manda.

FIG. 4.—17 FT. SEAM, MBUYURA RIVER, NGAKA COALFIELD.

GENERAL GEOLOGY.—The general geology of the rocks exposed and the structure of the coalfields had not been previously determined and the Geological Survey was able to make fossil discoveries of sufficient utility to enable a close correlation to be made of these strata with the coalfields and associated rocks of South Africa, Southern Rhodesia, and Nyasaland. The Survey was able to prove the existence of two reptilian bone beds, which with other fossiliferous discoveries show that these rocks may be correlated from the base of the Ecca to the Lower Stormberg. It was possible to divide these rocks into eight distinct divisions. These divisions have been based on lithological differences and on economic and palæontological grounds. An unconformity was proved between the basal beds and the basement gneiss, the lowest bed being a coarse conglomerate containing large boulders of gneiss. The succession is as follows :—

K8	Manda Beds. 440 ft.	Pink felspathic sandstones and marls with one bone bed ; also contains *Unio* spp. and *Rhexoxylon tetrapteridoides*.
K7	Kingori Sandstones. 1,200 ft.	Coarse, current-bedded grits and sandstones conglomeratic in part.
	——— Local disconformity ———	
K6	Lower Bone Bed 300 ft.	Greenish and grey mudstones, limestone nodules and sandstones, with reptilian bones and fossil wood and trees (*Dadoxylon*).
	——— Local disconformity ———	
K5	Ruhuhu Beds. 700–1,000 ft.	Fine-grained greenish sandstones and silt-stones, mudstones and shales calcareous throughout, with magnesian limestone beds and nodules ; occasional fossil wood (*Dadoxylon*) ; contains *Palæomutela keyserlingi* and *Glossopteris* fragments in the upper beds.
K4	Upper Coal Measures. 335 ft.	Grey clay-shales with coal seams ironstones and sandstones.
K3	Intermediate. Marls and Sandstones. 450 ft.	Coarse gritty sandstones and marls ; greenish or reddish, and usually one limestone stratum.
K2	Lower Coal Measures. 450 ft.	Gritty sandstones with coal seams, carbonaceous shales and ironstones.
K1	Basal Sandstones and Conglomerate. 1,690 ft.	The passage bed is a characteristic indurated splintery shale.

Total thickness 5,865 ft.

Very nearly all the best coal seams are confined to the Lower Coal Measures.

From a report on the reptilian bone fragments from Dr. S. Haughton of the South African Geological Survey the Lower Bone Bed is of Beaufort age ; the *Rhexoxylon tetrapteridoides* [1] in the Manda Beds indicates a Molteno age (Lower Stormberg) and the *Unios* [2] are known only from the Trias, which therefore indicates an age from the Middle Beaufort to the top of the Molteno Beds. It is therefore certain that the Manda Beds can be correlated with the Chiweta Grits of Nyasaland which are of Molteno age ; the Kingori Sandstones and the Lower Bone Bed are included in the Beaufort; the remainder, down to the base of the Basal Sandstones and Conglomerates, are correlated

[1] Identified by J. Walton, of Glasgow University.
[2] Identified by L. R. Cox, of the British Museum (Nat. Hist.).

with the Ecca. This corresponds exactly with the Southern Rhodesia Series from the Escarpment Grits down to the Lower Wankie Sandstones. The rest of the Upper Karroo in Tanganyika is found in the Kigoma area, north-east of Lake Tanganyika, where both Dr. E. O. Teale, Director of the Geological Survey, and P. Fourmarier have shown that there are strata described as Red Beds and overlying lavas believed to belong to the Karroo Period. These strata may be Jurassic. This probability of a continuous series in the Karroo extending into Middle Mesozoic corresponds with the long range of the Gondwana System of India, which includes rocks from the Upper Carboniferous to the Jurassic. There is, however, a suggestion that there is an overlap of Jurassic marine sediments on to the Karroo in the coastal area, since no continuous series has been proved. In the uppermost portion of the Tanga Series there is a great thickness of sandstones which probably belong to the uppermost Karroo, and Jurassic beds are apparently faulted against them.

Tectonics.—The general tectonics of the area are closely connected with the earliest Rift movements and appear to be prior to the Nyasan faulting. The main directions vary from N.E., N.N.E., through N., to

Fig. 5.—The Burning Coal Seam, Mhumbi, Ketewaka-Mchuchuma Coalfield.

Fig. 6.—The 5 ft. Seam, Mtambalala River, South Manda Coalfield.

N.N.W.; they are chiefly represented by straight lines; consequently the map (Fig. 1) appears like a jig-saw puzzle. The west faults are older, the north-west and northerly faults are younger. The whole of the area is almost surrounded by these straight-lined faults with large downthrows. One fault has a downthrow of at least 10,000 ft. The faulting [1] is normal and vertical and is due to the sinking of blocks of strata, the relative displacement of which is irregular. Vertical walls of gneiss were observed with Karroo rocks abutting against them; this is illustrated in the photograph (Fig. 2) where a waterfall tumbles over a wall of gneiss some 50 ft. high and the Manda Beds are seen outcropping at the base of the wall, dipping downstream. They also outcrop on the fault face, although they are not very distinctly seen, behind the trees. Dragging of strata down the fault face was observed; in some cases the drag has been downwards and the dip is away from the fault face of the gneiss. In other cases the beds have been pulled down in the direction of dip and down the fault plane. In all the innumerable sections of the Karroo rocks observed in the rivers and streams close to the fault not one instance of folding was observed. All the faults are normal and the tectonics therefore support the view of tensional strain in the

[1] Vide Figs. 7–11.

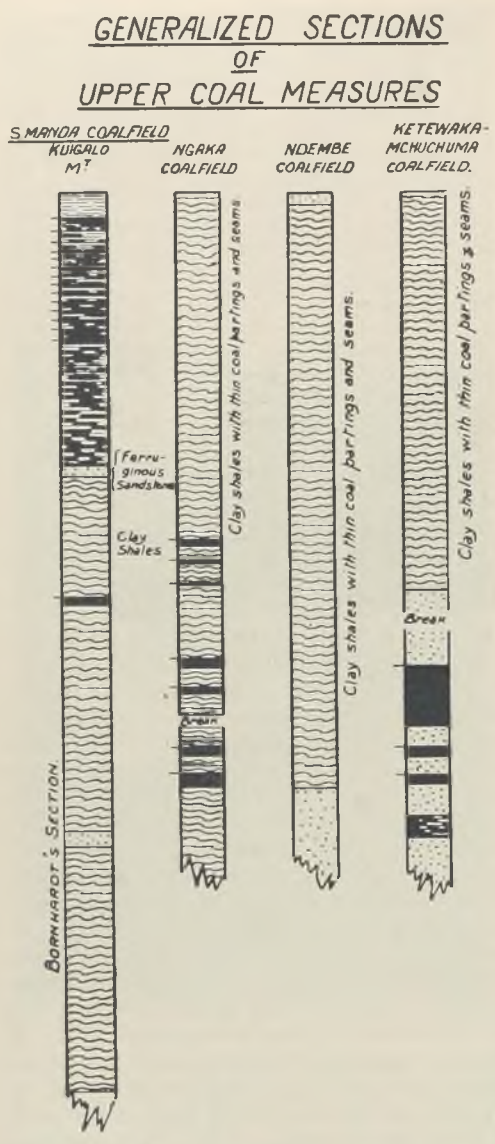


FIG. 7.

rocks of this region to account for the dislocation of the blocks. In the Rufiji area, 240 miles to the north-east of the Ruhuhu coalfields and possibly an extension of them, overfolding has been observed. For instance Mennell asserts "Upstream the chief features of interest are the faults and thrusts and the sandstone 'dykes'." Dr. E. Parsons also reports thrusts in the hinterland of Mombasa, the Kenya south-eastern coastal area. The sandstone dykes of the Rufiji point to tensional movement, which apparently followed the compressional movement. It is apparent that a great deal of the compressional phenomena so observed may be explained as local overturning consequent on the wedging of sediments after block faulting.

It is unlikely that any orogenic movement can have affected the Karroo rocks, for no evidence of compressional movement local or otherwise was noted. The hypothesis that forces at depth have resulted in a vertical upthrust movement is consistent with the features observed in this region. Upward movement is necessary to provide the conditions of real or apparent sinking of the blocks and normal faulting is characteristic of many of the Karroo areas in East Central Africa. It appears therefore that differential movements, which have affected the Karroo rocks and resulted in block displacement in this region, induced tensional results in that portion of the upper crust composed here of Karroo sediments.

HISTORICAL GEOLOGY.—The sequence of events is as follows :—

(*a*) Peneplanation ;
(*b*) warping and sedimentation ;
(*c*) uplift and erosion ;
(*d*) rift valley faulting, and
(*e*) recent erosion.

The topography to the north and south of the depression shows that previous to the deposition of the Karroo the ancient topography was flat and was subsequently warped down, forming a shallow depression in which the Karroo lacustrine sediments were deposited. Deposition commenced in Upper Carboniferous times and continued to the Upper Trias. Around this lake and in the shallow waters reptiles abounded and the picture suggests a large, somewhat shallow, lake, with tall reeds and horsetails and bordered by forests. The carbonized remains exhibited in much of the coal indicate a flora of the reed type, but as fossil trees and fragments of fossilized trees are found in various horizons of the overlying sediments it is probable that drift material helped in the formation of the coal. Dr. Cyril Fox (Vol. lviii, *Geol. Survey of India*, 1931, "The Gondwana System and Related Formations," p. 14) considers that a damp to wet temperate climate was best suited to the Glossopteris flora.

Subsequently to the accumulation of coal, conditions of lake sedimentation were continued, with alternations in the deposition

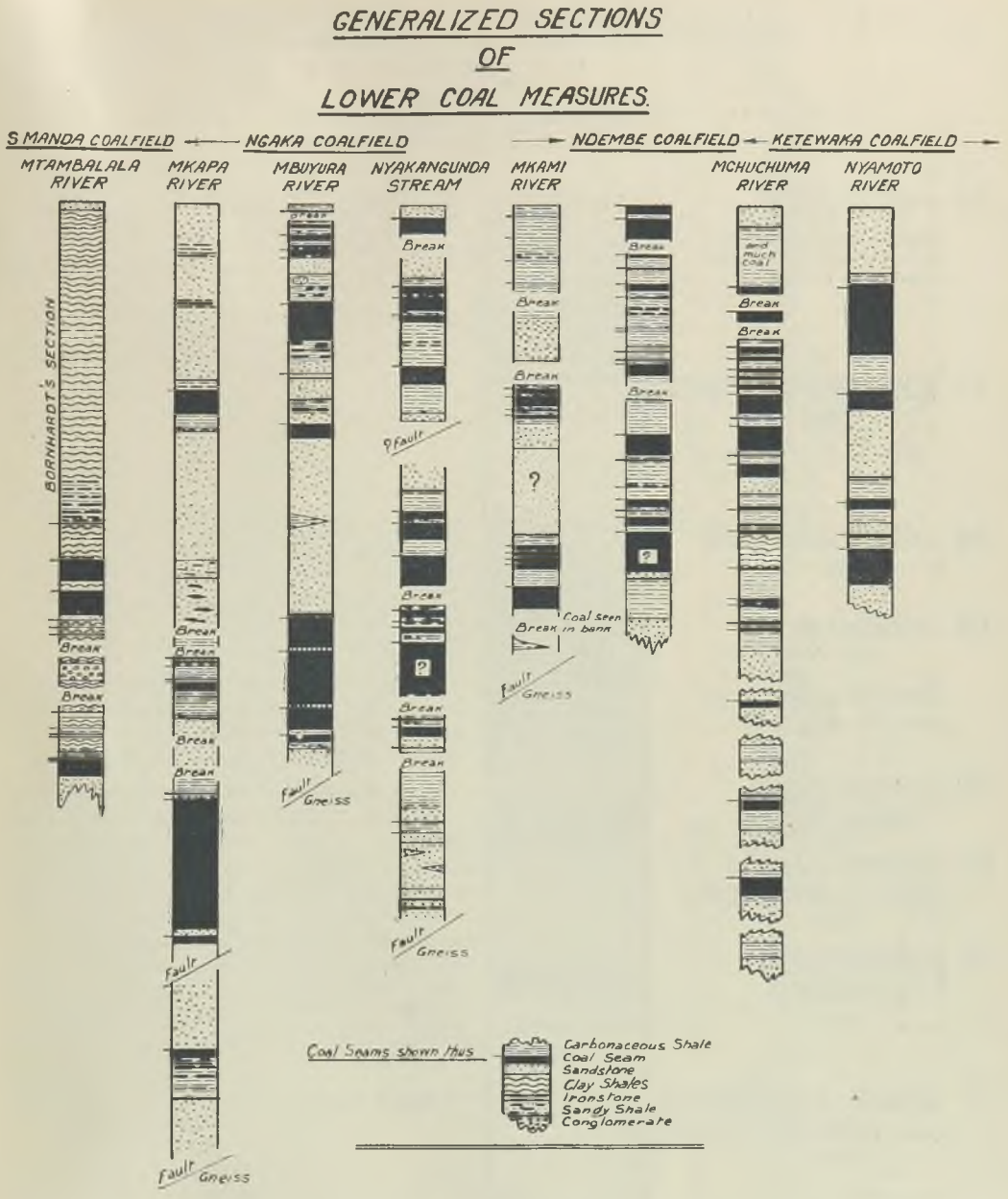
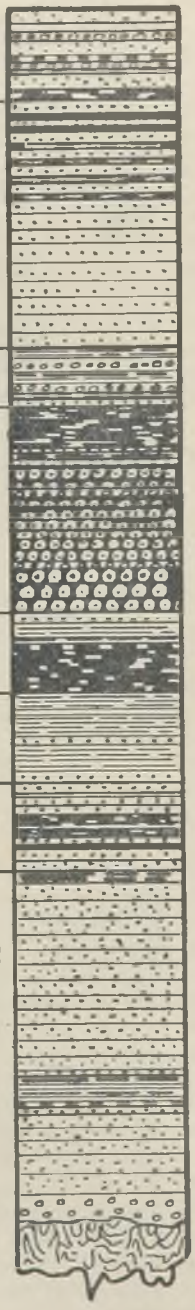


FIG. 8.

of arenaceous and argillaceous material and the only unique feature was the accumulation of a considerable number of fragments of reptilian bones. Conditions of coal formation were not again repeated for any long period, but in the Upper Ruhuhu Beds small films of coal are found suggesting a very brief interlude of vegetable deposition. Towards the end of the Karroo period the whole of the area was uplifted, the waters of the lake completely drained away and the vast accumulation of sediments was subjected to erosion. Everything points to there having been a much wider distribution of these rocks. Tensional strains at the earth's surface, due in all probability to the gradual and continued uplift since late Karroo times onwards, resulted in the fracturing

DIAGRAMMATIC SECTION OF KARROO BEDS



K8 MANDA BEDS
440'
Marles and Sandstones, alternate-pink to purple prevailing colour

Felspathic, red-purplish sandstones
Calcareous concretions in purple-purple green marls.
Upper Bone Bed, with calcareous concreations.

Coarse gritty sandstones, prevailing colour pink and purple conglomeratic in part with reddish shale intercalations.

K7 KINGORI SANDSTONES
1200'

K6 LOWER BONE BED
300'

Reptilion Bones and fossil wood and trees (Dadoxylon)
calcareous nodules in mudstones

Glossopteris Horizon fossil wood (Dadoxylon) occasional
Palaeomutela Beds.

K5 RUHUHU BEDS
700' - 1000'

Prevailing colour greenish grey.

Fine grained silrstones with conchoidal fracture and layers of calcereous nodules.
Fossil wood (Dadoxylon) occasional.

K4 UPPER COAL MEASURES
335'

Ironstone — Clay shales - with carbonized plant remains & coal seams.

Coal

K3 INTERMEDIATE MARLS & SANDSTONES
450'

Gritty sandstones and greenish to purple red marles - and one limestone band.

K2 LOWER COAL MEASURES
450'

Greenish sandstones and mudstones
Carbonaceous shales, coal seams and ironstones.
Massive Sandstones with coal seams.
Black splintery shales.

K1 BASAL SANDSTONES AND CONGLOMERATES
1690'

Massive sandstones.

Prevailing colour greenish and yellowish green.

Flags and shales.

Massive sandstones.

TOTAL THICKNESS
5865 FT

Unconformable junction with Gneiss.
Gneisses, Granulites, Marbles, Quartzites and Schists.

FIG. 9.

of the upper crust. The Karroo of the Ruhuhu region, with its 6,000 ft. of accumulated sediment, gradually sank between the major east and west faults. Thus blocks of Karroo sediments were wedged one against the other and against the gneiss. The faulting which continued with the formation of Lake Nyasa changed the drainage from a direct coastal, south-east direction to a south-west and westerly direction towards the lake.

NOTES ON THE COALFIELDS.—In the Ruhuhu Depression seven coalfields have so far been discovered. They are as follows :

(*a*) South Manda coalfield ;
(*b*) Ngaka coalfield ;
(*c*) Ketewaka-Mchuchuma coalfield ;
(*d*) West Ndembe coalfield ;
(*e*) Madambasi outcrop ;
(*f*) North Manda coalfield, and
(*g*) Lumecha coalfield.

The first, as already pointed out, has been known from the last century, existence of the last had been rumoured, but no definite or authentic account was known, the third was re-discovered, and all the others were discovered by the Geological Survey last year. The following notes are given on each field in the order of economic importance.

(*a*) *The Ngaka Coalfield.*—This field is situated to the west of the Ngaka Basin, the dip of the rocks being to the east and the strike north. The dip at the outcrop is 17°, lessening to 11° and 3½°. The Upper Coal Measures are found just below and east of Ndembe Mountain to as far as Ruanda on the Songea-Manda Road. The Lower Coal Measures are found faulted against the gneiss and the succession can be determined easily in a traverse from the gneiss fault on the west to the Ngaka River, the Upper Karroo rocks forming a low ridge west of the river for a great distance. Bones were found below Usili Mountain in the north and just north-east of Ruanda. Coal is found in all the streams that cut through the outcrop of the Coal Measures ; the best exposures are found in the Mkapa, Mbuyura, Nyakangunda, Mkami, Little Mkami and Lutuka Rivers and their tributaries ; it is also found in the alluvium of the Madali River just north of the Songea-Manda road. This proves that the coal seams persist along a strike of fifteen miles. The thickest seams were found in the first four rivers. The type of outcrop is illustrated in the photographs (Figs. 3 and 4) of the 17 ft. and 18 ft. seams

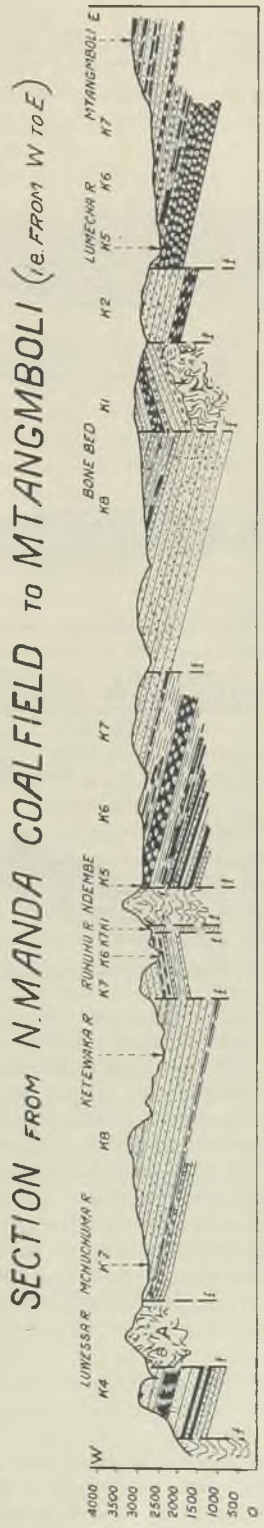


FIG. 10.

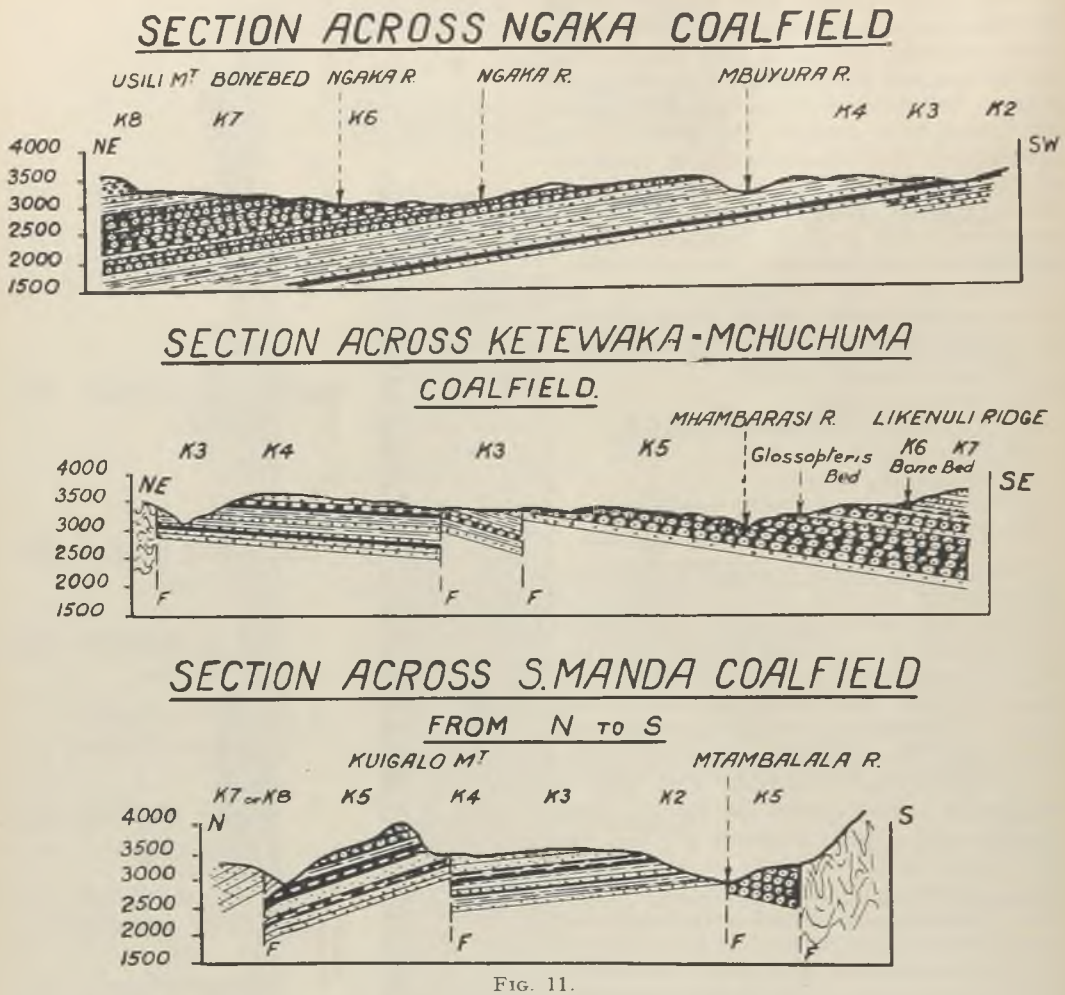


FIG. 11.

in the Mkapa and Mbuyura Rivers. Indications of this seam were seen in the Mkami and Little Mkami Rivers and a total thickness of 28 ft. of coal was found in the Nyakangunda stream. A total of 21 ft. of coal was noted in both the Mkapa and Mbuyura Rivers. The Nyakangunda stream section is the best exposure and indicates the possibilities of the amount of coal in this area; and this is not all, as boring will in all probability prove more coal seams, for there was no indication that the basal rocks were close below.

All these seams occur in the Lower Coal Measures which alone contain seams of economic thickness.

(*b*) *The Ketewaka-Mchuchuma Coalfield.*—This area lies to the north-east of the Ngaka Coalfield and north of the Ruhuhu River. It is bounded by faults on three sides; to the north, to the east, and to the west. The Ketewaka and Mchuchuma Rivers cut right through the coalfield and it is in the Mchuchuma, and the tributaries of the Ketewaka River, that the discoveries were made. In fact, subsequent search through old German files showed that one seam was once considered by a German missionary to be an active volcano. Dr. Kirschstein was commissioned to examine the occurrence and it was proved to be a burning coal seam (Fig. 5) which Kirschstein thought had been started by grass fires. It is quite probable that the oxidation of pyritiferous bands in the coal led to spontaneous combustion. Kirschstein reported 16½ ft. of coal, but the Survey found a total of 18 ft., of which the major seams are 10 and 5 ft. thick.

This coal occurs at Mhumbi, west of the Ketewaka River in the Nya-moto stream (the Swahili word "moto" meaning "fire"). To the east of the Ketewaka River two seams four and nine feet thick were found. A part of the coal was followed in a westerly direction between the Ketewaka and Mchuchuma Rivers where a seam of three feet was found. In the Mchuchuma River much coal was seen, a total thickness of 15 ft. being observed in broken vertical sections, while in the upper beds a considerable thickness of coal was exposed in horizontal section but under water; a minimum estimate being five feet. Thus there is a thickness of 20 ft. of coal in seams of two and three feet separated by sandstones and shales, together with one composite seam of a minimum thickness of five feet. All these rocks are the Lower Coal Measures, the Upper Coal Measures being absent.

The eastern portion of this coalfield is somewhat cut up by faulting, while the western section is apparently relatively undisturbed. There is therefore every likelihood that the eastern seams are represented by 12–13 ft. in the Mchuchuma River, pointing to a persistency along the strike of the whole field, for fifteen miles.

(*c*) *The South Manda Coalfield.*—This area was examined by Bornhardt in 1895–7 and several seams were found but only two (Fig. 6), amounting to five feet, are worthy of consideration. These seams are close enough to be worked as one. The Geological Survey was able to confirm the coal seams, but the succession of the Karroo rocks was revised, one set of beds being separated into the Upper and Lower Coal Measures, the important seams being in the Lower Coal Measures.

(*d*) *The West Ndembe Coalfield.*—A small infaulted portion of the Basal Sandstones and Conglomerates overlain by the Coal Measures was discovered to the west of Ndembe Mountain. Both the Coal Measures were recognized. Three seams of three, two, and five feet were seen. These have high dips close to the fault, but lessening away from the outcrop.

The other localities give promise of coal. In the Lumecha area thin seams of coal were found in the tributaries of the Lumecha River. In the Lukagu stream there is a seam of one foot and in the Luhila River a five-inch seam was found. In the Nyaka-Jugu River indications of coal were seen, but no seam was discovered. This can only be considered as being an area favourable for further prospecting. In the North Manda Coalfield the Upper Coal Measures were found, but no seams of any thickness were located although fragments of coal were found in the alluvium. Boring may eventually discover seams in the Lower Coal Measures beneath and this is likely, as this field is really an extension of the Mchuchuma-Ketewaka Coalfield, the two fields being interrupted by a block of gneiss.

A small outcrop was discovered infaulted at the crossing of two faults and in two stream traverses on the northern side of the Ruhuhu, at the eastern end of the Madambasi ridge some coal was also found.

Summarizing (vide Figs. 7–11), therefore, there are the following important fields:—

(1) The Ngaka Coalfield with one 17 ft. seam and many other seams varying from five to one feet thick.

(2) The Ketewaka-Mchuchuma Coalfield with a composite 18 ft. seam, of which a 10 and a 5 ft. seam are the chief.

(3) The South Manda Coalfield with a five foot seam.

(4) The West Ndembe Coalfield with two, three, and five foot seams.

(5) Two other areas with promise of coal.

In the first two the extent, the inclination, thickness, and the quality of the coal give promise of economic importance. All the coal outcrops are faulted against the gneiss and the Ngaka Coalfield from the field evidence promises to be less faulted and disturbed than the others. The Ketewaka-Mchuchuma Coalfield is as extensive, but less accessible, so that the Ngaka region will naturally draw the attention of mining interests first.

Other considerations, such as labour, wood for mining, and food are advantageous. In the first case the area is in the centre of one of the present principal sources of labour for the Territory. The price of unskilled labour in the Songea District is 10s. to 15s. per month and in the Njombe District 6s. to 9s. per month. The area is well watered and wooded, the coalfields are situated in forested country, and all the main rivers and many of the streams are perennial. Food is not abundant, but the demand would considerably help to create the supply.

Technical Examination of the Coal and Suggested Uses.—The coal is of shaly character and the samples examined, having been collected from outcrops, are for the most

part weathered and friable. In colour it is dull black with a greenish tinge, but it contains thin laminae of the true black lustrous variety. It can be kindled in the flame of an ordinary bunsen burner and burns with a short smoky luminous flame. The apparent specific gravity is high, varying from 1·38 to 1·83 in the case of 17 samples. Proximate analyses of 20 samples collected from the various coalfields show the coal to be typically of the non-coking variety, the "fixed carbon" and ash being left in the crucible after ignition in the form of a slightly coherent powder. In two cases only (Sc. 4 and Sc. 17) very slight coking effects were observed and it is of course possible that further prospecting may result in the discovery of coking seams, especially as such are known to exist in strata of similar geological age in the Mt. Waller area in Nyasaland on the other (west) side of Lake Nyasa. In the light of recent investigation upon the subject, it appears probable that high moisture content is inimical to the coking properties of a coal and in this connexion it may be noted that the two samples with slight coking properties carry 2·3 and 2·2% respectively of hygroscopic moisture, while of the remaining 18 examined all but 3 possess a higher percentage of moisture than 2·3.

The ratio of volatile matter to "fixed carbon", or fuel ratio, varies between the limits 1 : 1·4 and 1 : 3·2, the average for the 20 samples being about 1 : 2, indicating coal of a bituminous character. The percentage of ash although very variable is fairly low in the case of certain seams. Three samples showed less than 10%, ten showed more than 20%, and the remainder intermediate values. The ash content shows fairly close proportionality to the specific gravity and it may be mentioned that this empirical relationship enables the prospector to ascertain in the field by the aid of an extremely simple and portable apparatus (the Walker steelyard specific gravity balance) whether or not a given coal seam contains an undue proportion of mineral matter. Seams of low-grade coal with comparatively high specific gravity can thus be recognized on the spot and the collection of much useless material avoided.

The proportion of hygroscopic moisture, as might be expected from weathered outcrop samples, is variable and high, the coal from the thicker seams being less objectionable in this respect. It is to be hoped that samples from test shafts will prove of better quality. It is noteworthy that where the percentage of moisture is high that of volatile matter is correspondingly so. Results obtained from a proximate analysis are at the best arbitrary and as the concordance of data obtained therefrom depends upon careful observance of standard conditions, it appears probable that the average percentage of volatile matter in the unweathered coal should not greatly exceed 20; the considerably higher average obtained from the samples under consideration being most likely attributable to adsorbed moisture removable with difficulty under the standardized conditions of the test.

The percentage of total sulphur is not excessively high, three samples only showing more than 1%. Very approximately, the total sulphur percentage in the samples examined is in inverse proportion to the percentage of ash, showing that it is present chiefly as pyrite (i.e. in the coal and not as gypsum in the ash). Considering the nine samples with calorific value over 10,000 B.T.U. per lb., the average total sulphur percentage is less than 0·9. With a sulphur content of this order, even though entirely pyritic, clinkering effects should not be pronounced and the ash being infusible, light, and pulverulent, should not prove troublesome when the coal is used for steam-raising. A slightly higher percentage of pyrite is to be expected in the unweathered coal.

Ash in coal acts as a diluent, the rate of combustion as well as the amount of heat produced being inversely proportional to the percentage by weight present for any series of coals of similar physical properties and fuel ratio. Hygroscopic moisture must also be reckoned as a diluent, but it exerts in addition a "quenching" effect which is more pronounced with wet coals containing 10% or more of hygroscopic moisture. For coal with less than 5% of moisture it may be stated as a rough empiricism that the calorific value is inversely proportional to the percentage of inert matter present (ash plus moisture). In the graph figured (Fig. 12) the closed and open circles represent samples with less and more respectively than 5% of hygroscopic moisture. In this it is seen that the open circles lie off, and well below the curve. This point has been stressed to show that a considerably higher

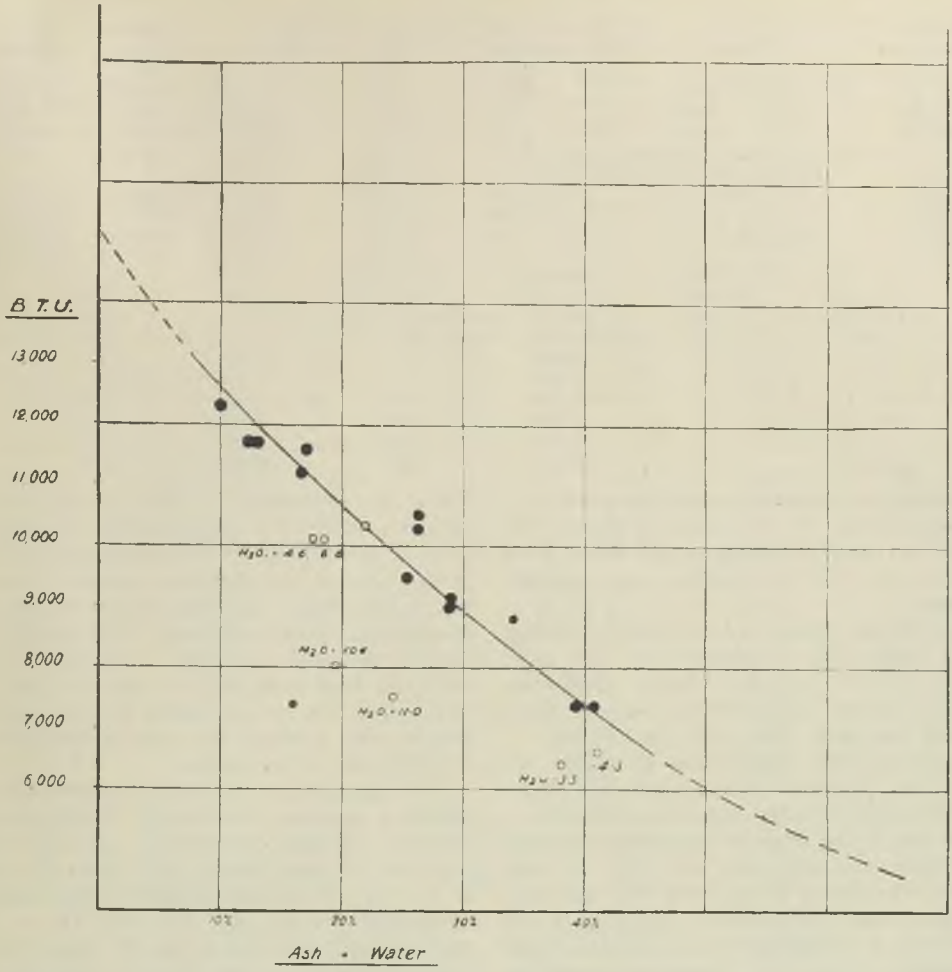


FIG. 12.—GRAPH SHOWING RELATION BETWEEN INERT MATTER (ASH AND WATER) AND CALORIFIC VALUE.

average calorific value is to be expected from ordinary run-of-mine coal, as compared with the present highly weathered outcrop samples, which generally contain an excessive proportion of moisture. In the ensuing tabulated results the calorific value is shown in British Thermal Units yielded on complete combustion of 1 lb. of coal and the evaporative power as lb. of saturated steam produced by complete combustion of the same quantity. Results obtained from the high moisture samples were somewhat variable. Taking those samples with under 5% moisture and under 20% ash the average evaporative power falls very little short of 12 lb. of steam per lb. of coal.

DETAILS OF RESULTS

(*a*) *The Ketewaka-Mchuchuma Coalfield.*—Samples from this coalfield comprise Sc. 1 to Sc. 9 inclusive. Of these Sc. 8 and Sc. 9 from the Mchuchuma River were lost on safari. The specific gravities and proximate analyses of the seven samples examined are shown in the accompanying tables.

All the above were non-coking except Sc. 4 referred to before. No. Sc. 2 and No. Sc. 3, showing high moisture content were from thin (1 foot) seams. The relation between moisture content and seam thickness is striking and is shown in the table below :—

No. of Sample.	*% Hygroscopic Moisture.*	*Thickness Seam Feet.*
Sc. 2	11·0	1
Sc. 3	10·1	1
Sc. 6	4·6	2
Sc. 1	4·3	9
Sc. 5	4·2	3
Sc. 4	2·3	5
Sc. 7	1·2	10

No. of Sample.	Locality.	Spec. Grav. (apparent).	Hygros. Moist. %	Vol. Matter %	Fixed Carb. %	Ash %
Sc. 1	E. Ketewaka Main	1·42	4·3	29·2	58·2	8·3
Sc. 2	Do. Middle	1·48	11·0	30·6	49·9	8·5
Sc. 3	Do. Lower	n. d.	10·1	28·6	47·1	14·2
Sc. 4	W. Ketewaka Mhumbi Coal (Nyamoto Lower Seam)	1·48	2·3	23·0	60·1	14·6
Sc. 5	Do. Nyantula	1·58	4·2	26·0	48·6	21·2
Sc. 6	Do. Do.	1·40	4·6	28·2	53·1	14·1
Sc. 7	Do. Nyamoto	1·13	1·2	23·4	50·2	25·2

No. of Sample	Seam Thickness Feet.	Calorific Value B.T.U. per lb.	Evaporative Power lb. Steam per lb.	Total Sulphur %	Fuel Ratio.
Sc. 1	9	11,700	12·1	1·71	2·0
Sc. 2	1	8,000	—	0·90	1·6
Sc. 3	1	7,500	—	0·79	1·7
Sc. 4	5	11,200	11·6	0·61	2·6
Sc. 5	3	9,500	9·9	1·08	1·9
Sc. 6	2	10,100	10·5	1·49	1·9
Sc. 7	10	10,500	10·9	0·53	2·2

It should be mentioned that the anomalous position of No. Sc. 1 is most probably due to the fact that the sample was taken from an outcrop over which water was actually flowing.

The calorific values of the three thickest seams from this coalfield are all over 10,000 B.T.U. per lb. Seam thickness, calorific value, evaporative power, total sulphur and fuel ratio are also shown.

The three best coals from this field are from the thickest seams and, of these, the fuel ratio is in no case less than 2·0.

(*b*) *The South Manda Coalfield.*—Samples from this coalfield are Nos. Sc. 10 and Sc. 11, the latter with fairly low ash and moisture, and evaporative power of 12 lb. per lb. is a promising coal, but the seam is rather narrow for convenient working. This coal possesses the highest fuel ratio of any examined, but does not coke.

(*c*) *The Ndembe Coalfield.*—The samples from this coalfield (Nos. Sc. 12, Sc. 12a, and Sc. 13) were not promising, the percentage of ash being definitely high and the fuel ratio in no case exceeding 2·0.

(*d*) *The Ngaka Coalfield.*—Seven samples from this large coalfield were examined (Sc. 14 to Sc. 19 inclusive and Sc. 17a). With the exception of No. Sc. 14 which carries nearly 37% of ash these all appear to be of good quality. The moisture content in the case of the narrower seams tends to be rather high, but this may be due to weathering effects and would most probably tend to diminish in depth. The two seams with the best coal (Sc. 15 and Sc. 16) are 17 ft. and 18 ft. in width respectively—rather wide perhaps for convenient mining of the whole of the seam.

Here again there is a relationship between moisture content and seam thickness as already remarked under 2 (*a*) above. The coals are all non-coking with the exception of No. Sc. 17 which displays slight coking tendencies (Cf. Sc. 4). Nos. Sc. 15, Sc. 16 and Sc. 17—all be it noted from thick seams—should prove useful for steam-raising, especially the second in which the ash falls as low as 7·5%. In each of these three cases the total sulphur content is under 1% and the ash is refractory.

No. of Sample.	Locality.	Spec. Grav. Apparent.	Hygros. Moist. %	Vol. Matter %	Fixed Carbon %	Ash %
Sc. 10	Mtambalala R. Upper Seam.	1·38	3·1	23·0	42·8	31·1
Sc. 11	Do. Lower Seam.	1·54	1·5	19·7	63·2	15·6

No. of Sample.	Seam Thickness Feet.	Calorific Value B.T.U. per lb.	Evaporative Power lb. Steam per lb.	Total Sulphur %	Fuel Ratio.
Sc. 10	3	8,800	9·1	0·26	1·9
Sc. 11	2	11,600	12·0	0·57	3·2

(*e*) *The Lumecha Coalfield.*—The single representative from this coalfield examined (Sc. 20) appeared to be comparatively unweathered and showed a fair proportion of lustrous coal alternating in narrow laminæ with the dull variety. Unfortunately

No. of Sample.	Locality.	Spec. Grav. Apparent.	Hygros. Moist. %	Vol. Matter %	Fixed Carbon %	Ash %
Sc. 12	Ndembe Stream	1·83	1·3	21·2	37·9	39·6
Sc. 12a	Do. Cutting	n. d.	3·5	19·9	40·6	36·0
Sc. 13	Do. Top Seam	1·61	8·3	24·9	36·9	29·9

No. of Sample.	Seam Thickness Feet.	Calorific Value B.T.U. per lb.	Evaporative Power lb. Steam per lb.	Total Sulphur %	Fuel Ratio.
Sc. 12	2·25	7,400	7·7	0·36	1·8
Sc. 12a	5	7,400	7·7	0·24	2·0
Sc. 13	3·3	6,400	6·6	0·29	1·5

No. of Sample.	Locality.	Spec. Grav. Apparent.	Hygros. Moist. %	Vol. Matter %	Fixed Carbon %	Ash %
Sc. 14	Mkapa River	1·53	4·3	21·8	37·0	36·9
Sc. 15	Do., Lower Seam Main.	1·41	2·5	23·1	63·7	10·7
Sc. 16	Mbuyura River Lower Seam Main.	1·41	2·7	26·0	63.8	7·5
Sc. 17	Nyakangunda R.	1·59	2·2	23·9	49·8	24·1
Sc. 17a	Do. Upper Seam	n.d.	6·6	29·8	41·2	22·4
Sc. 18	Mkami River	1·59	3·1	22·1	48·9	25·9
Sc. 19	Mbalawala River	1·38	6·6	26·9	55·4	11·1

No. of Sample.	Seam Thickness Feet.	Calorific Value B.T.U. per lb.	Evaporative Power lb. Steam per lb.	Total Sulphur %	Fuel Ratio.
Sc. 14	3·5	6,600	6·8	0·27	1·7
Sc. 15	17	11,700	12·1	0·74	2·8
Sc. 16	18	12,300	12·8	0·90	2·4
Sc. 17	8 ?	10,300	10·7	0·49	2·1
Sc. 17a	4·75	9,000	9·3	0·29	1·4
Sc. 18	3	9,100	9·4	0·48	2·2
Sc. 19	3	10,100	10·5	0·44	2·1

No. of Sample.	Locality.	Spec. Grav. Apparent.	Hygros. Moist. %	Vol. Matter %	Fixed Carb. %	Ash %
Sc. 20	Lukago River	1·41	7·3	28·0	50·0	14·7

No. of Sample.	Seam Thickness Feet.	Calorific Value B.T.U. per lb.	Evaporative Power lb. Steam per lb.	Total Sulphur %	Fuel Ratio.
Sc. 20	1	10,300	10·7	0·57	1·8

the seam is only one foot thick, as the coal is of fair quality, although the moisture content is rather excessive. Details are given above.

COMPARISON WITH OTHER COALS OF SIMILAR GEOLOGICAL AGE.—Reference has already been made above to the coals from the Mt. Waller area in Nyasaland on the opposite side of the lake. These seams, although consisting of good quality coal are at present too remotely situated to permit of exploitation. Details of proximate analyses and calorific values are quoted in the case of three samples from that locality.[1]

[1] *Colonial Reports—Miscellaneous.* No. 60. Report on the Results of the Mineral Survey, 1907–8, No. II of Series. By Professor Wyndham Dunstan.

The resemblance to the Ruhuhu coals is very marked, the most noticeable departures being the higher calorific value of the Mt. Waller coals (attributable in some measure to their low moisture content as well as their strong coking properties). It is not known whether the samples in question were from outcrop or from depth. Their low moisture and high calorific value suggest the latter. The average fuel ratio of the three samples is about 2·4 which is closely comparable with that of the best of the Ruhuhu coals. The general similarity in composition, geological age, and geographical situation of the Mt. Waller and the Ruhuhu coalfields foster the belief that systematic prospecting will show the Ruhuhu coal to be of considerably better quality than that indicated by this

Locality.	Hygros. Moist. %	Vol. Matter %	Fixed Carbon %	Ash %	Total Sulphur %	Calorific Value B.T.U. per lb.
Zindira Stream	1·3	23·8	56·9	18·0	0·59	12,300
Rumpi R. (Higher Seam).	1·3	28·1	59·8	10·9	0·64	14,200
Do. (Lower Seam)	1·0	24·1	66·7	8·2	0·62	14,400

preliminary examination of weathered outcrop samples. The likelihood of the occurrence of coking seams on the eastern side of the lake must not be disregarded. Two out of the twenty samples examined displayed a tendency to coke and without undue optimism this may be taken as an indication that coking seams exist.

Another useful comparison may be made with coal from the approximately corresponding geological horizon in India (Permo-Carboniferous to Permian). Details of analyses of coal from the Bengal, Bihar and Orissa coalfields are subpended:[1]

Locality and Description of Samples.	Hygros. Moist. %	Vol. Matter %	Fixed Carbon %	Ash %	Calorific Val. B.T.U. per lb.
Raniganj or Upper Measures (Average of 22 samples).	4·8	32·2	53·4	9·6	12,180
Barakar or Lower Measures (Average of 3 samples).	1·7	24·8	64·0	9·5	13,226

The fuel ratio of the Raniganj coal is 1·7, that of the Barakar coal 2·6. The coal from the Upper and Lower Measures is bituminous, but only that from certain seams has good coking properties. It constitutes one of the chief sources of supply.

As Natal coal is at present largely used in this Territory a few representative analyses thereof may be quoted for comparison.[1] The Natal coal seams are of the same geological age as those from the Ruhuhu area, but appear to be of better quality. Coking properties are strongly developed.

SUMMARY AND SUGGESTED ECONOMIC USES.—The 5 ft., 9 ft. and 10 ft. seams of the Ketewaka-Mchuchuma coalfield, and the 8 ft., 17 ft., and 18 ft. seams of the Ngaka coalfield are all workable and can be opened up inexpensively from the surface. They carry coal of fair quality which should prove adaptable for steam-raising purposes although not the equal in this respect of the Natal coal now largely in use on the eastern sections of the Tanganyika Government Railways and available at Dar es Salaam and Tanga at the round price of 25s. per ton. On the basis of the results of the analyses carried out on what is perhaps not entirely representative material,[2] the average ash content of these six seams is about 15%, and the average calorific value over 11,000

Locality.	Hygros. Moist. %	Vol. Matter %	Fixed Carb. %	Ash %	Total Sulphur %	Calorific Val. B.T.U. per lb.
Durban Navigation Collieries.	1·6	27·1	60·0	11·3	1·51	12,970
Natal Steam Coal Co.	1·2	18·5	70·7	9·6	n. d.	13,550
Ballengeich Collieries	1·8	22·7	60·2	15·3	1·26	12,220
Northern Natal Navigation Collieries Ltd.	1·8	26·8	64·0	7·4	1·00	13,580
Sample of Natal coal in use on Tanganyika Govt. Railways (Analysed in laboratory of Geological Survey Dept.).	0·5	21·3	71·4	6·8	1·99	13,500

[1] *The Mineral Industry of the British Empire and Foreign Countries.* War Period. Coal, Coke, and By-Products (1913–19). Part II.

[2] It was not found practicable in a preliminary survey of this nature to make use of precise sampling methods, the specimens selected consequently representing a somewhat higher grade than the true average of the outcrop. This should be more than compensated by the improvement in quality of the mined coal.

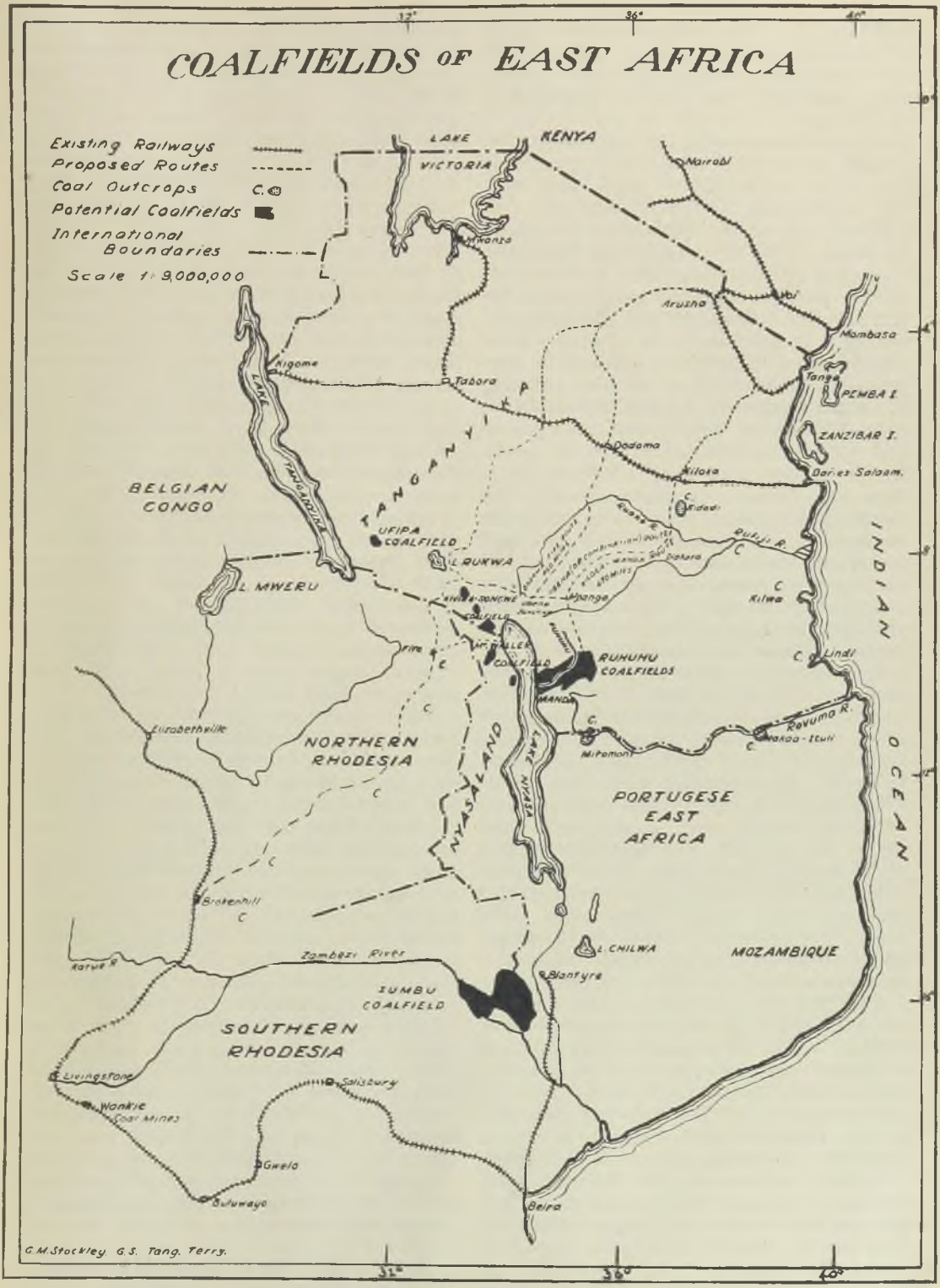

COALFIELDS OF EAST AFRICA
Existing Railways
Proposed Routes
Coal Outcrops
Potential Coalfields
International Boundaries
Scale 1:9,000,000
LAKE VICTORIA
KENYA
Nairobi
Mombasa
Arusha
Tanga
PEMBA I.
ZANZIBAR I.
Dar es Salaam
Kigoma
Tabora
TANGANYIKA
Dodoma
Kilosa
Kidodi
BELGIAN CONGO
LAKE TANGANYIKA
UFIPA COALFIELD
L. RUKWA
Ruaha R.
L. MWERU
Kilwa
Lindi
RUHUHU COALFIELDS
Elizabethville
NORTHERN RHODESIA
NYASALAND
LAKE NYASA
Revuma R.
Mikindani
Mtemoni
PORTUGESE EAST AFRICA
INDIAN OCEAN
Broken Hill
Zambezi River
L. CHILWA
MOZAMBIQUE
Blantyre
IUMBU COALFIELD
SOUTHERN RHODESIA
Livingstone
Salisbury
Wankie Coal Mines
Gwelo
Bulawayo
Beira
G.M. Stockley G.S. Tang. Terry.

FIG. 13.

B.T.U. per lb. The average moisture content of these six seams is about $2\frac{1}{2}\%$, which value may be expected to diminish in depth with beneficial effect upon the quality of the coal.

A large proportion of the coal on account of high ash content would no doubt prove unsuitable for locomotive work even with the employment of forced draught. In a paper published in THE MINING MAGAZINE for March, 1926, Dr. Dixey of the Nyasaland Geological Survey has advocated the use of the pressure type of gas-producer for treating such low-grade material and conserving by-products, but even more advantageous would be a process of low-temperature distillation at the pithead, in a plant designed to produce the maximum range of useful by-products, comprising fuel as well as lubricating oils, tar acids, fertilizer, and semi-coke. Of late years there has been a recrudescence in the commercial application of this and other methods of obtaining oil from lignite and low-grade bituminous coal stimulated by the increased world demand for and consumption of oil fuel. Of a host of such processes evolved within the last decade particular mention may be made of the Crozier process, which is stated to have been successfully employed in Tasmania and to be especially suitable for the treatment of non-coking bituminous coal. As in all low-temperature (below 600° Cent.) distillation methods the process aims to avoid "cracking" of the various primary oils produced, which are separated at the outset in a state of comparative purity by a special fractionating device, thereby obviating the necessity for erection and maintenance of costly refinery plant. The retort is furthermore stated to be simple in construction and practically automatic in action.

For high-ash Karroo coals with a wide potential radius of marketable distribution, production of fuel oil and by-products at pithead appears to be the most practical method of exploitation, since the cost of transport to the consumer (possibly several hundred miles distant) of a considerable proportion of useless material is thereby eliminated. As regards South Africa, coal costs the consumer on the average about 500% of the pithead price and this is almost wholly attributable to transport charges.

For a low-temperature distillation unit designed to deal with 1,000 tons of material per 24 hours (an average payable throughout capacity), and to produce about 70 tons of tar and 300 tons of semi-coke, the capital outlay would be high—probably in the neighbourhood of a quarter of a million pounds sterling. This estimate excludes the cost of the coal mining plant, it being assumed that suitable coal is available at the unit at about 4s. per ton.

Production of petrol by hydrogenation of the coal is another possible method of treatment, though at present only emerging from the experimental stage. Research recently carried out by P. N. Lategan upon South African bituminous coal showed an average laboratory production of 135 gallons of petrol per ton of coal treated, but it is doubtful if such large yields would be realized in practice. In both this and the low-temperature class of treatment, plant is an expensive item. In the latter the yield of petrol is comparatively small, but a number of by-products is produced, the most important of which from the point of view of quantity is smokeless solid fuel or semi-coke. For the process to prove successful this commodity must be assured of a ready market. By hydrogenation a much larger yield of petrol is realized and by-products do not bulk large.

Treatment of extensive deposits of brown coal by low-temperature distillation has been carried on for some years in Germany on a sound industrial basis. Great Britain has lagged behind in this field as her coal deposits, being of high-grade, are less amenable to treatment. They may respond more readily to the so-called fluidification or hydrogenation processes, and although numerous technical difficulties still remain to be surmounted it is perhaps to such processes rather than to any other that the coal industry of Great Britain must look for rejuvenation. A combination of the two classes of process is now being investigated, and in a recent paper read before the Chemical, Metallurgical and Mining Society of South Africa W. R. Feldtmann states that "low temperature carbonization is now receiving renewed attention, the idea being to subject the tar obtained by this process to hydrogenation, and to use the semi-coke for the production of the necessary hydrogen in the form of water gas".

None of the seams sampled is suitable for the production of metallurgical coke,

but as already remarked the possible existence of coking seams in the general locality must not be excluded.

Conclusions.—At the first glance (vide Fig. 13) the position of the coalfields appears to be a decisive factor in preventing their exploitation in the near future. When, however, the prospects of railway construction are considered, as well as the probable adaptability of the coal for extraction of petrol and by-products, the position is seen to be worthy of further consideration. In the first case a proposed route for the Tanganyika Southern Railway passes through the area. This railway will form one of the last links in the Imperial Cape to Cairo through-route, i.e. between Northern Rhodesia and Nyasaland and the Tanganyika Central Railway, but alternative routes have been proposed by different experts and the matter is still under consideration. One of these routes starts from Dodoma (on the Central Railway) and passes first through a considerable amount of unproductive country with difficult escarpments to surmount, then via the Iringa Highlands, Buhora Flats, Mbeya, and Mbosi, to Fife on the borders of Northern Rhodesia. Another route starts from Kilosa (also on the Central Railway) and, following the low-lying country, including the Kilombero Valley to the east of the Iringa Highlands, finishes at Manda on the shores of Lake Nyasa. A disadvantage of the latter route is the subsequent necessity for transhipment across the lake. A compromise between these two routes has been suggested and appears to be more favourably entertained, since it includes part of and combines the advantages of both. It is known as the Ubena or Combination Route. This would start from Kilosa, continue as far as Mpanga on the Manda route and then cross over to the Dodoma—Fife route, joining the latter at Ubena. It has the advantage of tapping productive areas along almost its entire length without the disadvantages of a transhipment. Mpanga is some 75 miles south of Iringa and the route passes within 130 miles of the Ngaka Coalfield. A possible branch line with the dual object of opening up the Ungoni District for native produce and developing the coal merits consideration. Should, however, the Kilosa—Manda alternative be decided upon the railway will actually pass through the coalfields, which will then of course be worked to supply the railway.

The other aspect is the possible exploitation of the coal as a source of petrol, etc. Here certain difficulties will be encountered. It is true that high yields of petrol can be obtained from coal by hydrogenation. For instance, it was stated recently in The Mining Magazine (March, 1931, p. 133) that " the results of the Fuel Research Board, carried out under the auspices of the Department of Scientific and Industrial Research, so far achieved show that a yield of 120 to 130 gallons of motor spirit per ton of coal should be readily obtainable in a suitable plant using a modified Bergius process ". The initial cost, however, of erecting plant of sufficient capacity to permit of economic working would be very heavy. With the completion of the Zambezi Bridge and construction of the railway as far as the southern end of Lake Nyasa transport difficulties will have been largely overcome, although subsidiary feeder railways, or possibly pipelines, will still be necessary. These remarks may be made to apply also to the Mt. Waller and Kivira-Songwe areas, should the question of the development of these coalfields arise. While on the subject of communications it may be mentioned that an old road used previous to and during the Great War between Manda and Songea passes across the southern portion of the Ngaka Coalfield and could be put into repair at comparatively small cost.

The immediate local demand for petrol is small, but the imports of motor spirit into Tanganyika have increased from £33,000 in 1925 to £150,000 in 1929. Consumption in the country is increasing rapidly and may soon justify the establishment of a local industry such as that indicated. It need hardly be added that it will be necessary to test the coal first under practical conditions before envisaging the whole commercial possibilities. Unsettled local conditions no less than the existing world trade depression militate strongly against the logical development of mineral resources such as these. At some date not far distant, however, improved communications will enable them to be utilized, with the benefit of the improved technique which has accrued.

In conclusion, should coking seams be discovered, there are extensive deposits of iron ore (magnetite) awaiting development in the Ukinga and Upangwa areas, some 10 to 25 miles to the north of the Ketewaka-Mchuchuma Coalfield.

GRANBY-TYPE MINE CARS

By C. M. CAMPBELL

The author, who was connected with the Granby company at the time this car was introduced, shows how alterations in mining methods altered the outlook on that property.

In view of recent announcements to the effect that "Granby" type mine cars are now being built in England and that such cars are to be used in the Roan Antelope mine, the writer feels that a short article dealing with the origin and special advantages of this item of mine equipment will be of interest.

In 1900 the Granby Consolidated Mining, Smelting, and Power Co., Ltd. began production from its copper mines in Phoenix, British Columbia. The end of the first year's operations showed a recovery of 31 lb. of copper and $2·25 in gold and silver per ton of ore and a cost for the coarse ore, loaded on cars, of $2·06 per ton. The work also showed that the reserves averaged appreciably below that figure and that it was therefore necessary that sweeping reductions should be made in future costs. Square-set mining was therefore abandoned for the open stope system then being introduced in Michigan and Alaska and a new shaft was sunk and equipped with large skips running in balance and electrically driven. It was also decided to crush the ore at the mine and large crushers with openings 30 in. by 42 in. were installed at the railway terminals.

One of the most striking innovations was in the method of underground transport. In those days drives were small, often crooked, with sharp curves and indifferent grades. The cars were of 1,500 to 3,000 lb. capacity, 18 in. gauge, running on light rails and hand trammed or occasionally gathered into trains with horse haulage. The new drives were straight whenever possible and large enough for a 3 ft. track and large cars. The curves and grades were determined with an instrument, the governing feature being safe and rapid transport of large tonnages. Much thought was given to the type of car to be used and it was decided to purchase cars of the type found most satisfactory by the railways for hauling ore. The tunnel levels were therefore supplied with hopper-bottom steel cars. These were 6 ft. high, 6½ ft. wide, with a 15 ft. over-all length and with a

FIG. 1.—ORIGINAL INSTALLATION OF GRANBY CARS AT PHOENIX, BRITISH COLUMBIA.

capacity of 177 cu. ft., equivalent to 10 tons of Phoenix ore. They were hauled in trains by a 10-ton electric locomotive.

The large crushers were introduced because it was cheaper to crush than to break by mining methods. Correspondingly large chutes were therefore installed and the cars were built with large openings in the bottom. Oversize rocks would, however, occur and often smaller rocks would wedge together forming an arch over the openings. If this material could not be pinched loose it had to be blasted, or drilled and blasted. This was hard on the equipment, particularly the mine cars. A brakeman would work for some time with his pinch-bar, but it was imperative that as little time should be lost as possible and ultimately, if this procedure was not successful a half stick of powder was introduced where it would do the most good. Sometimes it resulted in the car being side-tracked for the repair shop. These cars also developed another defect of a minor character. Due to heavy and large rock the doors soon ceased to close tightly and fine material was distributed along the track and this had to be cleaned up. The 6 ft. height was also found to be a handicap when rock had to be shovelled from the sill floor and to eliminate this handicap low, gable-bottom, side-dump cars were made up.

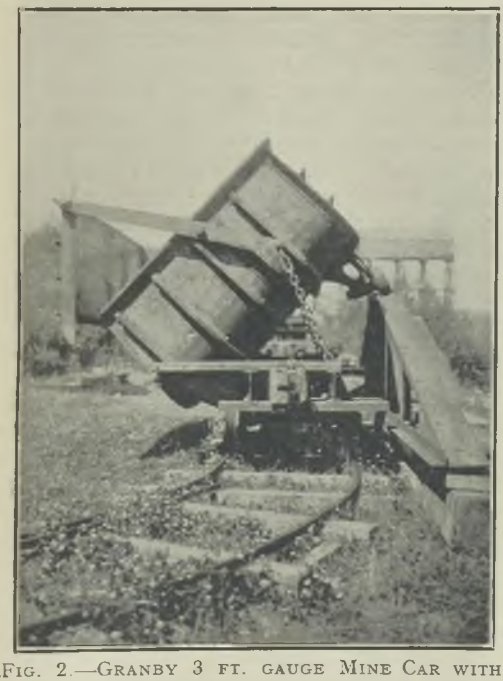


FIG. 2.—GRANBY 3 FT. GAUGE MINE CAR WITH 45° DUMPING ANGLE.

FIG. 3.—A POPULAR TYPE OF GRANBY CAR—2 FT. GAUGE.

The expenditure for car repairs was not inconsiderable and the matter was the subject of much discussion. Finally the suggestion of an automatic side-dumping car, passed ahead by the shift bosses, was developed and the car shown in Fig. 1 was put into operation in 1906. A side-dump car was also tried out in which the box was dumped by an air cylinder, but this type was inferior to the automatic type and had limited use. The automatic type, as illustrated, continued in use till the mine was worked out in 1919. They were then sold to the Sullivan mine, strengthened on account of the heavier ore in that mine, and are still in use after a quarter of a century of service. These cars have 90 cu. ft. capacity and are 5 ft. high, 6 ft. wide, and 10 ft. over all in length.

These cars were, therefore, a success from the first. Additional cars needed were equipped with automatic couplers and roller bearings. The operation of these trains was so quiet that the motorman was kept busy ringing his bell in order to give warning of the approach of a train.

Another variation is shown in Fig. 2. Cars of this type were built at the Phoenix plant for the Anyox mine, also operated by the Granby Company, and were of heavier construction owing to the heavier nature of the ore at that mine. They also have a free-swinging door and dip at an angle of 45° in order to facilitate the removal of a certain amount of fine and sticky ore.

In most mines the swinging door is not needed and many properties use a car similar in type to that shown in Fig. 3. This particular car has a gauge of 24 in., a height of 4 ft. 2 in., a capacity of 56 cu. ft., and weighs 3,000 lb.

For certain conditions the railway type of car is still supreme. For crushed ore,

FIG. 4.—10-TON CAPACITY GRANBY CAR WITH FREE-SWINGING DOOR TO PASS LARGE PIECES OF ORE.

or fine ore not too fine to sift through the bottom openings, its large capacity, easy unloading qualities, and low repair costs, with this type of a load, make it attractive.

Some companies in the last decade have gone to the coal mines for inspiration and low-cost box-cars, with a low centre of gravity, using a rotary dump, have been built. In coal plants only one car is dumped at a time as each car has to be uncoupled from the train and weighed in order to give the miner who loaded the car credit for his work. This practice does not apply in metal mines and in some cases rotary dumps are built that will dump several cars at once. In this case the saving in the cost of the invividual car is often used up in the extra cost of the dumping apparatus. The ore train has also to be limited in length or broken into sections and each section dumped separately. The present practice in the Sullivan mine is to operate 30 Granby type cars in a train hauled by two motors in tandem. For long trains the Granby dump has obvious advantages over the rotary dump.

FIG. 5.—AUTOMATIC-DUMPING FLAT CAR FOR LARGE ROCK MASSES.

Another feature of the Granby dumping method is the elasticity of its operation. In the Phoenix mines it was necessary for various reasons to fill many of the empty stopes with waste. For this purpose large tonnages, which had to be mined anyway, were available on different levels. The dumping block, illustrated in the photos, cost only a few dollars, and could be easily moved and set up where desired and the rock dumped into these stopes. Waste from the tunnel levels could easily be dumped on the surface. Where the dump was on the side

hill no trestle work was needed ; the dump block was moved as required and periodically the trackmen would pinch the track closer to the edge.

About the year 1912 an electric shovel was installed in an open-cut on the surface and a type of car which, when heaped, held not less than 10 tons, was constructed for this service. These cars, with free swinging doors to pass large rocks, are shown in Fig. 4. Large tonnages of waste had to be sorted out in this pit and this waste often came down in large masses, too large even for the 10 ton car. In order to get these right out of the way without drilling and blasting a couple of small cars with shallow boxes and doors that automatically dropped when being dumped were constructed. It was soon found that the doors were not needed and they were removed and the car then had the appearance shown in Fig. 5. It was essentially a flat car with a wheel attached to the platform. Very large masses were, by this means, easily loaded and dumped.

The result of these changes in mining methods was that, in 1913, when the grade was represented by 17·68 lb. recovery, and a 4·2 lb. slag loss, equivalent to an original copper content of 1·1% and 80 cents in gold and silver, the cost of the ore, crushed to 6 in., loaded on cars, including maintenance of plant, disposal of large quantities of waste, and all development expense, had dropped to 75·4 cents per short ton with a cost of 65·5 cents from the tunnel levels. During this 13-year period of average low copper prices, dividends paid aggregated close to $6,000,000. Of all the changes the improvement in transport was one of the important items.

BOOK REVIEWS

Lehrbuch der Erzmikroskopie, Volume 2. By H. SCHNEIDERHÖHN and P. RAMDOHR. Cloth, octavo, 714 pages, illustrated with 7 text-figures, 235 photomicrographs, and 1 coloured plate. Price 72 R.M. Berlin : Gebrüder Borntraeger.

Very notable advances have been made during the last few years in the use of the ore-microscope for the study of opaque minerals from polished surfaces. The method is now so well established that it has become an essential part of the investigation of ore minerals, not only for their identification, but also to show their genetic relationship and other important data bearing on the probable economic value of mineral deposits. No one has contributed more to the successful development of this method of investigation than Professor H. Schneiderhöhn whose well-known researches, extending over a long period of years, have placed him as the foremost authority on this important subject. His book "Anleitung zur Mikroskopischen Bestimmung und Untersuchung von Erzen und Aufbereitungsprodukten besonders im Auffallenden Licht," published in 1922, has been recognized as an authoritative work of reference on the study of opaque minerals in incident light. Since the appearance of that book, however, special instruments have been designed for the examination of polished surfaces in incident polarized light, and for estimating their reflecting powers. Progress became rapid, and refinements of the method necessitated a new book on the subject.

Professor Schneiderhöhn, in collaboration with Professor Ramdohr, has now published the second volume of "Lehrbuch der Erzmikroskopie," a comprehensive work which will include three volumes, the first and third of which are to be published at an early date. The first volume will deal mainly with technique, the third will contain determinative tables, and the second volume, now under review, deals with specific minerals. The various mineral species are grouped under elements, simple sulphides, sulpho-salts, strongly reflecting oxides and oxidized ores and, lastly, under gangue minerals and oxidized ores of weak absorptive power. The authors recommend that future descriptions of minerals should follow the scheme adopted by them in this volume, which is as follows : (1) The chemical composition, crystalline form, lattice structure, cell size, other physical properties ; (2) physical characters displayed during the polishing process ; (3) colour and reflective power ; (4) other optical characters under incident polarized light ; (5) etching effects ; (6) internal characters of individual crystals ; (7) structure and texture ; (8) diagnosis ; (9) mode of occurrence and paragenesis, with localities ; (10) previous literature. The descriptions of the 200 mineral species given in this volume are based on the examination of 6,000 polished sections of ore

minerals from different parts of the world, and a great deal of the information is new to science.

The volume contains 714 clearly printed pages, packed with information ; it contains 235 photomicrographs excellently reproduced ; has a complete bibliography, and is fully indexed for mineral species and for place names. It can confidently be recommended as a book that will long remain the standard work on this subject.

WILLIAM R. JONES.

Patterns for Eight Simple Relief Models Illustrating Geological Structures. Designed by Dr. F. SMITHSON. Price 5s. 6d., Mounted on cards, 13s. 6d. London : Thomas Murby & Co. New York : D. Van Nostrand Co.

The patterns are in black and white on stout paper and directions for cutting out and making the models are included. In No. VII (which was submitted in mounted form, as an example, by the publishers) there is an obvious inaccuracy which detracts from its educational value, but in general the models illustrate simple structures and are clear and easily understandable.

MURRAY STUART.

☞ 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

BRISBANE

June 23.

Production at Mount Isa.—It is officially reported that, apart from some necessary adjustments, there have been no difficulties in bringing the Mount Isa mine and plant into productive operation. Until the end of May, owing to these adjustments in the concentrating mill, the mine had not been called upon to produce to its full capacity, but up to 1,000 tons of mixed carbonate and sulphide ore had been delivered in one day. By the 30th of the month some 13,000 tons of ore had been treated at the mill. The concentrates therefrom at that time were being passed through the filter plant and thence to the Dwight-Lloyd sintering machine. Until sufficient stocks were on hand to start the blast furnace, the sinter produced was being accumulated. The first furnace was blown in on June 8, and the second one on the 14th. On the latter date the mine was officially opened by the State Minister for Mines (Hon. E. A. Atherton). On the 19th the first consignment of silver-lead, weighing about 200 tons, left the field for Townsville, and it is expected that later on this quantity will be despatched daily.

Eulogistic Speeches.—At the opening function at Mount Isa, the operating company (Mount Isa Mines, Ltd.) was represented by the chairman of the Sydney board of directors (Mr. W. M'Rea). In the course of his speech on the occasion, Mr. M'Rea made particular reference to the initiatory and praiseworthy work done by Mr. W. H. Corbould, especially in enlisting the co-operation of financiers overseas ; and also to Mr. Leslie Urquhart, chairman of the Mining Trust, Ltd., the controlling corporation. As remarked by Mr. Atherton on the occasion, the opening of what will eventually become a gigantic industry in this far away portion of the Australian Commonwealth compels attention to the mountains of wealth yet to be discovered in this great, but as yet little known, continent. The Minister also made special mention of those who brought the Mount Isa enterprise to fruition when the prices of metals were at the lowest ebb, and said that no body of men were more eminently fitted to do justice to the country's proud heritage than the company which had undertaken a colossal task and had now started the wheels of industry revolving in the far north-west of Queensland.

Mining Work at Mount Isa.—In the mining sections at Mount Isa development work continues in the mine at Lawlor's foot-wall and hanging-wall levels on the Rio Grande lode, and north and south from the hanging-wall cross-cut. On the Black Star lode, stoping is in progress at Doherty's shaft over the Nos. 3 and 2 levels. In May sub-levels were being connected at Nos. 4 and 1 levels. Near Lawlor's shaft ore is being transferred from the surface to the main haulage level by means of a scraper, which drags the material from the dump into a winze connected with the level below. Six glory-holes are being worked. Ore

transport, which began on May 6, has been proceeding smoothly at the rate of about 770 tons a day and full capacity is being gradually approached as circumstances permit.

Overseas Capital for Mining.—Mr. H. T. Price, representing a strong financial group in London, has just arrived in Brisbane to investigate gold-mining in this State, with a view to British money being invested in that industry here. As a preliminary measure, Mr. Price has formed a small syndicate in Sydney for the purpose of acquiring suitable properties. He says that an abundance of British capital is available for genuine mining development in Queensland. The interests of this syndicate, he states, will be watched by the British Australian Syndicate, Ltd., which has recently been registered, and which has already conducted preliminary exploration in North Queensland. Special attention is being directed towards the old Palmer goldfield in the extreme north.

The Mount Coolon Options.—The British company, Gold Mines of Australia, Ltd., under the terms of its option, is pushing ahead with prospecting and development work at the Mount Coolon goldfield, inland north-westerly from the port of Bowen, North Queensland. The main shaft, at latest reports, was down 300 ft., drives had been put in each way 100 ft., and the lode had been cut in a cross-cut at 78 ft. A further distance has to be driven on the lode in order to connect up with two other shafts (the Red and the White) as well as with the workings in the Dig Again mine. In September last it was announced that this company had exercised their option over the Mount Coolon Gold Mining Company's property, and are holding further options with a view to purchasing the Native Bear mine and mill, as well as over the Dig Again mine. The work on hand is the sinking of the Red shaft of the Mount Coolon Company and the Kangaroo shaft of the Dig Again mine.

A Promising Outlook.—The State Minister for Mines in Queensland (Mr. A. E. Atherton), after a six weeks' tour in the North, speaks very hopefully of the prospects of gold-mining in that region. He noticed a great revival in prospecting, and, in consequence of what he saw, expects that the gold yield of this State for 1931 will be materially greater than for several years past. As an instance of encouraging finds of gold that are likely to develop satisfactorily, the Minister mentions a crushing of 9 tons 13 cwt. of quartz, taken from a claim at Reid River, in the Charters Towers district, which yielded an average of 14 oz. of gold, worth £3 3s. an ounce, to the ton. From another place (Lolworth Creek, 70 miles from the once famous Charters Towers goldfield), a trial parcel of ore, on being crushed, returned about 3 oz. of gold, worth £4 an ounce, per ton.

Queensland Coal Industry.—The Queensland Government have called for tenders for the purchase of one of the three State coal mines held by the State—the Styx No. 3, situated on the north-coast railway between Rockhampton and Mackay. The No. 2 State mine at this place was closed down after a loss of £71,492 had been incurred, on account of the disturbed nature of the seam being worked. On No. 3 the loss has been nearly £71,500, although of late years there has been a small but decreasing profit. The two other coal mines owned by the State are the one on the Bowen field and the Mount Mulligan, further north, near Chillagoe. Till the end of the last financial year, the former had to its credit a profit of £49,000, but up to the same date the Mount Mulligan mine had suffered a total loss of £177,692. Another State mine—that at Baralaba, in the Central district—was destroyed by floods after it had cost the country £57,579. Mount Mulligan is now being worked on tribute by men, working on the co-operative principle, who had been employed by the Government in the mine. On the whole, the net result of Queensland's experiments in State coal mining has been a loss, up to June 30, 1930, of £324,478. In connexion with the Queensland coal industry, the Federal Government is obtaining a report from the Council for Scientific and Industrial Research on the question of whether the vast coal seams of Central Queensland, including brown, bituminous, anthricitic, and semi-anthricitic coal, are suitable for the extraction of petrol by the hydrogenation process.

Broken Hill Central Power Plant.—The Western New South Wales Electric Power Proprietary, Ltd., was formed by three Barrier companies—North Broken Hill, Ltd., Broken Hill South, Ltd., and the Zinc Corporation, Ltd.—to erect a central plant at Broken Hill to supply power to the mines of those companies. It is now reported that good progress has been

maintained with this undertaking. The new plant will consist of five units and the first of these is expected to be in operation in the first week in July. Each of the other four will be brought into commission as it is finished. One effect of the plant will be to reduce working costs.

Broken Hill Block 14.—At the half-yearly meeting of the Broken Hill Block 14 Co., held in Melbourne early this month, the chairman of directors (Mr. T. B. Birkbeck) stated that, owing to the low price of metals and the high cost of production, the company's mine had been closed down since July last. Both the mine and plant are being kept in such a condition that work can be resumed at short notice as soon as conditions become favourable. The total net loss for the half year amounts to £8,244.

Bendigo Goldfield.—One result of the move launched recently to revive mining at the old Victorian Bendigo goldfield is that a company is being formed, with a capital of £10,000, to work the South New Moon mine at Eaglehawk, which was formerly a rich producer of gold. It is stated that the new company will acquire a lease, now held by Mr. C. Martin, on the Golden Gully line of reef, about a mile north of Eaglehawk. It is intended for the present to confine work to levels in the existing workings above that at 500 ft.

VANCOUVER

July 8.

General.—While gains have been recorded in metal prices during the past month yet, with the exception of the Consolidated Mining and Smelting Company, lead and zinc mines in British Columbia are not in a position to derive immediate benefit from the recent improvement as it will require a very considerable advance in price levels to warrant a resumption of activity at most of the smaller mines.

Copper Mines.—In view of the serious decline in market value for their product, the dividends recently declared by the Howe Sound and Granby companies for the second quarter of the current year, albeit at reduced rates, must be regarded as satisfactory and made possible by the exercise of every economy and careful administration. In the case of the former, the rate of 50 cents compares with 75 cents for the previous quarter, while the Granby dividend has been reduced from 50 to 25 cents. Although Howe Sound has found it necessary to suspend work at its Chelan property in the state of Washington, it is gratifying to know that even when copper fell to below 8 cents, this company announced its intention to continue operations at the Britannia mine.

The Kootenays.—How materially the Sullivan mine contributes to the leading position held by the Consolidated Mining & Smelting Company in the mineral industry may be recognized from the fact that to the end of 1930 this mine produced 12,004,559 tons out of 19,989,036 tons obtained from all the company's properties since 1894. In recent years the proportion of the Sullivan's output has been much greater, the figures in 1930 being 1,924,017 tons compared with 2,100 tons from the other mines. This mine is rated as the largest zinc producer and one of the great lead mines of the world and, while no statement as to ore reserves has ever been published, it is believed that these are ample for longer than the life of the present generation. The Consolidated Company has recently acquired control of the Pacific Coast Terminals, situated on the Fraser river at New Westminster. For some years the greater part of its bar metal products has been shipped through this port, where comparatively light harbour dues obtain, and this factor has contributed to the decision to utilize these facilities for the export of fertilizers from the new plant at Trail. By taking over these premises, which comprise extensive water-front property, equipped with docks, warehouses of modern construction, and railway terminal, the Consolidated has secured adequate storage accommodation and handling facilities for the conduct of its own export business.

Nelson.—At the annual general meeting of Reno Gold Mines Ltd., held in Vancouver on June 17, Sir Kenneth I. Crossley, Bart., was elected president and Mr. O. C. Thompson re-appointed managing director. The auditor's report for the 16 months' period, January 1, 1930, to April 30, 1931, shows that, after provision had been made for depreciation, depletion of mine property and taxation, there remained a net profit of $14,460·75. From this sum, when the deficit as at December 31, 1929 amounting to $3,698·33, was deducted, there remained a surplus of $10,762·42. The management reports that development in the sulphide zone on the 4th level is opening a more uniform and higher grade shoot of ore than that

encountered in the oxide region. A start has now been made with No. 5 tunnel at mill-site elevation and a systematic programme of lateral prospecting by portable diamond drill inaugurated.

Bridge River.—Development at the Pioneer mine during the past month would appear to have added materially to the intrinsic value of that property. The drift on the 8th level has now been extended into the recently acquired Countless claim, which covers the prolongation of the diorite stock to the north-west. It is stated that ore of considerably higher grade than the run-of-mine average has been encountered in the course of this development. A bullion recovery in excess of $60,000 for the month of June represents a record production in the history of the company, which made its second quarterly distribution of 3 cents per share on July 2. As a result of the success attending the Pioneer Company's operation, considerable interest has been displayed in the potentialities of neighbouring properties. On the P. E. mines, Ltd., group adjoining the Pioneer to the south-east, some exploratory work is in progress. At the Lorne mine, now controlled by Bralorne Mines, Ltd., development of the King vein is proving encouraging and on the holdings of the Bridge River Consolidated Mines, Ltd., work has been started by the new management.

Placer Mining.—The report of spectacular gold finds in the gravel beds along Rainbow creek in the Nation river area of the Omineca Mining Division led to a migration of miners and fortune seekers almost comparable with the stampedes of early days. A feature of these deposits is the occurrence of black sand carrying values in gold, platinum, and iridium, some of the returns being phenomenally high. Placer leases have been staked along the creek for a distance of 20 miles, where it is estimated that approximately 200 men are now at work. Later advices, however, rather discount the importance of these discoveries and, while the district is considered to offer excellent prospects, the Mines Department points out that it is one that requires systematic development prior to profitable exploitation. Placer gold was first discovered in British Columbia in the late fifties. In the year 1868, when the Cariboo rush had reached its height, those bonanza deposits yielded nearly $4,000,000. Since that time the output has steadily dwindled, the production for the past year being slightly in excess of $152,000. The present activity marks the first real revival in this the original source of mineral wealth in the Province. More immediate, and perhaps more tangible results may be anticipated from the series of drilling tests that are being continued by the Consolidated Company on the Slade creek deposits in the Manson creek area. These gravels have been under investigation for several years, their development being regarded with much interest by the Department, as a special study of this area in 1924 led to the conclusion that a very considerable portion could be profitably dredged. On Germansen creek, also a tributary of Manson creek, drilling tests are in progress to determine the feasibility of large-scale operations. While the Omineca division is said to be the most active in placer prospecting at the moment, much work is going on in Cariboo, Atlin and the other well known areas. Hydraulic mines are generally having a good season, with many enterprises approaching the production stage.

Non-Metallic Minerals.—A comprehensive survey of the non-metallic mineral resources of the Province has been authorized by the Hon. W. A. McKenzie, Provincial Minister of Mines. In addition to the collection of data, the problems relative to the preparation of various materials for market will be investigated and in these matters the active co-operation of industrialists and mine owners is to be enlisted. This province possesses considerable deposits of magnesite, ceramic clays, soda, mica, bentonite, diatomite, high quality limestones, rock and earth pigments, and asbestos, which are considered to warrant commercial development. The output of structural material in 1930 amounted to $4,092,563 and other non-metallic minerals produced were valued at $436,234.

TORONTO

July 17.

Porcupine.—The output of the six producing gold mines of the Porcupine area during June was valued at $1,584,020 from the treatment of 264,823 tons of ore as compared with $1,415,905 produced from 256,007 tons in May. The operating statement of the Hollinger Consolidated for the first six months of the year shows production valued at $4,862,687 as compared with

$10,263,594 for the previous full year. The falling off in the output is due to the carrying out of the programme of development including the preparation of the Schumacher shaft to start production for the first time, which necessitated a curtailment of operations on the levels from the main shaft. Profits amounted to $1,503,469, as against $4,083,861 for the full fiscal year. The Dome Mines during June produced bullion to the value of $328,700, the highest monthly rate this year. For the first six months of the year production reached a total of $1,758,340, with the mill handling approximately 44,000 tons of ore per month of an average grade of $6·35 per ton. Underground development is proceeding satisfactorily, and new ore is being broken out in sufficient tonnage to maintain mill operations at the current level of 1,500 tons per day. The new mill of the McIntyre is running satisfactorily treating about 1,200 tons a day and in a few weeks will be running at its rated capacity of 2,000 tons. With the new mill in operation and practically all construction completed the company is now in a position to carry out its programme of expansion which calls for 10 miles of underground development per annum. Diamond drilling at the 4,025 ft. level has encountered high-grade ore and drifting at the 3,750 ft. level has opened up ore running about $7·50 per ton. The net earnings before depreciation for the quarter ending June were $461,470, as compared with $484,035, for the corresponding period of last year. During the quarter ending June the mill of the Vipond treated 25,802 tons, with a recovery of $142,000. The Porcupine Crown has been dewatered and connexions made with the workings at the 1,000 ft. level. Cross-cutting is being carried on at the 1,450 ft. level to reach the downward continuation of ore-bodies. Production at the Coniaurum continues at the rate of about $60,000 per month and operating costs have been steadily reduced until they are now down to about $4·50 per ton. Development results at the 2,250 and 2,500 ft. level have been somewhat disappointing as the ore below the 2,000 ft. level has proved to be erratic and mineralization at this horizon appears to be lean. The March mine is maintaining production around $20,000 monthly, while operating costs have been steadily reduced to approximately $4·00 per ton. The directors are planning to obtain additional capital in order to open up new levels. The new pilot mill of the Canusa is almost completed and will shortly be in operation. A raise from the 100 ft. level is in ore. The old Ankerite mine is being dewatered with a view to the resumption of operations.

Kirkland Lake.—The output of this field during June was valued at $1,886,233 from the treatment of 144,415 tons of ore as compared with the production in May of $1,865,241 from the treatment of 148,390 tons of ore. The Lake Shore has greatly increased its output, the figures for June are not yet available but it is understood that they will reach approximately $1,000,000, the improvement being due to the higher grade of the ore going to the mill. The mill is treating between 2,100 and 2,200 tons of ore daily. Ore dimensions and values below the 1,400 ft. level show improvement. In addition to the three parallel veins which constitute the main workings, and will be opened on five new levels, a large ore-body indicated by diamond drilling carrying high gold content will be tapped by a winze. Wright-Hargreaves is pushing development operations on the 2,700 ft. level and opening up good ore, values in some sections running from $20 to $35 per ton. A second shaft is to be sunk to a depth of 4,000 ft., work on which is expected to be well under way before the end of the year. The Teck-Hughes is taking good ore from the 3,600 ft. level, where at present work is being centred on a section that is returning average values of over $20 to the ton in gold. As work proceeds downwards, mineralization continues to show improvement. Production by the Kirkland Lake gold mine is well maintained, mill heads now running more than $12·50 to the ton. Mining operations are revealing better values than at any former time. The opening up of the 3,875 ft. level has disclosed ore of a grade that is considerably above the mine average, although the mineralization is somewhat erratic. At the Moffatt-Hall drifting on the 150 ft. level has disclosed a vein running $21·50 to the ton in gold over a width of 5½ ft. The shaft will be put down to a depth of 500 ft. The mill of the Barry-Hollinger is treating between 90 and 100 tons of ore per day with mill-heads running from $8 to $10 per ton. An ore-body stated to be 30 ft. in width and carrying gold content of $12 to the ton is being opened up on the 1,875 ft. level. The Bidgood is making good progress in shaft sinking which has now reached the

275 ft. level, where cross-cutting is being undertaken. A programme of deeper development will be carried out.

Rouyn.—The Noranda mine is steadily increasing its production of gold while curtailing its copper output. The gold produced during the month of June amounted to approximately $500,000 and the figures for this month will run close to $600,000. Underground development below the 1,475 ft. level is entering the new ore zone indicated by diamond drilling earlier in the year. The ore is opening up well and in some sections extends over widths of from 25 to 200 ft. Several millions of tons of new ore are indicated of a grade which compares favourably with the average run of the mine. The formal opening of the refinery of Canadian Copper Refiners, Ltd., at Montreal east, in which the Noranda has a controlling interest, took place on June 25. It represents an expenditure of over $3,000,000 and has a rated capacity of 75,000 tons of refined copper per annum. At present, however, it is on a production basis of 40,000 tons yearly. The new refinery will also have a large output of gold, for the treatment of which some additional plant will be installed. The mill of the Siscoe gold mine is operating at the rate of 160 tons of ore daily with an output of approximately £70,000. The management have under consideration an increase in the mill capacity to 500 tons per day. Three levels have been opened up on the ore zone and a station is now being cut at 600 ft. Some promising new sections have recently been opened up. At the Granada Rouyn bullion production is stated to be running from $25,000 to $30,000 per month. The mill is treating about 70 tons per day of $14 ore. A proposal for the reorganization of the company, increasing the capital from $1,000,000 to $1,500,000 and changing the name to the Granada Gold Mines, Ltd., has been approved by the shareholders, and the additional capital thus secured will enable the management to carry out a programme of deeper mining.

Patricia District.—The annual report of the Howey Gold Mines, Ltd., for 1930 stated that milling started on April 1, and that by the end of the year 110,748 tons had been milled with a production of $160,428, recovery averaging $4·17 per ton, and operating charges amounting to $4·23 a ton. For the first five months of 1931 production totalled $313,768, to yield an operating profit of $27,601. Ore reserves above the 1,000 ft. level were sufficient to keep the 500-ton mill in operation for three years. The management plans the installation of new equipment to increase the mill capacity to 900 tons of ore per day. Patricia Lake Birch is carrying out surface exploration on its property and preliminary shaft sinking will soon be started. Surface work has opened up some important showings which the company proposes to explore underground.

Manitoba.—Hudson Bay Mining and Smelting Company is continuing its rate of operations at 3,000 tons per day despite the present low price of copper. The company treats its own zinc concentrates at the plant, turning out slab zinc which is almost 99% pure. Copper is shipped from the Flin Flon in the form of blister which is treated in the refinery of the Canadian Copper Refiners. The tailings from the mill operation are treated by the cyanide plant on the property, where gold and silver are removed in sufficient quantities to make this extra operation profitable. The Sherritt-Gordon is operating steadily. The first unit of the mill is running somewhat above its rated capacity of 600 tons of ore per day. Shipments of concentrate are going forward regularly to the Flin Flon smelter and are stated to average more than 24% copper. Some improvement has also been shown in gold production. Development is being actively carried on at Gem Lake in the Central Manitoba field. Shaft sinking is under way and two new levels at 625 and 750 ft. will be opened up by about the last of October. Cross-cutting under Kickley Lake will also be undertaken to explore favourable sections to the south of the present centre of operations. The Amisk Gold Syndicate, holding 37 claims in Saskatchewan about 12 miles from Flin Flon, is planning extensive development work there. Machinery and equipment costing approximately $250,000 will be shipped from England, including a rock drilling outfit, with compressor, capable of handling 90 tons per day. Two shafts have been put down to depths of 114 and 240 ft. respectively, and have revealed gold values assaying $15 to the ton.

New Beryl Mining Industry.—The occurrence of beryl in considerable quantities in Renfrew County, Ont., has been known for some years. Attention has lately been attracted to these deposits by the demand

for beryllium for industrial purposes, especially in the manufacture of areoplanes. The Madewaska Syndicate, a group of Toronto capitalists, has secured a tract of about 10,000 acres and are now carrying on active exploration at three different points. The beryl has been analysed and found to contain 6% beryllium. Hitherto the use of this metal has been restricted owing to its high costs, but the syndicate expects to be able to put it on the market at considerably less than the present quotations and to build up a new and profitable industry.

JOHANNESBURG

July 9.

Phenacite in the Transvaal.—It is reported that phenacite, carrying beryllium in payable quantities, has been discovered in lode form on a farm in north-eastern Transvaal. This is the first known occurrence of phenacite in South Africa. Samples of the phenacite are reported to have assayed from 12·80 to 15·45% beryllium, and tests have shown that almost 100% of the metal can be extracted from the ore. The occurrence has been proved over a distance of a mile and a half.

Interesting Finds in Rhodesia.—A Bulawayo correspondent tells an interesting story concerning a discovery which has been made on claims near the Sabiwa, in the Gwanda district, Southern Rhodesia. The property is said to be the "Old Berlin claims." Legend surrounds the "Old Berlin." The story runs that in the very early days, before the Matabele rebellion, a very rich strike was made in the locality by a lone prospector. He, it is stated, disappeared during the rebellion, and was never seen again. He is said to have confided to an intimate friend that he had discovered a reef of great value, and that before being driven out by the rebellion he had concealed his discovery and had buried gold of considerable value. Since those days many a miner and syndicate have set out in quest of the treasure, but in vain. Whether the recent strike be the mine in question or not, there is certainly reason to believe it is of much value, for, although the reef at present has not the appearance of being a big one, the values are said to be as high as 57 dwts. Reports carrying news of great potential importance are current in Gwelo regarding gold mining developments in the midlands. The chief item, which is really big if it has substance, is that Mr. Kirton, one of the joint vendors of the Sherwood Starr Mine to the London and Rhodesian Mining and Land Company, has discovered a similar formation—jasperite—on his farm near Umvuma.

A Rhodesian Gold Bounty (?)—It was stated recently in the Legislative Assembly of Southern Rhodesia that last year £274,000 was spent by the Government on 2,700 farmers. At the annual meeting of the Salisbury Chamber of Mines the president (Mr. Digby Burnett) pointed out that if £274,000 were spent on the colony's mining industry it would be equal to a bounty of 10s. per oz. on the gold produced. "What mining development would take place if such a bounty were offered!" Mr. Burnett exclaimed. "I say without fear of contradiction that £100,000 or £200,000 spent annually in the form of bounties per ounce on gold produced on low-grade mines would be money well invested and better invested in all probability than half the present annual expenditure on the Agricultural Department, and I maintain the farmers would automatically reap benefit from the increased prosperity this would bring about."

Northern Rhodesian Gold.—Reports of gold discoveries in Northern Rhodesia have appeared in the Rhodesian and South African newspapers during the last few weeks. It is stated that the Luiri Gold Areas Company has struck a rich leader in a hill six miles north-west of Matala, and that rock therefrom is being transported to the company's plant for treatment. Mr. P. K. Horner, the consulting engineer, has been on a visit to the locality. Touching other new developments in the north, it is gathered from a Broken Hill correspondent that the Rhodesia Minerals people have been very busy of late in the Mumbwa district, particularly in the region of the Nangoma River, east of Luiri. A motor road is now being cleared and there are evidences of potentially important discoveries.

South African Tin Quota.—A letter has been received from the Tin Restriction Committee asking the Union Government to obtain the agreement of the South African tin mining companies to limiting production to 0·65% of the total production, or approximately 956 tons per annum. As some of the Transvaal tin mines are closed down, and the Zaaiplaats and Mutue Fides companies already operating on a restricted scale, there will be no difficulty in obtaining

the consent of the tin industry to the proposed quota. The producers, however, are requesting the Government to obtain more definite information in regard to the future of the quota and the degree to which the latter will be binding in the event of the market improving.

Platinum Outlook Brighter.—The rise in the price of platinum to £8 per oz. has revived hopes regarding the future of the Transvaal platinum industry. There is reason to believe that the sudden and substantial improvement in the market value of the metal indicates that the leading producers have at last reached an understanding regarding stabilization. In any case it is of great importance to the Transvaal's two producing companies—Potgietersrust Platinums and Waterval (Rustenburg) Platinum Mining Co.—as their revenue will be increased by some thousands of pounds per month.

PERSONAL

C. E. Blackett has returned to Western Australia.

H. E. Collins is home from Sierra Leone.

C. H. Feldtmann has left for New Guinea.

Hugh Gemmell is home from Malaya.

J. O. Haselden is home on short leave from Spain.

P. K. Horner has returned from Rhodesia.

W. Harvey Laity has returned from Rhodesia.

C. F. Lloyd-Jones is returning from Iraq.

E. T. Mellor, who is here from South Africa, is returning to Johannesburg in November to set up in consulting practice.

J. R. Miller is home from Malaya.

N. E. Odell is on an expedition to Labrador, from which he returns next month.

M. R. Read is returning from Uganda.

Jack Spalding has left for India.

K. S. Twitchell passed through London from Arabia on his return to New York.

C. L. Williams is home from Ecuador.

Frank Wigglesworth Clarke, of the U.S. Geological Survey, died recently at the age of 84. He was well known among mineralogists and geologists in this country and will be particularly remembered as the auther of a standard work—his "Data of Geochemistry."

John Lyons Agnew, vice-president of the International Nickel Company of Canada, Ltd., died suddenly at Copper Cliff, Ont., on July 9 of heart failure. He was born in Pittsburg, Pa., in 1884 and in 1904 went to Canada and entered the service of the Canadian Copper Company, where his abilities won him rapid promotion in the growing nickel-copper industry of the district. In 1913 he became smelter superintendent, occupying that position during the difficult days of mass production of the war. On the reorganization of the company in 1922 Mr. Agnew became president of the International Nickel Company of Canada, operating subsidiary of the International Nickel Company Inc. of New Jersey. Under his management research work was energetically prosecuted with the object of finding new uses for nickel, the success of which enabled the company greatly to increase its output. The search for new mines was actively undertaken, resulting in the development of the Frood mine, and when the company became amalgamated with the Mond group two and a half years ago Mr. Agnew was appointed vice-president. Mr. Agnew, who was a keen business man, was closely associated with many important mining enterprises and was a past president of the Canadian Institute of Mining and Metallurgy. His death came virtually on the eve of the completion of one of the largest programmes of Canadian industrial expansion, in which more than $50,000,000 has been expended during the past three years in the construction of new plants and mining development.

TRADE PARAGRAPHS

Sentinel Waggon Works, Ltd., of Shrewsbury, advise us that D.G. Sentinel waggons are now fitted with pneumatic tyres to meet road traffic preferences in this country and that the permissible laden weight has been increased by amended legislation in this country to the extent of an additional 2 tons.

Samuel Osborn and Co., Ltd., of Sheffield, publish a pamphlet devoted to their "Solidend" tools and blanks. These consist of the S.O.B.V. cutting alloy of full section butt welded on to a high tensile steel shank, the welding being done by a special process which secures a complete fusion of metals. Moreover a one inch square tool or blank, for example, has a one inch cube of S.O.B.V. welded on to it. It is claimed that the weld is unbreakable and that these tools can be ground as easily as solid tools. Furthermore, neither forging nor heat treatment has any effect on the weld.

British Engineering Standards Association, of 28, Victoria Street, London, S.W.1, have issued new specifications relating to conveyor troughing for use underground in mines, the sampling and analysis of coal, and boiler and pump tests. The first mentioned has been prepared with a view to securing interchangeability between the troughing used in the various types of shaker conveyors, three capacities of troughing having been standardized. The three types have been so designed that they can all be manufactured from a single set of dies, which should cheapen the cost to the users.

Bureau of Information on Nickel of the Mond Nickel Co., Ltd., of Imperial Chemical House, London, S.W. 1, have issued two further booklets, one devoted to the use of nickel alloy steels in the manufacture of gears and geared units, and the other on the use of similar steels in the "Blue Bird" motor car with which Sir Malcolm Campbell obtained the speed record. More recently they have issued three further bulletins, one devoted to the physical properties of nickel-iron and some related alloys, one to the use of such alloys in low-frequency transformers, and one to nickel and its alloys in chemical plant which, as references elsewhere in this issue show, is published appropriately enough. Their *Nickel Bulletin* for July contains further references to the last mentioned.

Mining and Industrial Equipment, Ltd., of Southampton Row, London, W.C. 1, report

that new orders have been received for the following. For England: Two 18 ft by 10 ft. thickeners and two 50 sq. ft. Rovac filters to deal with flue dust slurry, one 4 ft. by 5 ft. Hum-mer electric screen for ground gypsum, one 4 ft. by 7 ft., 1-surface, type 60, Hum-mer electric screen for power station clinker, one No. 70 "Impax" pulverizer for coal, one 6 ft. by 5 ft., 2-surface, type 39, Hum-mer electric screen for coal, one 3 ft. by 5 ft., type 39, Hum-mer, electric screen for coke, and one 2 ft. by 8 in. Hardinge mill for laboratory use. For South America: Two 6 ft. by 36 in. Hardinge ball-mills for ore, and one 8 ft. by 48 in. Hardinge pebble-mill for ore.

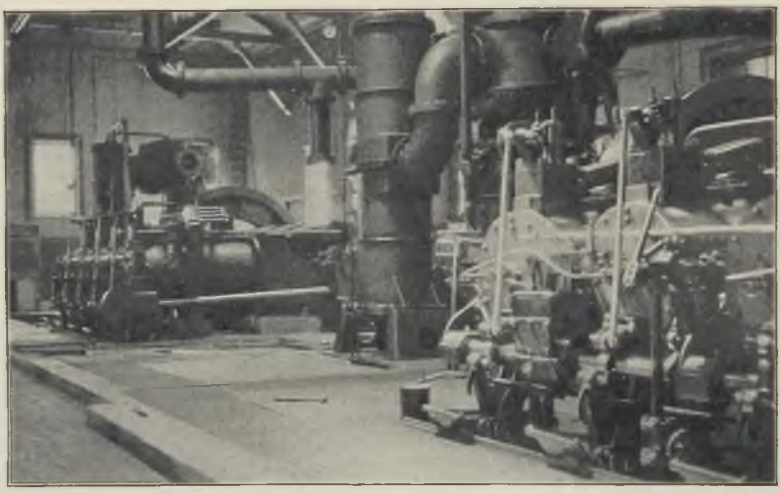
The Premier Gas Engine Co., Ltd., with which is incorporated **Crossley Bros., Ltd.,** of Sandiacre, Notts, in a recently prepared booklet,

BRITISH CHEMICAL PLANT EXHIBITION, 1931

An exhibition of remarkable interest to chemical engineers and metallurgists was held during the week July 13–18 in connexion with the Jubilee Celebrations of the Society of Chemical Industry, referred to elsewhere in this issue. Among many exhibits of special interest to metallurgical chemists the following may be mentioned as of principal importance:

Hadfields, Ltd., of Sheffield. The exhibit by this firm was referred to in these pages last month.

Elliott Brothers (London), Ltd., of Century Works, Lewisham, London, S.E. 13, were showing



CROSSLEY-PREMIER 500 H.P. HORIZONTAL OIL ENGINES AT LAKE VIEW AND STAR MINE.

to which reference was made here last month, publish a number of photographs of the various mining power-plant installations of their manufacture. Reproduced in this issue is a photograph of that at the Lake View and Star Mine in Western Australia. The complete plant consists of two 500 and one 1,000 b.h.p. horizontal oil engines, of which the twin unit is shown here. The twin engines are employed for driving air-compressors and the large single unit is direct coupled to a 620 k.w. alternator.

Dressing and Screening Co., Ltd., of Mansfield Road, Alfreton, Derbys., send us further leaflets relating to their products One of these refers to "Demant" perforated plates and wire mesh having a glass hard surface which ensures a greater resistance against attrition. This in turn increases the life of the screen. The process by which this surface hardness is produced is said to differ from conventional case-hardening practice and is claimed to give an absolutely smooth and uniform surface to the edges of the holes in the perforated plates or to the wire members, as the case may be. The process is also said to yield no adhering scale and so is applicable to fine-dimension sieves. Another wire screen is that which has a heavy lead coating and is suitable for use in handling corrosive chemicals.

a variety of pyrometers and other heat economy and control equipment.

Manlove, Alliott, and Co., Ltd., of Nottingham, were making a particular feature of their "Easifilt" vertical pressure leaf filter and also a laboratory or semi-scale model of the same.

Brown Bayley's Steel Works, Ltd., of Sheffield, were showing corrosion-resisting steels and irons suitable for the manufacture of chemical plant, notably special forms of austenitic steels for resisting severe corrosive attack.

Babcock and Wilcox, Ltd., of Babcock House, Farringdon Street, London, E.C. 4, were displaying representative samples of deep pressings in mild steel as exemplified by a switch-gear box, annealing pot, piston cooling barrel, and a gear case.

W. C. Holmes and Co., Ltd., of Huddersfield, were demonstrating their products by means of cinematograph films, photographs, models, etc., notable among these were Holmes Connersville air and gas meters, exhausters and blowers.

A. Gallenkamp and Co., Ltd., of 1–3, Clifton Street, Finsbury Square, London, E.C. 2, were exhibiting a variety of laboratory apparatus, including a number of electrically heated furnaces with automatic temperature control of great accuracy.

Johnson Matthey and Co., Ltd., of 78, Hatton Garden, London, E.C. 1, besides showing examples of the precious metals with indications of their applications for industrial and research purposes were also exhibiting apparatus made of or lined with silver, suitable for use in certain foodstuffs industries.

G. A. Harvey and Co. (London), Ltd., of Greenwich Metal Works, Woolwich Road, London S.E. 7, were making a particular feature of chemical plant which is a department of their constructional metal work which has increased in importance in recent years. They were also showing examples of woven wire and perforated metal work, as usual.

Huntington, Heberlein, and Co., Ltd., of 47–51, King William Street, London, E.C. 4, were showing the H.H. jigging screen and an H.H. vibrating screen together with a model of a roasting furnace. The principal feature of their vibrating screen is the simple means of operation, the machine being driven by a special kind of high-speed unbalanced pulley.

The Dorr Co., Ltd., of Abford House, Wilton Road, Victoria, London, S.W. 1, were demonstrating their well-known ore-dressing equipment by means of a number of models, notably the bowl classifier, the rotary vacuum filter, and the principle of counter current decantation and washing processes as applied, for example, to the production of caustic soda and phosphoric acid.

Mond Nickel Co., Ltd., of Imperial Chemical House, Millbank, London, S.W. 1. The exhibits on this stand comprised a variety of samples of pure nickel, Monel metal, and nickel-chromium, corrosion-resisting steel, both in the partly and the fully manufactured forms, together with photographs showing typical applications of these materials in all branches of chemical engineering.

Tungstone Patent High Pressure Die Casting Co., of Market Harborough. This exhibit is worth mentioning on account of a remarkably ingenious pump for handling corrosive and erosive liquids, the distinguishing feature of which is that it is without piston and, in fact, operates by means of a series of controlled impulses of compressed air, the control of the impulses being effected by means of non-return ball valves.

Thomas Firth and John Brown, Ltd., of Sheffield, were showing a complete range of chemical plant and equipment manufactured from their well-known Staybrite acid-resisting steel and H.R. Crown heat-resisting steels. Their new F.D.P. steel besides being corrosion resisting, in common with others in the nickel-chromium series, resists disintegration and so does not require heat treatment during fabrication into requisite shapes.

Gwynnes Pumps, Ltd., of Hammersmith, London, W. 6, were showing Gwynne-Doulton centrifugal pumps which are specially designed for dealing with acids and other corrosive chemicals, being lined with stoneware on all those parts which come into contact with liquors. Both single and two-stage units were demonstrated, designed for continuous operation and suitable for heads of 10 to 90 feet and also another type suitable for heads of from 50 to 150 feet.

Thomas Broadbent and Sons, Ltd., of Huddersfield, were making a special feature of a small scale working model of a continuous self-discharging centrifugal separator for treating slurry of all kinds containing up to 10% of fine solids. Such a machine is capable of treating coal slurry at the rate of 2,000 gallons per hour and during a recent test the effluent water was found to contain not more than 1% of solid matter, while the recovered coal dust delivered from the machine had a moisture content of about 20%.

Baird and Tatlock (London), Ltd., of 14–17, Cross Street, Hatton Garden, London, E.C. 1. Of particular interest on this stand was a demonstration designed to show the great strength of a new grade of the well-known Whatman filter paper, the wet strength of which is given as eight to nine times that of a good filter paper of similar thickness. Furthermore, this paper resists the action of NaOH in all usual concentrations. Whatman filter papers are manufactured by W. and R. Balston, Ltd., and sold by **H. Reeve Angel and Co., Ltd.,** of 9, Bridewell Place, London, E.C. 4.

Silica Gel, Ltd., of Bush House, London, W.C. 2, occupied a stand to demonstrate air dehydration, solvent recovery, and other applications of this remarkable silica reagent, the function of which is to adsorb moisture. Thus to exemplify but one application, air which requires dehumidification is passed through compartments packed with the gel which is capable of adsorbing moisture up to 99% of that present and which can be reactivated (i.e. when it has become saturated) by passing a flow of hot air through the adsorption cells. It is also useful for benzole refining and refrigeration processes.

RUSTON-BUCYRUS No. 4 EXCAVATOR

In the June issue of the MAGAZINE reference was made here to an important modification in the design of the Ruston-Bucyrus ½-yard universal excavator. We have now received from the company's head office at Lincoln the complete catalogue of the new machine from which it is evident that the modification referred to is but one of a number of improvements effected in the design of this useful machine, of the various previous types of which 700 have been manufactured—450 having been sold in this country.

Dealing first with change in the mounting, to which some attention has already been given, this involves not only the substitution of chain for gear drive on the travelling gear but also a completely new type of bottom frame which is now of cast steel, and improved caterpillar mounting which affords greater ground clearance. There is now less bearing pressure on the ground.

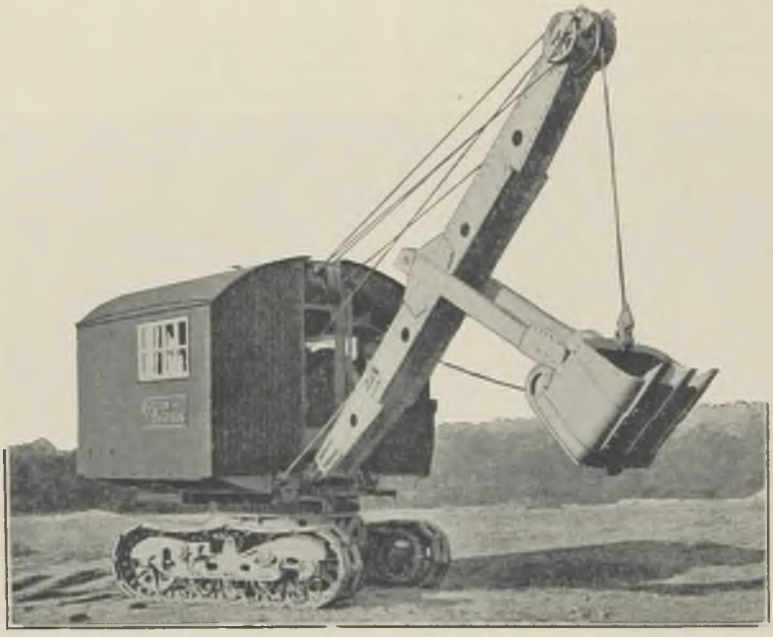
The front end has also been modified. In the case of shovels a new box girder boom which is light but strong has been incorporated. Its reduced weight, without loss of strength, permits higher slewing speeds coupled with reduced digging stresses. The shovel bucket of mild steel with cast steel back is of new shape to give increased strength and efficiency. A foot-operated brake is fitted to the drum which operates the derricking of the boom. In the case of draglines, the boom is now 30 ft. in length instead of 28 ft. as heretofore. The dragline bucket has also been strengthened. In the case of the trench digger the increased length of boom permits the excavation of a trench 2 ft. deeper than formerly.

The drive of these excavators is from petrol-paraffin engines of the Dorman type, or Diesel engines of Ruston and Hornsby manufacture, or they may be electrically operated. In the case of

the Diesel drive a small petrol engine starting equipment can be supplied if desired. The machine as a shovel is illustrated in the accompanying photograph.

THE WATTS VARIOMETER

E. R. Watts and Son, Ltd., of 104, Victoria Street, London, S.W.1., have published a new catalogue of their surveying instruments. This deals more particularly with their vertical magnetic force variometer for use in geophysical prospecting by the magnetic method. This is a new instrument which has but recently been perfected, and for which the magnets are made by the **Cambridge Instrument Co., Ltd.,** another British concern which has turned its attention to the manufacture of the delicate apparatus required for work of this description.



RUSTON-BUCYRUS No. 4 ½-YARD SHOVEL.

The Watts variometer, which is illustrated in the accompanying drawing, is of an improved type, which embodies a number of refinements leading towards increased precision, convenience in operation, and portability. It is made in three parts—the instrument proper, the centre-work or base, and the tripod. The reading of the instrument consists of observing an image of the scale of an auto-collimating telescope, reflected by a mirror which is carried on a horizontally pivoted magnet system. Observations are made by reading the image against the scale proper. The difference between observations made at various stations is a measure of the difference in the vertical magnetic force at those places. The scale has plus and minus 20 graduations, a deflection of one division being equal to about 30 gamma.

The magnet system consist of two flat magnets of cobalt steel mounted horizontally and parallel to each other upon a central block of elektron. This is provided with quartz knife edges which when in use rest upon two cylindrical quartz bearings enabling the magnets to balance freely Damping is supplied by heavy copper dampers partially enclosing the ends of the magnets. The elektron block carries adjustable balance weights in the form of headless screws for the adjustment of the magnet (gravitat onally) and the calibration of the scale divisions. The magnet may be adjusted to any given vertical intensity, which should be stated at the time of ordering the instrument. Unless otherwise ordered, the instrument is set so that its zero reading corresponds to the vertical intensity of approximately 0·43 Gauss.

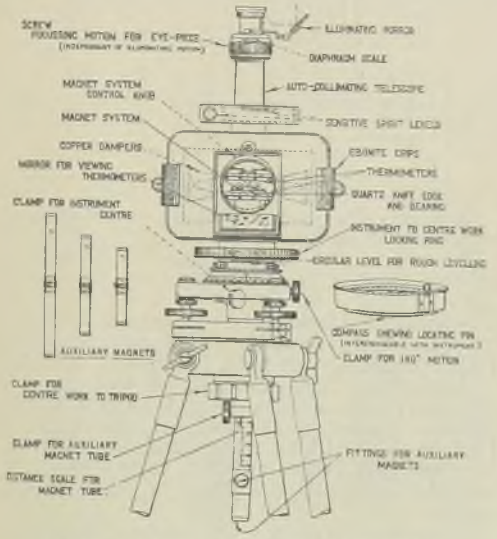
On the top face of the block is a small mirror which reflects back the image of the diaphragm scale. The magnet system is raised from its bearings by a small table with three adjustable points connecting with corresponding slots under the elektron block and operated by an external knob. This latter has a cam connexion by means of which, in lowering the magnet, the motion is rapid at first and then more gradual as the knife edges approach the bearings. The external knob is provided with a safety catch, which, when in action, prevents the magnet being lowered accidentally.

Two thermometers are fitted in the box containing the magnet system, having a range from −10° to 20° and from 20° to 50° C. In order to insulate the magnet as far as possible from variations in temperature, the metal casing is totally enclosed in a closely fitting cork-lined outer casing which is removable in two sections. A mirror is provided in the outer casing, coincident with a glass window in the inner box, by means of which the thermometers may be observed from the eyepiece end of the telescope. Ebonite grips are fitted to the outer casing further to insulate the instrument from temperature changes through handling. Two sensitive spirit levels, entirely enclosed in a special mounting, are fitted above the casing.

The auto-collimating telescope consists of an objective, set for infinite focus, a diaphragm scale, and a Gauss eyepiece. This latter has an unsilvered mirror through which the observer views the scale and which at the same time reflects light from the illuminating mirror on to the scale. Screw focussing which does not revolve the eyepiece itself is provided, and in addition the small illuminating mirror revolves with the illumination hole without affecting the focussing.

The instrument is attached to the centre-work by three pegs which enter three holes in the head plate and are locked by a small movement of the locking ring. A fourth peg is provided to ensure that the instrument is in its correct position.

The centre-work has three levelling screws protected from dust and adjustable for wear.



WATTS VERTICAL FORCE VARIOMETER.

The head plate revolves on a vertical axis and is clamped by a scolloped head screw. An arrangement of stops is provided so that this plate carrying the instrument when oriented may be turned exactly 180° without reference to the circle. This enables the two readings at magnetic East-West and West-East to be taken with the minimum of instrument manipulation. A readily operated joint enables the centre-work to be attached quickly to the tripod and during the course of a survey it can remain so attached, but on the completion of the survey or the transference to a new area the centre-work should be detached and packed in the case with the instrument. This ensures protection from damage to all working parts of the variometer during transport.

Beneath the centre-work is a telescopic tube graduated with a scale of millimetres (270 to 360) which receives the standard auxiliary magnets. These are used to bring the scale into view under strongly magnetic conditions, whereby the useful range of the instrument is very considerably extended. The figures of the scale represent the distance in millimetres between the centres of the magnet system and the auxiliary magnet. Three auxiliary magnets are provided, the constants of which are given in the certificate, and which, when not in use, are kept in the instrument box in soft iron tubes.

A 3-inch circular compass, interchangeable with the instrument on the head plate of the centre-work, is provided for the orientation of the latter into the magnetic meridian.

The tripod is of open frame design, light but very rigid, with three sliding legs.

METAL MARKETS

COPPER.—The general trend of the copper market was downwards during July, sentiment having been adversely influenced by the haggling over the Hoover proposals and the grave economic troubles in Germany, which country is such an important factor in this market. Electrolytic copper in New York receded from 8·75 cents to 8 cents during the month and Standard values in London also lost considerable ground. With stocks excessive and industrial demand subdued, the future of the market is likely to depend largely on international political developments.

Average price of Cash Standard Copper: July, 1931, £34 9s. 1d.; June, 1931, £35 17s. 6d.; July, 1930, £48 6s. 10d.; June, 1930, £50 1s. 4d.

TIN.—Despite the fact that at times it showed signs of latent strength, the tin market last month was definitely easier, confidence having been undermined by the unfavourable German developments. With Siam now included in the Tin Restriction Scheme, the latter is pretty water-tight however and naturally the market now expects to see the definite effects of the restriction measures manifested in a stronger statistical position. Given a little luck, the "bulls" may shortly find their long spell of disappointment broken, although, of course, the general world position is not favourable to firm commodity markets at present.

Average price of Cash Standard Tin: July, 1931, £111 11s. 1d.; June, 1931, £105 0s. 8d.; July, 1930, £134 11s. 10d.; June, 1930, £136 7s. 8d.

LEAD.—The tendency of this market during July was easier, despite the fact that confidence was assisted by the further agreement reached amongst producers to increase the rate of output-curtailment from 15 to 20%. It is possible that this measure may, unless world consumption shrinks further, eventually bring supply into closer equilibrium with demand. In view of the unsettled world political and economic situation, however, one must continue to regard the outlook with a certain degree of caution.

Average mean price of soft foreign lead: July, 1931, £12 16s. 3d.; June, 1931, £11 15s. 4d.; July, 1930, £18 2s. 2d.; June, 1930, £17 19s. 4d.

SPELTER.—This market was also rather easier during the past month despite the fact that the international meeting of producers at Ostend decided upon the formation of a Cartel which should immediately take measures to enforce a general output-reduction of 45% on the basis of the best individual quarterly production during 1927–30 and to take care of the stocks. Industrial buying, however, has remained disappointing on the whole, which is not to be wondered at in view of the tangled and gloomy international economic position.

Average mean price of spelter: July, 1931, £12 10s. 9d.; June, 1931, £11 10s. 2d.; July, 1930, £16 9s. 5d.; June, 1930, £16 14s. 7d.

LONDON DAILY METAL PRICES.

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

	COPPER.				TIN.		ZINC (Spelter).	LEAD.		SILVER.		GOLD.
	Standard.		Electro-lytic.	Best Selected.				Soft Foreign.	English.	Cash.	For-ward.	
	Cash.	3 Months.			Cash.	3 Months.						
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	d.	d.	s. d.
July												
13	33 18 1½	34 11 10½	38 0 0	—	108 12 6	110 7 6	12 7 6	12 11 3	14 0 0	13	13	84 11½
14	33 11 10½	34 5 7½	37 0 0	34 15 0	109 12 6	111 7 6	12 13 9	12 13 9	14 0 0	13 7/16	13 7/16	84 11½
15	33 6 3	34 1 3	37 0 0	—	107 16 3	109 11 3	12 7 6	12 5 0	13 15 0	13 1/16	13 1/16	84 11½
16	33 6 3	34 0 7½	37 0 0	—	108 2 6	109 18 9	12 3 9	12 6 3	13 15 0	13¼	13 1/16	84 11½
17	34 18 9	35 11 3	37 0 0	36 0 0	112 17 6	114 16 3	12 15 0	12 18 9	14 0 0	13	12 15/16	84 11½
20	34 16 3	35 10 7½	37 10 0	—	112 13 9	114 13 9	12 12 6	12 16 3	14 5 0	13⅛	13 1/16	84 11½
21	34 13 1½	35 8 1½	37 10 0	35 15 0	111 16 3	113 16 3	12 8 9	12 17 6	14 5 0	13	12 15/16	84 11½
22	34 3 9	34 18 9	37 10 0	—	110 8 9	112 8 9	12 6 3	12 16 3	14 5 0	13	12 15/16	84 11½
23	33 9 4½	34 5 7½	37 0 0	—	108 8 9	110 8 9	11 15 0	12 11 3	14 0 0	12 15/16	12¼	84 11½
24	33 4 4½	34 1 3	37 0 0	34 15 0	108 2 9	110 6 3	12 0 0	12 11 3	14 0 0	13	12 15/16	84 11½
27	33 0 0	33 16 10½	37 0 0	—	108 13 9	110 13 9	11 15 0	12 10 0	14 0 0	13 1/16	13 1/16	84 11½
28	32 18 9	33 15 7½	36 10 0	34 5 0	108 16 3	110 18 9	11 17 6	12 15 0	14 0 0	12 15/16	12 15/16	84 11½
29	33 2 6	33 17 6	36 10 0	—	108 11 3	110 13 9	11 16 3	12 11 3	14 0 0	12 15/16	12 15/16	84 11½
30	32 14 4½	33 11 10½	36 0 0	—	108 6 3	110 12 6	11 12 6	12 10 0	14 0 0	13 1/16	13 1/16	84 11½
31	32 12 6	33 9 4½	36 0 0	33 15 0	108 2 6	110 8 9	11 5 0	12 5 0	13 15 0	13	13	84 11½
Aug.												
4	32 13 9	33 11 3	35 15 0	33 15 0	110 18 9	113 7 6	11 10 0	12 6 3	13 15 0	13 1/16	13 1/16	84 9¾
5	32 16 3	33 13 9	35 15 0	—	109 2 6	111 11 3	11 3 9	12 6 3	13 15 0	13⅛	13¼	84 11½
6	32 14 4½	33 11 10½	35 15 0	—	108 11 3	111 1 3	11 0 0	12 2 6	13 10 0	13 1/16	13 1/16	84 11½
7	32 11 3	33 9 4½	35 15 0	35 15 0	110 12 6	113 3 9	11 7 6	12 3 9	13 10 0	12 15/16	12 15/16	84 11½
10	32 10 7½	33 9 4½	35 15 0	—	112 11 3	115 1 3	11 7 6	12 2 6	13 10 0	12 15/16	12 15/16	84 11½

Iron and Steel.—The British pig-iron market remained dull throughout July, the industry operating on a reduced basis. No. 3 Cleveland foundry remained unaltered at 58s. 6d. per ton. Finished steel was also dull, especially as British steelmasters decided to make no changes in their fixed prices. Business in Continental steel was interfered with by the dubious Continental situation.

Iron Ore.—This market has been dull and easy with hardly any business passing. Best Bilbao rubio is available at 14s. 6d. per ton, c.i.f. or perhaps a little less.

Antimony.—At the close of July English regulus was quoted at £34 up to £42 10s. per ton. Chinese was quiet, with material for shipment priced at about £20 to £20 10s. c.i.f. whilst spot was quoted at about £22 10s. to £23 5s. per ton.

Arsenic.—Cornish white is in very short supply, being nominally quoted at £20 to £20 10s. f.o.r. mines. High-grade Mexican is priced at £17 5s. to £17 10s. c.i.f. Liverpool.

Bismuth.—Prices were officially reduced during July by 6d. to 6s. per lb. for 5 cwt. lots and over.

Cadmium.—The market has remained dull but steady with the quotation unchanged between 1s. 9d. and 1s. 10d. per lb. according to quantity.

Cobalt Metal.—The price has been reduced to 7s. per lb., with usual discounts.

Cobalt Oxides.—Keen competition remains in evidence. Black oxide is easier at 4s. per lb. and grey at 4s. 9d.

Chromium Metal.—The price is unaltered at about 2s. 6d. per lb., with a moderate demand from users.

Tantalum.—This is a stagnant market, with prices very nominal between £40 and £50 per lb.

Platinum.—Demand has been dull owing to depression in the luxury trades. The official price is steady at £7 14s. to £8 per oz.

Palladium.—Quiet conditions prevail in this market, the value being about £3 12s. 6d. to £4 per oz.

Iridium.—The tendency was easier during July, sponge and powder declining to £18 to £19 per oz.

Osmium.—The market is quiet, with the price steady at £13 per oz.

Tellurium.—There is hardly any business passing, and the price is quite nominal at 9s. 6d. per lb.

Selenium.—Demand is maintained on a moderate scale, and the quotation is steady around 7s. 8d. to 7s. 9d. per lb. ex warehouse, Liverpool.

Manganese Ore.—The market has been idle and easy, buyers being off the market for the present. Quotations are nominally about 11d. to 11¼d. per unit c.i.f. for best Indian, 10¼d. to 10½d. for good 48% Indian and 9¾d. to 10½d. c.i.f. for washed Caucasian, according to quantity and market.

Aluminium.—Demand is restricted, with producers maintaining their quotation at £85 per ton, less 2%, delivered for ingots and bars.

Sulphate of Copper.—British material remains at about £19 10s. to £20 per ton, less 5%.

Nickel.—Makers continue to quote £170 to £175 per ton, according to quantity.

Chrome Ore.—Supplies are in excess of demand, but the price is steady with good 48% ores quoted at 74s. to 75s. c.i.f.

Quicksilver.—At the close of July spot material was valued at £16 15s. to £17 per bottle, net.

Tungsten Ore.—Values experienced a rise during July, but subsequently relapsed owing to the falling-off in the German demand and closed with buyers bidding 13s. 1½d. to 13s. 3d. per unit c.i.f. for August–September shipment whilst sellers' ideas were in the neighbourhood of 13s. 6d. to 13s. 7½d. c.i.f.

Molybdenum Ores.—The tendency has been easy and the current value of 80 to 85% concentrates is now about 28s. 6d. to 30s. per unit c.i.f., although some producers are asking more.

Graphite.—Prices are nominal with about £13 c.i.f. quoted for good 85 to 90% Madagascar flake and £14 to £15 c.i.f. for 90% Ceylon lumps.

Silver.—The price of spot bars opened at 13 3/16d. on July 1, but fell away until 13d. was quoted on July 13, subsequently remaining fairly steady around that level, closing at 13d. on July 31.

STATISTICS

PRODUCTION OF GOLD IN THE TRANSVAAL.

	Rand.	Elsewhere.	Total.
	Oz.	Oz.	Oz.
July, 1930	871,468	41,184	912,652
August	878,474	42,607	921,081
September	860,311	42,865	903,176
October	884,632	41,929	926,561
November	844,038	40,715	884,753
December	867,202	41,290	908,492
January, 1931	873,872	40,704	914,576
February	800,991	38,946	839,937
March	869,331	41,667	910,998
April	840,259	42,078	882,337
May	867,949	42,330	910,279
June	855,073	42,677	897,750
July	872,198	44,645	916,843

TRANSVAAL GOLD OUTPUTS.

	June.		July.	
	Treated Tons.	Yield Oz.	Treated Tons.	Yield Oz.
Brakpan	94,500	£145,029	100,500	£155,771
City Deep	86,500	22,148	87,500	22,146
Cons. Main Reef	65,500	22,313	68,000	22,826
Crown Mines	263,000	82,562	271,000	84,014
D'rb'n Roodepoort Deep	46,300	15,025	47,700	15,456
East Rand P.M.	154,000	41,753	160,000	43,092
Geduld	84,000	26,833	86,400	27,704
Geldenhuis Deep	71,600	16,371	73,400	16,922
Glynn's Lydenburg	6,200	2,194	6,200	2,331
Government G.M. Areas	203,000	£402,005	213,000	£414,634
Kleinfontein	50,600	10,151	52,600	10,882
Langlaagte Estate	76,000	£110,638	80,000	£114,131
Luipaard's Vlei	31,000	7,866	32,500	£34,500
Meyer and Charlton	17,800	£16,988	18,400	£17,577
Modderfontein New	164,000	67,312	169,000	67,866
Modderfontein B	74,000	22,077	77,000	22,788
Modderfontein Deep	44,300	22,397	46,000	23,370
Modderfontein East	72,500	21,520	75,000	21,885
New State Areas	82,000	£171,962	83,000	£172,236
Nourse	70,000	21,126	72,000	21,712
Randfontein	228,000	£262,269	235,000	£266,527
Robinson Deep	97,000	27,921	99,000	28,589
Rose Deep	62,500	13,006	63,200	12,989
Simmer and Jack	81,400	22,422	83,000	22,975
Springs	70,300	£144,996	74,500	£152,729
Sub Nigel	35,000	29,354	36,500	30,608
Transvaal G.M. Estates	15,600	5,121	16,200	4,919
Van Ryn	44,000	£41,764	45,000	£42,611
Van Ryn Deep	62,000	£94,087	64,000	£95,038
West Rand Consolidated	81,000	£91,554	61,000	£65,931
West Springs	70,500	£74,825	74,500	£77,300
Witw'tersr'nd (Knights)	60,000	£51,297	63,000	£54,374
Witwatersrand Deep	34,000	10,043	37,300	11,890

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, 1930	2,549,250	28 7	20 1	8 6	1,084,504
May	2,741,634	28 1	19 8	8 5	1,153,549
June	2,651,970	28 2	19 7	8 7	1,141,197
July	2,706,900	28 5	19 8	8 9	1,184,107
August	2,693,100	28 3	19 6	8 9	1,174,828
September	2,653,250	28 5	19 8	8 9	1,160,430
October	2,741,080	28 5	19 7	8 10	1,212,822
November	2,628,800	28 4	19 7	8 9	1,145,097
December	2,661,200	28 6	19 9	8 9	1,160,548
January, 1931	2,721,316	28 3	19 8	8 7	1,171,456
February	2,481,600	28 6	20 1	8 5	1,045,980
March	2,718,400	28 2	19 9	8 5	1,151,017
April	2,592,800	28 7	20 1	8 6	1,105,711
May	2,751,400	27 10	19 6	8 4	1,149,105
June	—	—	—	—	1,140,399

NATIVES EMPLOYED IN THE TRANSVAAL MINES.

	Gold Mines.	Coal Mines.	Diamond Mines.	Total.
July 31, 1930	201,111	14,670	5,490	221,271
August 31	202,257	14,788	5,754	222,799
September 30	205,061	14,706	5,767	225,534
October 31	206,778	14,482	5,032	226,292
November 30	205,030	13,973	4,748	223,751
December 31	203,473	13,763	4,607	221,843
January 31, 1931	209,442	13,865	4,325	227,632
February 28	209,777	13,740	4,333	227,850
March 31	207,239	13,436	4,106	224,781
April 30	206,770	13,242	4,030	224,042
May 31	207,109	13,305	3,689	224,103
June 30	207,209	13,286	3,345	223,840
July 31	208,155	13,512	1,817	223,484

PRODUCTION OF GOLD IN RHODESIA.

	1928	1929	1930	1931
	oz.	oz.	oz.	oz.
January	51,356	46,231	46,121	45,677
February	46,286	44,551	43,385	42,818
March	48,017	47,388	45,511	42,278
April	48,549	48,210	45,806	43,776
May	47,323	48,189	47,645	43,731
June	51,762	48,406	45,208	44,118
July	48,960	46,369	45,810	—
August	50,611	46,473	46,152	—
September	47,716	45,025	46,151	—
October	43,056	46,923	45,006	—
November	47,705	46,219	44,351	—
December	44,772	46,829	46,485	—

RHODESIAN GOLD OUTPUTS.

	June.		July.	
	Tons.	Oz.	Tons.	Oz.
Cam and Motor	24,400	10,871	24,800	9,931
Globe and Phœnix	6,048	5,438	6,110	5,298
Lonely Reef	6,775	3,334	7,000	3,232
Luiri Gold	1,197	£2,936	—	—
Rezende	6,400	2,657	6,400	2,645
Sherwood Star	4,500	£8,701	4,800	£8,611
Wanderer Consolidated	14,800	3,563	15,200	3,680

WEST AFRICAN GOLD OUTPUTS.

	June.		July.	
	Tons.	Oz.	Tons.	Oz.
Ariston Gold Mines	5,015	£9,096	—	—
Ashanti Goldfields	11,978	14,135	12,510	14,463
Taquah and Abosso	9,770	£14,773	9,170	£13,876

AUSTRALIAN GOLD OUTPUTS BY STATES.

	Western Australia.	Victoria.	Queensland.
	Oz.	Oz.	Oz.
July, 1930	34,174	2,327	728
August	38,579	1,864	323
September	32,034	1,992	429
October	39,687	1,685	628
November	33,708	2,174	436
December	42,097	3,105	260
January, 1931	27,306	—	405
February	38,370	4,458*	458
March	34,946	4,482	898
April	38,691	3,250	732
May	38,255	—	—
June	47,507	—	—
July	38,785	—	—

* Jan. and Feb.

AUSTRALASIAN GOLD OUTPUTS.

	June.		July.	
	Tons	Value £	Tons.	Value £
Associated G.M. (W.A.)	5,282	5,628	5,452	8,719
Blackwater (N.Z.)	4,080	7,702	4,030	8,011
Boulder Persev'ce (W.A.)	7,246	16,741	7,340	16,550
Grt. Boulder Pro. (W.A.)	11,394	31,698	11,631	31,744
Lake View & Star (W.A.)	10,120	20,221	—	—
Sons of Gwalia (W.A.)	12,684	14,625	13,964	15,327
South Kalgurli (W.A.)	6,541	10,657	8,766	15,583
Waihi (N.Z.)	17,439	6,328* / 46,714†	18,435	6,341* / 42,522†

* Oz. gold. † Oz. silver.

GOLD OUTPUTS, KOLAR DISTRICT, INDIA.

	June.		July.	
	Tons Ore	Total Oz.	Tons Ore	Total Oz.
Balaghat	3,350	2,004	3,750	2,208
Champion Reef	8,125	5,284	8,400	5,552
Mysore	14,194	7,020	14,012	6,812
Nundydroog	4,831	4,581	2,119	4,603
Ooregum	9,980	4,790	10,360	5,005

MISCELLANEOUS GOLD, SILVER, AND PLATINUM OUTPUTS.

	June.		July.	
	Tons	Value £	Tons	Value £
Chosen Corp. (Korea)	9,140	12,117	—	—
Frontino Gold (C'lbia)	3,740	15,912†	4,040	15,768
Fresnillo	90,910	2,467*d*‡	—	—
New Goldfields of Venezuela	3,959	1,359*	5,800	1,940*
Oriental Cons. (Korea)	16,950	100,019*d*	16,981	102,415*d*
St. John del Rey (Brazil)	—	44,500	—	44,400
Santa Gertrudis (Mexico)	24,636	50,550*d*	—	—
West Mexican Mines	1,520	31,000*d*	—	—

d Dollars. * Oz. gold. † Includes Marmajito output. ‡ Loss.

PRODUCTION OF TIN IN FEDERATED MALAY STATES.

Estimated at 72% of Concentrate shipped to Smelters. Long Tons.

July, 1930	5,525	January, 1931	5,450
August	4,153	February	5,470
September	4,048	March	4,461
October	4,807	April	4,510
November	4,812	May	5,089
December	5,019	June	4,813

OUTPUTS OF MALAYAN TIN COMPANIES.

In Long Tons of Concentrate.

	May	June	July
Ayer Hitam	89½	59½	148¾
Batu Caves	17½	18½	30
Changkat	50	50	55
Gopeng	59⅜	59½	72
Hongkong Tin	98	113	—
Idris Hydraulic	27⅜	23¾	33½
Ipoh	29⅜	19½	17½
Kampar Malaya	70½	80	78
Kampong Lanjut	74	95	73
Kamunting	266	243	237
Kent (F.M.S.)	18	36	36
Kinta	22	22½	23½
Kinta Kellas	39½	41½	—
Kramat Tin	85	70	95
Kuala Kampar	68	53	46
Kundang	16	25	18
Lahat	20½	223	17½
Lower Perak	89	132	116
Malaya Consolidated	34½	27½	27½
Malayan Tin	154¾	148½	153
Malim Nawar	29	29	25
Pahang	180	216	262
Penawat	101½	71½	81½
Pengkalen	62½	62½	68
Petaling	176	128	114½
Rahman	95½	71½	71½
Rambutan	12	12	10½
Rantau	33	14½	14
Rawang	68	76	150
Rawang Concessions	70	80	60
Renong	31	35½	27¾
Selayang	24	22¾	14½
Southern Malayan	172½	178½	151½
Southern Perak	64½	73½	20¾
Southern Tronoh	72	40	39
Sungei Besi	—	36	47
Sungei Kinta	31½	41	18
Sungei Way	131	89½	77¼
Taiping	35	25	22
Tanjong	44½	36	—
Teja Malaya	24½	24¾	18½
Tekka	34½	34½	29
Tekka-Taiping	48	33	76
Temengor	8½	6¾	—
Temoh	53½	39½	—
Tronoh	87	84	81
Ulu Klang	53	—	—

OUTPUTS OF NIGERIAN TIN MINING COMPANIES.

In Long Tons of Concentrate.

	May	June	July
Amari	—	—	—
Anglo-Nigerian	42½	43	47
Associated Tin Mines	259	181	200
Baba River	—	4	4
Batura Monguna	—	3½	—
Bisichi	—	32	—
Daffo	3	—	—
Ex-Lands	59½	44	48
Filani	4½	4	—
Jantar	22	20	—
Jos	10⅜	10⅜	—
Juga Valley	7	6	6
Kaduna Syndicate	20	25	—
Kaduna Prospectors	8	9	—
Kassa	10	10	11
London Tin	196	140	140
Lower Bisichi	4½	4	4
Naraguta	—	—	—
Naraguta Durumi	—	—	—
Naraguta Extended	9½	8	—
Naraguta Karama	—	—	—
Naraguta Korot	—	—	—
Nigerian Consolidated	—	11	—
Offin River	3¾	3½	3
Ribon Valley	18	12	14
South Bukeru Areas	—	—	—
Tin Fields	3½	4½	6
Tin Properties	—	—	—
United Tin Areas	20¾	17	16½
Yarde Kerri	—	14	4

OUTPUTS OF OTHER TIN MINING COMPANIES.

In Long Tons of Concentrate.

	May	June	July
Anglo-Burma (Burma)	11	27	—
Aramayo Mines (Bolivia)	217	186	244
Bangrin (Siam)	76	71½	92½
Beralt	30*	32*	34*
Consolidated Tin Mines (Burma)	82	96	116
East Pool (Cornwall)	45½	48½	—
Fabulosa (Bolivia)	69	70	—
Geevor (Cornwall)	—	—	—
Kagera (Uganda)	7	—	—
Kamra	70	72½	—
Malaysiam Tin	17	21	—
Mawchi	267*	267*	—
Patino	1,333½	1,333	—
Pattani	33	37½	—
Rooiberg Minerals	15½	—	—
San Finx (Spain)	23½	22½	—
Siamese Tin (Siam)	200½	162½	190½
Tavoy Tin (Burma)	33	55	50
Tongkah Harbour (Siam)	70	55	54
Toyo (Japan)	66	81½	75½
Zaaiplaats	20½	—	—

* Tin and Wolfram.

COPPER, LEAD, AND ZINC OUTPUTS.

		June	July
Broken Hill South	Tons lead conc.	3,642	—
	Tons zinc conc.	3,729	—
Burma Corporation	Tons refined lead	5,880	5,880
	Oz. refined silver	10,000	460,000
Electrolytic Zinc	Tons zinc	5,191	—
Indian Copper	Tons copper	350	345
Messina	Tons copper	777	743
Mount Isa	Tons lead bullion	—	2,211
Mount Lyell	Tons concentrate	3,863*	—
North Broken Hill	Tons lead conc.	5,660	5,170
	Tons zinc conc.	4,780	4,630
Poderosa	Tons copper ore	—	—
Rhodesia Broken Hill	Tons V_2O_5	19½	22½
	Tons slab zinc	1,025	—
Roan Antelope	Tons concentrates	2,225	3,645
San Francisco Mexico	Tons lead conc.	3,409	3,654
	Tons zinc conc.	3,447	3,664
Tetiuhe	Tons lead conc.	445	878
	Tons zinc conc.	1,125	2,069
Trepca	Tons lead conc.	3,304	3,899
	Tons zinc conc.	2,416	2,916
Zinc Corporation	Tons lead conc.	4,347	—
	Tons zinc conc.	2,963	—

* To July 15.

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

	May.	June.
Iron Ore ..... Tons ..	191,280	201,612
Manganese Ore ..... Tons ..	13,985	4,383
Iron and Steel ..... Tons ..	227,757	246,334
Copper and Iron Pyrites ..... Tons ..	21,758	25,301
Copper Ore, Matte, and Prec. ... Tons ..	5,107	2,572
Copper Metal ..... Tons ..	14,894	15,579
Tin Concentrate ..... Tons ..	5,007	5,936
Tin Metal ..... Tons ..	1,329	990
Lead Pig and Sheet ..... Tons ..	20,858	23,520
Zinc (Spelter) ..... Tons ..	18,410	15,100
Zinc Sheets, etc. ..... Tons ..	1,725	1,386
Aluminium ..... Tons ..	934	892
Mercury ..... Lb.	132,889	70,934
Zinc Oxide ..... Tons ..	682	572
White Lead ..... Cwt.	14,921	12,174
Red and Orange Lead ..... Cwt.	1,804	3,511
Barytes, ground ..... Cwt.	45,391	47,648
Asbestos ..... Tons ..	2,744	1,354
Boron Minerals ..... Tons ..	329	986
Borax ..... Cwt.	13,440	30,075
Basic Slag ..... Tons ..	4,406	1,382
Superphosphates ..... Tons ..	11,592	1,792
Phosphate of Lime ..... Tons ..	20,494	29,258
Mica ..... Tons ..	215	175
Sulphur ..... Tons ..	12,027	1,104
Nitrate of Soda ..... Cwt.	171,386	48,634
Potash Salts ..... Cwt.	112,604	87,080
Petroleum : Crude ..... Gallons	24,031,962	38,597,851
Lamp Oil ..... Gallons	16,343,457	20,507,282
Motor Spirit ..... Gallons	79,025,819	83,457,352
Lubricating Oil .... Gallons	9,366,958	7,327,197
Gas Oil ..... Gallons	5,539,121	5,388,784
Fuel Oil ..... Gallons	47,463,303	43,478,285
Asphalt and Bitumen ..... Tons ..	16,574	20,406
Paraffin Wax ..... Cwt.	86,653	105,953
Turpentine ..... Cwt.	12,687	16,186

OUTPUTS REPORTED BY OIL-PRODUCING COMPANIES.

In Tons.

	May.	June.	July.
Anglo-Ecuadorian	20,505	20,257	21,354
Apex Trinidad	47,640	48,310	50,070
Attock	1,628	1,594	1,819
British Burmah	4,336	4,401	4,495
British Controlled	39,274	—	38,763
Kern Mex	1,027	960	912
Kern River (Cal.)	2,499	2,587	3,068
Kern Romana	741	935	877
Kern Trinidad	5,078	4,932	4,751
Lobitos	25,684	25,909	28,107
Phœnix	66,418	61,359	71,862
St. Helen's Petroleum	4,930	5,278	5,266
Steaua Romana	83,040	80,610	80,830
Tampico	2,857	2,606	2,418
Tocuyo	2,556	2,136	—
Trinidad Leaseholds	14,650	15,650	17,400

QUOTATIONS OF OIL COMPANIES' SHARES.

Denomination of Shares £1 unless otherwise noted

	July 10, 1931.			Aug. 10, 1931.		
	£	s.	d.	£	s.	d.
Anglo-Ecuadorian		8	0		5	9
Anglo-Egyptian B.	1	10	0	1	7	6
Anglo-Persian 1st Pref.	1	8	0	1	6	0
,, ,, Ord.	2	3	0	1	11	9
Apex Trinidad (5s.)		8	0		6	0
Attock		16	3		15	0
British Burmah (8s.)		4	0		3	9
British Controlled ($5)		1	9		1	6
Burmah Oil	2	10	6	2	1	3
Kern River Cal. (10s.)		2	6		1	9
Lobitos, Peru	1	3	0		16	3
Mexican Eagle, Ord. (4 pesos)		8	0		6	9
,, ,, 8% Pref. (4 pesos)		9	3		8	6
Phœnix, Roumanian		5	6		4	0
Royal Dutch of Trinidad (6s. 8d.)	18	5	0	16	5	0
Shell Transport, Ord.	2	18	9	2	2	0
,, ,, 5% Pref. (£10)	10	5	0	10	5	0
Steaua Romana		5	6		4	6
Trinidad Leaseholds	1	5	6		18	9
United British of Trinidad (6s. 8d.)		4	0		3	0
V.O.C. Holding	1	9	3	1	2	6

PRICES OF CHEMICALS. August 10.

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

		£	s.	d.
Acetic Acid, 40%	per cwt.		16	9
,, 80%	,,	1	14	3
,, Glacial	per ton	56	0	0
Alum	,,	8	7	6
Aluminium Sulphate, 17 to 18%	,,	6	15	0
Ammonium, Anhydrous	per lb.			11
,, 0·880 solution	per ton	15	10	0
,, Carbonate	,,	27	10	0
,, Nitrate (British)	,,	16	0	0
,, Phosphate, comml.	,,	40	0	0
,, Sulphate, 20·6% N.	,,	6	10	0
Antimony, Tartar Emetic, 43/44%	per lb.			10
,, Sulphide, golden	,,			9
Arsenic, White	per ton	20	0	0
Barium, Carbonate, 94%	,,	4	10	0
,, Chloride	,,	8	5	0
,, Sulphate, 94%	,,	6	15	0
Benzol, standard motor	per gal.		1	3
Bleaching Powder, 35% Cl.	per ton	7	0	0
Borax	,,	13	10	0
Boric Acid	,,	22	0	0
Calcium Chloride, solid, 70/75%	,,	5	5	0
Carbolic Acid, crude 60's	per gal.		1	1½
,, ,, crystallized, 40°	per lb.			5½
Carbon Disulphide	per ton	16	10	0
Citric Acid	per lb.			11
Copper Sulphate	per ton	18	5	0
Creosote Oil (f.o.b. in Bulk)	per gal.			4
Cresylic Acid, 98-100%	,,		1	8
Hydrofluoric Acid, 59/60%	per lb.			6
Iodine	per oz.		1	0
Iron, Nitrate 80° Tw.	per ton	6	10	0
,, Sulphate	,,	2	2	6
Lead, Acetate, white	,,	32	7	6
,, Nitrate (ton lots)	,,	28	15	0
,, Oxide, Litharge	,,	26	10	0
,, White	,,	36	10	0
Lime, Acetate, brown	,,	7	5	0
,, ,, grey, 80%	,,	12	0	0
Magnesite, Calcined	,,	9	10	0
Magnesium Chloride	,,	5	10	0
,, Sulphate, comml.	,,	3	15	0
Methylated Spirit Industrial 61 O.P.	per gal.		2	1
Nitric Acid, 80° Tw.	per ton	23	0	0
Oxalic Acid	per cwt.	1	14	6
Phosphoric Acid. S.G. 1·500	per ton	29	15	0
Pine Oil	,,	42	10	0
Potassium Bichromate	per lb.			4½
,, Carbonate, 96/98%	per ton	24	0	0
,, Chlorate	,,	27	10	0
,, Chloride 80%	,,	9	5	0
,, Ethyl Xanthate	per 1,016 kilos	55	15	0
,, Hydrate (Caustic) 88/90%	per ton	27	5	0
,, Nitrate	,,	19	17	6
,, Permanganate	per lb.			5½
,, Prussiate, Yellow	,,			6¾
,, ,, Red	,,		1	8
,, Sulphate, 90%	per ton	10	10	0
Sodium Acetate	,,	16	15	0
,, Arsenate, 45%	,,	20	10	0
,, Bicarbonate	,,	10	10	0
,, Bichromate	per lb.			3½
,, Carbonate (Soda Ash) 58%	per ton	6	0	0
,, ,, (Crystals)	,,	5	5	0
,, Chlorate	,,	26	5	0
,, Cyanide 100% NaCN basis	per lb			8
,, Ethyl Xanthate	per 1,016 kilos	53	5	0
,, Hydrate, 76%	per ton	14	10	0
,, Hyposulphite, comml.	,,	9	2	6
,, Nitrate (ordinary)	,,	10	0	0
,, Phosphate, comml.	,,	10	0	0
,, Prussiate	per lb.			4¾
,, Silicate	per ton	9	10	0
,, ,, (liquid, 140° Tw.)	,,	8	10	0
,, Sulphate (Glauber's Salt)	,,	2	15	0
,, ,, (Salt-Cake)	,,	2	17	6
,, Sulphide Conc., 60/65%	,,	8	15	0
,, Sulphite, pure	per cwt.		14	0
Sulphur, Flowers	per ton	9	5	0
,, Roll	,,	6	5	0
Sulphuric Acid, 168° Tw.	,,	4	5	0
,, ,, free from Arsenic, 140° Tw. ..	,,	3	0	0
Superphosphate of Lime (S.P.A. 16%)	,,	3	9	0
Tartaric Acid	per lb.			10½
Turpentine	per ton	49	10	0
Tin Crystals	per lb.			10½
Titanous Chloride	,,			10
Zinc Chloride	per ton	9	10	0
Zinc Dust, 90/92%	,,	20	0	0
Zinc Oxide (White Seal)	,,	35	0	0
Zinc Sulphate	,,	8	5	0

SHARE QUOTATIONS

Shares are £1 par value except where otherwise noted.

GOLD AND SILVER:	July 10, 1931. £ s. d.	Aug. 10, 1931. £ s. d.
SOUTH AFRICA:		
Brakpan	2 17 6	2 15 0
City Deep	4 0	4 3
Consolidated Main Reef	1 0 0	1 1 3
Crown Mines (10s.)	4 7 0	4 5 0
Daggafontein	2 8 0	2 9 6
Durban Roodepoort Deep (10s.)	15 9	14 6
East Geduld	2 15 0	2 17 0
East Rand Proprietary (10s.)	11 3	13 3
Geduld	4 1 3	3 18 9
Geldhenhuis Deep	8 6	8 3
Glynn's Lydenburg	5 0	5 0
Government Gold Mining Areas (5s.)	1 12 6	1 11 0
Langlaagte Estate	1 5 9	1 4 0
Meyer & Charlton	18 0	18 0
Modderfontein New (10s.)	3 1 3	2 12 6
Modderfontein B (5s.)	10 6	9 3
Modderfontein Deep (5s.)	1 2 0	1 0 0
Modderfontein East	1 9 6	1 7 0
New State Areas	2 3 9	2 3 0
Nourse	15 9	16 3
Randfontein	1 1 6	1 1 9
Robinson Deep A (1s.)	15 6	15 6
" B (7s. 6d.)	9 6	9 3
Rose Deep	4 9	5 6
Simmer & Jack (2s. 6d.)	3 3	3 6
Springs	3 2 0	2 19 6
Sub Nigel (10s.)	3 2 0	3 2 6
Van Ryn	8 6	8 3
Van Ryn Deep	1 3 9	1 0 0
Village Deep (9s. 6d.)	2 3	2 3
West Rand Consolidated (10s.)	9 4	9 6
West Springs	10 6	12 9
Witwatersrand (Knight's)	8 6	9 0
Witwatersrand Deep	3 6	3 9
RHODESIA:		
Cam and Motor	19 6	1 0 0
Gaika	3 6	3 6
Globe and Phœnix (5s.)	12 9	13 6
Lonely Reef	16 3	15 0
Mayfair	3 9	3 9
Rezende	1 0 0	17 6
Shamva	1 0	1 0
Sherwood Starr (5s.)	13 9	12 6
GOLD COAST:		
Ashanti (4s.)	1 13 9	1 13 0
Taquah and Abosso (5s.)	4 0	3 6
AUSTRALASIA:		
Golden Horseshoe (4s.) W.A.	2 6	2 3
Great Boulder Propriet'y (2s.), W.A.	1 3	1 0
Lake View and Star (4s.), W.A.	9 0	8 6
Sons of Gwalia, W.A.	3 9	4 0
South Kalgurli (10s.), W.A.	13 6	11 6
Waihi (5s.), N.Z.	13 6	13 6
Wiluna Gold, W.A.	16 6	13 0
INDIA:		
Balaghat (10s.)	2 0	2 0
Champion Reef (10s.)	6 6	6 0
Mysore (10s.)	7 0	7 3
Nundydroog (10s.)	12 6	13 6
Ooregum (10s.)	3 0	2 9
AMERICA:		
Camp Bird (2s.), Colorado	3	3
Exploration (10s.)	2 6	2 6
Frontino and Bolivia, Colombia	11 3	11 3
Mexican Corporation, Mexico (10s.)	4 3	3 6
Mexico Mines of El Oro, Mexico	1 6	1 6
Panama Corporation	15 0	13 6
St. John del Rey, Brazil	18 6	18 6
Santa Gertrudis, Mexico	6 9	6 9
Selukwe (2s. 6d.), British Columbia	2 3	1 9
MISCELLANEOUS:		
Chosen, Korea	3 0	2 6
Lena Goldfields, Russia	6	6

COPPER:		
Bwana M'Kubwa (5s.) Rhodesia	4 0	3 6
Esperanza Copper	13 0	13 9
Indian (2s.)	1 3	1 0
Loangwa (5s.), Rhodesia	2 6	2 4
Luiri (5s.), Rhodesia	1 0	1 3
Messina (5s.), Transvaal	7 6	6 0
Mount Lyell, Tasmania	16 9	14 6
Namaqua (£2), Cape Province	4 6	4 6
Rhodesia-Katanga	11 3	10 0
Rio Tinto (£5), Spain	20 0 0	16 15 0
Roan Antelope (5s.), Rhodesia	11 3	9 6
Tanganyika Con.	1 3 0	18 9
Tharsis (£2), Spain	2 15 0	2 9 6

LEAD-ZINC:	July 10, 1931. £ s. d.	Aug. 10, 1931. £ s. d.
Amalgamated Zinc (8s.), N.S.W.	6 3	6 3
Broken Hill Proprietary, N.S.W.	9 6	8 6
Broken Hill, North, N.S.W.	1 17 6	1 12 6
Broken Hill South, N.S.W.	1 6 0	1 3 9
Burma Corporation (10 rupees)	8 0	6 9
Electrolytic Zinc Pref., Tasmania	13 9	12 6
Mount Isa, Queensland	12 0	8 0
Rhodesia Broken Hill (5s.)	1 0	1 0
San Francisco (10s.), Mexico	11 6	9 6
Sulphide Corporation (15s.), N.S.W.	6 0	5 6
ditto, Pref.	10 6	8 0
Zinc Corporation (10s.), N.S.W.	16 10	13 9
ditto, Pref.	2 12 6	2 15 0

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

DIAMONDS:		
Consol. African Selection Trust (5s.)	10 0	9 6
Consolidated of S.W.A. (10s.)	4 0	3 6
De Beers Deferred (£2 10s.)	4 0 0	3 12 6
Jagersfontein	1 0 0	16 3
Premier Preferred (5s.)	1 15 6	1 9 6

FINANCE, ETC.:		
Anglo-American Corporation (10s.)	12 9	11 9
Anglo-French Exploration	9 6	8 0
Anglo-Continental (10s.)	3 0	2 3
Anglo-Oriental (Ord., 5s.)	9 0	6 6
ditto, Pref.	7 3	8 3
British South Africa (15s.)	1 1 6	17 9
Central Mining (£8)	7 15 0	7 10 6
Consolidated Gold Fields	1 3 0	1 1 3
Consolidated Mines Selection (10s.)	7 3	6 9
Fanti Consols (8s.)	6 3	6 0
General Mining and Finance	15 6	14 6
Gold Fields Rhodesian (10s.)	4 0	3 6
Johannesburg Consolidated	1 4 0	1 1 0
London Tin Corporation (10s.)	13 0	11 9
Minerals Separation	2 17 6	2 10 6
National Mining (8s.)	3	3
Rand Mines (5s.)	2 18 0	2 13 9
Rand Selection (5s.)	9 6	9 0
Rhodesian Anglo-American (10s.)	10 0	8 0
Rhokana Corp.	4 12 6	3 15 0
Rhodesian Selection Trust (5s.)	10 0	9 6
South Rhodesia Base Metals	2 0	2 0
Tigon (5s.)	6 6	3 0
Union Corporation (12s. 6d.)	2 15 0	2 13 9
Venture Trust (10s.)	4 0	3 9

THE MINING DIGEST

A RECORD OF PROGRESS IN MINING, METALLURGY, AND GEOLOGY

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

GOLD METALLURGY IN CANADA

In the *Canadian Mining Journal* for July C. S. Parsons gives a brief resume of the progress made in recent years in the metallurgy of gold and extracts from his paper are given here. The author says that prior to 1900, three-fourths of the gold produced from crushed ore was still collected and recovered by amalgamation, although MacArthur and Forrest had made the use of cyanide practical in 1888. In 1913 the flotation process was introduced on a stable basis. These two processes represent the only new principles discovered in the metallurgy of gold during the last forty years. Many other advances have been made, but all of them have been associated with the operation of these two processes—cyanidation and flotation.

To-day, cyanidation is by far the most important method of recovering gold and in Northern Ontario mines, it is almost exclusively used. The world's annual production of gold has quadrupled since the introduction of cyanidation forty-two years ago. The advances made have followed one another in rapid succession, but they have been chiefly associated with, and have been brought about by, improved mechanical methods of handling the ore, such as crushing, grinding, classification, agitation and filtration.

In the early days relatively coarse crushing in stamp-mills was practised, every possible means being taken to avoid the production of slimes. At that time sands were considered more amenable to cyaniding than slimes as apparatus such as agitating tanks and filters had not been developed. The crushed ore was crudely classified and at many plants the slimes were thrown away. The large losses arising from discarding these slimes brought out the constructive spirit of the industry and means of economically handling this product were devised. The first slime treatment was in batch decanters and pressure filter presses, the slimes being for some time agitated in tanks equipped with mechanical agitation. After allowing the slimes to settle, the gold solution was siphoned off and the slimes either flushed to waste or passed through a filter press.

The sands were treated by leaching in tanks. A long period of contact with the cyanide solution was necessary to dissolve the gold which in many cases was only partly freed from the rock by the coarse crushing practice. This required large installations of tanks which had to be filled and afterwards discharged. Moreover, it was essential that the sands be spread evenly in the tanks, otherwise poor percolation would result. Mechanical distributors, such as the Butters, were invented for this purpose and methods of rapidly discharging the tanks were devised.

One of the chief difficulties in the sand-leaching process was due to the presence of slimes in the sands. As the crushed ore was classified in cones and V-shaped boxes, the separation of the slimes was very imperfect, and the slime remaining in the sands slowed up the leaching. In South Dakota, a mill was having so much trouble from the presence of slime in sand-leaching vats that it was losing money. As the trouble was due to faulty classification; and "necessity being the mother of invention," the forerunner of the highly efficient mechanical classifier of to-day was developed. It consisted of crude shallow tank with reciprocating racks for removing the sands and a weir for overflowing the slimes. This proved highly satisfactory in comparison to the cone and V-shaped box classifiers previously used.

About 1896 it was discovered that oxygen played an important part in dissolving the gold in cyanide solution. It was also noted that fine gold dissolved more rapidly than coarse and that a better extraction was obtained from the slimes than from the sands. This led to the development of air agitation and a number of agitators using air lifts were designed, among them being the Pachuca or Brown tank, and later, the Dorr tank.

About 1903 the tube-mill was introduced as a secondary grinder. It was widely used on ores which had to be finely ground to liberate the gold. The tube-mill was destined to play an important part in the treatment of the gold ores in the new Ontario camps.

Counter-Current-Decantation.—For treating the large quantity of slimes produced by tube-mill grinding, a system of counter-current-decantation was developed; the method devised by John V. N. Dorr, proving the most successful. Round, shallow, flat-bottom tanks, with slowly moving rakes in the bottom, were used, and as the ore settled from the cyanide solution it was raked to the centre of the tank and discharged. The cyanide solution carrying the dissolved gold, overflowed the rim of the tank, the process being continuous. This system was not found altogether satisfactory because on some ores a large loss of dissolved gold values entrapped in the settled slimes occurred. For the purpose of recovering these valuable solutions, filters using the vacuum principle were devised. The Moore and Butters filters of the intermittent type were among the first developed and are still used. Later the continuous and highly efficient vacuum filters, such as the Oliver and American, were designed.

The improvements in methods of handling slimes paved the way for the fine grinding in tube-mills in cyanide solution and laid the foundation for the tremendous growth of the process in the days to follow the opening of the great gold camps of Porcupine and Kirkland Lake in 1908 and 1912. Since the discovery of these fields, Ontario practice has been the centre of progress in cyanidation.

All-Slime Process.—As the Ontario ores were found to require fine grinding in order to recover the gold, the all-slime process was used and has

been developed there to its present day economical and efficient state. New methods of crushing and grinding the ores have been devised and introduced in these gold camps. Stage crushing was introduced, whereby the ore is crushed in stages by different types of crushers, the crusher used in each stage being designed for that particular operation. Improvements in crushing and grinding practice have been very rapid during the last few years resulting in a reduction in milling costs. This has been brought about as much by careful and painstaking testing in the mills as by the introduction of the new and better types of crushing and classification machinery.

When Hollinger and Dome first built their mills, stamps were used, followed by fine grinding in the tube pebble mills. These have now been replaced at the Hollinger by rod-mills using steel rods, and the tube-mill which used steel balls as a media for grinding, instead of pebbles. All the new mills since then have adopted ball- or rod-mills followed by tube-mills using steel balls. Closed circuit grinding in these units in conjunction with the mechanical classifier has been universally approved. The bowl classifier, which was invented in the Golden Cycle mill in Colorado, has been found to be of great practical advantage in the mills at Kirkland Lake, where very fine grinding has been found necessary. With this classifier much finer grinding has been economically feasible. At Teck Hughes, Sylvanite, and other Kirkland Lake Mines, extremely fine grinding is practised with marked economies over earlier practice.

New Use for Bowl Classifier.—A few years ago J. S. Denny introduced a new use for the bowl classifier at the McIntyre mine, whereby the bowl was used to concentrate the pyrite in the ore which carried high gold values and required finer grinding than the quartz. The bowl is operated so that the pyrite builds up in the rake return product to several times its original concentration, and is then returned for re-grinding to the tube-mill until all passes a 200-mesh screen. This method produced a saving in the cost of grinding, as the quartz, which constitutes the larger part of the ore, was eliminated from the grinding circuit at a much coarser size and only the pyrite, which constituted a very small proportion of the ore, was returned for re-grinding to the mills.

Counter-current-decantation reached its highest development in the Ontario field and is still used to-day in conjunction with vacuum filtration. Continuous vacuum filtration has become highly developed in Porcupine and Kirkland Lake and has resulted in great economies. The tailing or waste from the counter-current-decantation plants which used to go to the tailing dumps contains dissolved values locked up in the slimes. These values are now recovered through filtration by vacuum filters. These methods also recover three-fourths of the cyanide which was formerly lost in the tailing. Double filtration is now practised in nearly all the mills. The filtered cake from the first filter is re-pulped and again filtered and washed on a second filter.

New and more efficient types of machinery are being developed and tried out every year, and owing to changes in design of equipment mills can now be built more compact. For, by the use of the Dorr tray thickener, a type which multiplies the settling area, and, therefore, the capacity per unit of floor space, the size of the mill building can be reduced and in the Canadian north country this means much less expenditure for heating. This is a very important factor because heating alone in some of the mills is 6% of the total operating costs. There is also the possibility that a further reduction in floor space will be achieved. This expectation is based on the fact that in some mills over 70–80% of the gold is dissolved in the grinding circuit and that the remaining recoverable gold is mostly extracted on the filters. In consequence, only a small proportion is dissolved during the lengthy treatment in the agitators and thickeners. It would, therefore, seem as though both a saving in the floor space and in the cost of treatment might be effected by introducing a third filtration step in place of so long an agitation period.

Flotation Process.—The flotation process previously mentioned, as one of the outstanding developments in metallurgy, has been recently found applicable to gold ores. To-day gold ores are being concentrated by flotation and the concentrates re-ground and cyanided for recovery of the gold values. Not all gold ores can be so treated, but certain ores, such as for example, the McIntyre Porcupine ore, lend themselves to such treatment. In Colorado some small deposits have been successfully operated using flotation on a coarsely ground ore, the flotation concentrate being sold to a custom cyanide plant for the recovery of the gold. The advantage of this method of treatment is that the initial cost of the plant is much less than that of a cyanide mill. In 1923 an investigation was made on the possibility of treating the gold ores of Kirkland District and it was found that a slightly lower tailing could be obtained by flotation than by cyanidation for the same degree of grinding. At the McIntyre it has been found that both the free gold and gold associated with sulphides can be concentrated at relatively coarse grinding for the initial flotation step, and about 75% of the ore discarded as waste. This leaves 25% of the ore as a concentrate containing practically all the gold, originally in the ore. This small bulk will be re-ground and cyanided. By using this process there will be a saving of possibly three-quarters of a million dollars in the cost of building the new mill as compared to the cost of a new all cyanide mill. There is also the possibility of treating the cyanide tailing by flotation to recover the sulphides for further treatment. Work done at the Wright Hargreaves and Sylvanite mills in 1927 showed that a tailing as low as ·40 cents in the –200 mesh portion could be made. The difficulty encountered by this method was the recovery of the gold from this flotation concentrate. The gold was found to be locked up in the pyrite and even by extremely fine grinding and treatment by bromo-cyanide, only about 60% could be extracted. Figures on smelter returns from this concentrate were also disappointing. There is room for intensive research on the problem of extracting the gold from such a concentrate.

Low-Grade Ores.—In regard to the possibility of treating low-grade gold ore-deposits by the discovery of new metallurgical processes which will reduce the costs of recovery of the gold so as to make them workable, this much can be said, that the operation of such deposits from a metallurgical point of view is more likely to become possible from improvements in the design and construction of

the machines used and the application of the results of careful test-work on the ore to discover just what steps are necessary for the recovery of the gold, than from newly discovered principles. The cost of crushing and grinding is one of the deciding factors in the treatment of low grade ores. If the ore can be treated without the necessity of fine grinding, then there is a much better chance of working the deposit. The cost of crushing and grinding will average about 30–40% of the total operating costs of milling. The test-work done on the Howey Gold ore, for instance, showed that high recoveries could be obtained at fairly coarse grinding at about 40 mesh. There was some doubt at the time as to the possibility of operating a cyanide plant on such coarse material owing to the probable mechanical difficulties involved in the operation of the tanks and agitators. This practice, at the Howey Gold Mines, has demonstrated that it is possible to carry out successful cyanide plant operation on much coarser material than was thought possible before, which means a material reduction in milling costs. The low-grade ore of the Malartic Mine in Quebec was found equally amenable to the cyanide process at fairly coarse grinding.

In the last few years tremendous improvements have been made in crushing, grinding, and classification machinery. Outstanding is the cone crusher, which reduces the ore in one operation to the same extent that formerly required a set of gyratory crushers followed by rolls, with a marked saving in power as well as simplifying the mill construction and operation. The bowl classifier, which has been previously referred to, can now be obtained as single unit to overflow 3,000 to 4,000 tons of ore a day. Many other such innovations are effected every year, but, despite improvements both in the mining and metallurgy of gold, the average cost of producing an ounce of gold has not been lowered. Gold is worth $20·67 an ounce at the mint and the average world cost of producing this gold is between $12·00 and $14·00. This figure varies at different mines largely depending on the grade of the ore and the size of the operation. It is higher for low grade deposits and lower for high grade ores. The Teck Hughes' cost in 1930 was $8·34 per ounce. While it would be incorrect to say that due to the greatly improved methods it is now possible to work a grade of ore which thirty years ago could not be made to yield a profit, on the other hand there are numerous deposits now being operated profitably which, owing to the refractory nature of the ore, could not have been worked a few years ago. Considering this situation from the point of view of the cost of producing an ounce of gold, it would seem that over a period of years a balance has been maintained between higher cost of labour and materials and the lowering of the costs by improved processes and new and more efficient types of machinery.

HALL-INTERSTATE, LOST PILGRIM MINES, IDAHO

In the thirty-second annual report of the mining industry of Idaho for 1930 S. Campbell, Inspector of Mines, gives an account of the Bunker Hill and Sullivan M. and C. Company's Hall-Interstate, Lost Pilgrim mines, in Valley County, Idaho, and extracts from his report are given here.

Ore.—The ore is a coarse mixture of galena, sphalerite, and tetrahedrite, which occurs as segregations, with sphalerite predominating. The lead and zinc minerals are coarse-grained, distinctly recognizable, and easily distinguished from each other. The gangue minerals are siderite, quartz, and decomposed wall rock. The ore is exceedingly friable and mining operations reduce it to a fine mass in which particles seldom exceed one inch in diameter. Down to 20-mesh in size it is easily crushed, but grinding to lower sizes is difficult. When it is ground to 65-mesh, the ore minerals are liberated from the gangue.

Mining Methods.—The vein has a general east and west strike and stands vertical. Two large faults are parallel to the vein and it is occasionally offset by transverse faults. The faulting has crushed the wall rock and ore to such an extent that the ground is extremely heavy and very difficult to hold open. On account of this condition the square-set and back-fill method is necessary and all stopes are kept filled to within one floor of the working face. Bunker Hill-type crib manways and slides are used in the main rises and in all stope rises. The transverse faulting, which offsets the vein, makes it difficult to keep the stope rises in alignment. Waste rises are driven into the walls at steep angles for back filling. All timbers are framed on the surface.

Equipment.—The principal buildings in addition to the mill are: A commodious boarding house; office and manager's residence; assay office; sawmill; foreman's residence; barn; compressor and change house; blacksmith shop; warehouse; two power houses; and numerous cabins.

Stratton Creek power plant.—160 k.w. generator driven by Pelton water wheel operating under a head of 520 ft., water delivered through 14 and 10 in. pipe line; Woodward governor, volt regulators, and overload protection; 3-phase, 2,200 volts reduced to 220 volts for power purposes. Constructed in 1924.

Deadwood power plant.—375 k.w. generator driven by a double-wheel Pelton water wheel operating under a head of 180 ft. water delivered through a 30 in. electrically welded steel pipe line 4,050 ft. long; Pelton governor, volt regulators, and semi-automatic equipment; 3-phase, 2,300 volts reduced to 220 volts for power purposes. Constructed in 1929.

Mining equipment.—One-ton Manch storage battery locomotive capable of pulling 10 cars; 385 cu. ft. compound Ingersoll-Rand compressor, driven by a 60 h.p. motor; Waugh Model 8 drill sharpener; Gardener-Denver rock-drills with water attachments; Anaconda-type air-driven hoist in main rise, tugger hoists in stope rises; 3 in. air line and 16 lb. rails in Independence tunnel; complete assaying equipment; sawmill, 56 in. ripsaw, 30 in. cut-off saw, combination mine-timber-framer, 14 in. wedge saw; each saw is driven by an individual motor.

Transport.—From about November 10 to June 20 of each year the roads are closed to wheeled vehicles and the only means of communciation, other than Forest Service telephone, is by dog sled. The teams are employed under contract and two are necessary to meet the schedule of three mail deliveries to the mine per week. The trip between the mine and Cascade requires two days.

The contract calls for a 100 lb. load and the transport of one company official or injured employee when necessary, but the contractor is obliged to carry only the mail. Two cents per lb. is paid for freight and five cents per lb. for personal baggage.

During the summer months three 5-ton dump-body trucks are used for hauling the concentrates and supplies. The trucks operate on a 24-hour schedule and make two round trips per day. All hauling is done under contract at a price of $10·00 per ton in each direction. As supplies of all kinds in sufficient quantities to maintain operations throughout the winter months must be hauled during the open season, the trucks moving in both directions are usually fully loaded.

Mill.—At the present time the mill has a capacity of 100 tons per 24 hours; however, the building is sufficiently large to house milling equipment for a capacity of 300 tons and it is necessary to add but little more machinery to bring the mill up to the latter capacity.

Grinding.—The ore is transported from the mine by a 1 ton, storage-battery locomotive pulling 10 cars and is delivered directly into the 250-ton crude-ore bin from which it is drawn through a chute on to a 24 in. belt conveyor. The conveyor dumps on to a tapered bar grizzly, 36 in. long by 18 in. wide with 1½ in. slots. After passing over the grizzly, the ore is crushed to a maximum size of 1½ in. in a 9 by 15 Blake crusher. The undersize from the grizzly and discharge from the crusher go to a 16 in. belt conveyor, which delivers it (dry) to a Colorado impact-screen with a ⅜ in. screen opening. The undersize from the screen goes to the fine-ore bin and the oversize to a 3 ft. Symons cone crusher that discharges directly into the fine-ore bin, which has a capacity of 300 tons.

The ore is fed from the fine-ore bin by a belt-feeder on to a 20 in. belt conveyor equipped with an automatic sampler, and then goes to a 6 ft. by 22 in. Hardinge ball-mill, where it is ground to 65-mesh. The ball-mill operates in closed circuit with a 4½ ft. duplex-type Dorr classifier without the use of pump or elevator.

Rougher Circuit.—The overflow from the classifier goes direct to a 10-cell Fahrenwald flotation machine, termed the lead rougher cells. The first five cells of this machine make a rough lead concentrate, which goes to the lead circuit; the last five cells make a low-grade concentrate, which is returned to the Dorr classifier by a 2in. Wilfley pump and the tails go to the zinc circuit.

Lead Circuit.—The product from the first 5 cells of the rougher circuit goes to a 4-cell Fahrenwald flotation machine, which makes a high-grade lead concentrate and a tailing. The tailing is returned to the Dorr classifier by a 2 in. Wilfley pump and the lead concentrate passes through a 5 ft. 4 in. by 6 ft. Oliver filter, which discharges into a 1,400-ton storage bin.

Zinc Circuit.—The tailings from the rougher circuit are delivered into a 6 by 6 ft. conditioner tank by a 3 in. Wilfley pump. The product from the conditioner is fed directly into a 10-cell Fahrenwald flotation machine, termed the zinc rougher cells. The first five cells of this machine make a rough zinc concentrate, which goes to the zinc cleaner; the last five cells make a low-grade zinc concentrate, which is returned to the conditioner tank; and the tailings go to waste where they are settled in a pond and clear water only overflows.

The product from the first five cells of the zinc rougher goes to a 6-cell Fahrenwald flotation machine, which makes a high-grade zinc concentrate and a tailing. The tailing is returned to the conditioner, and the concentrate passes through a 5 ft. 4 in. by 8 ft. Oliver filter, which discharges into a 2,800-ton storage bin.

Reagents and Where Used.

(*a*) Grinding circuit.—1·4 lbs. of zinc sulphate and 0·17 lb. of aerofloat per ton of ore are fed into the Hardinge ball-mill.

(*b*) Rougher circuit.—·01 lb. of cresylic acid per ton of ore is added at the sixth cell.

(*c*) Lead circuit.—None.

(*d*) Zinc circuit.—To each ton of ore 1 lb. of copper sulphate, 2 lb. of aerofloat, and 0·025 lb. of zanthate are added in the conditioner—cresylic acid and zanthate are added to the product from the last five cells of the zinc rougher before being returned to the conditioner.

Drives.

(*a*) Grinding circuit.—Line shaft, belt-connected to 30 h.p. motor drives: Blake crusher; belt conveyors; feeders; automatic sampler; impact screen.

Symons cone-crusher, by 50 h.p. motor, Tex-rope connected.

Hardinge ball-mill, by 50 h.p. motor, Tex-rope connected.

Classifier, by 3 h.p. motor, belt-connected.

(*b*) Flotation circuit.—Each individual cell in all flotation machines is driven by a 3 h.p. motor, Tex-rope connected.

The two filters are driven from a line shaft belted to a 15 h.p. motor.

(*c*) Pumps.—Six 2 in. Wilfley pumps direct-connected to a 5 h.p. motor.

One 3 in. Wilfley pump direct-connected to a 10 h.p. motor.

(*d*) Blower.—10 h.p. motor, belt-connected.

Average Assays.—The average assays of the mill feed and products are as follows:

	Au. $	Ag. Oz.	Pb. %	Zu. %	Cu. %
Mill feed	1·00	10·00	3·50	10·00	0·50
Lead cons. ...	15·0	160·00	55·00	9·00	5·00
Zinc cons. ...	0·60	5·00	1·20	58·00	0·40
Tails	0·01	0·33	0·07	0·71	0·07
Average total recoveries	76·50%	95·00%	97·00%	85·00%	60·00%

Electrolytic Cadmium Plant.—Cadmium occurs as an impurity in practically all zinc ores. The quantity present is very small and rarely exceeds a few tenths of 1 per cent. This metal is an objectionable contamination in electrolytic zinc, and its removal from the zinc solution in the zinc plant is an expensive but essential part of the process. The removal of cadmium is accomplished by agitating the zinc-bearing solutions with finely divided zinc dust. This action precipitates the cadmium, together with other impurities, chiefly copper, nickel, and cobalt, as a finely divided metallic material known as "purification residue." This residue, in which the cadmium has been concentrated about one hundred fold, constitutes the feed to the cadmium plant. The residue also contains about 40% zinc, which is recovered and returned to the zinc plant after the cadmium and other impurities have been removed. Thus the cadmium unit performs an additional function, namely, that of salvaging zinc which would have been a loss in the zinc plant, thereby increasing the efficiency of that plant.

The purification residue is stored in a stock pile from which it is carried to the cadmium plant by a conveyor and fed into a ball-mill. The sludge from the mill goes into a lead-lined leach tank, where it is agitated with 27% sulphuric acid, spent electrolyte from the zinc plant. The cadmium is dissolved, and the copper remains as a residue in the form of cement copper. The residue, which contains a high copper content, is then filtered from the solution and shipped to a copper smelter.

The solution carrying the cadmium is then passed over zinc plates by which the cadmium is precipitated as a metal sponge. The cadmium sponge floats to the surface of the solution and is scraped into a launder, which carries it to a Burt filter in which it is filtered and washed. This sponge is contaminated with zinc, nickel, cobalt, lead and iron and must be redissolved and electrolyzed to produce high-grade cadmium metal. The solution after passing through the boxes is barren of cadmium, but is rich in zinc; the purification of this solution is discussed later. The zinc plates used to precipitate the cadmium are rapidly consumed and a relatively large number are required; handling is expedited by an overhead crane which travels above the precipitation boxes and over the railroad siding.

The cadmium sponge dissolves slowly in dilute sulphuric acid; if it is partly oxidized, the solubility is greatly increased. The sponge, therefore, after leaving the Burt filter, is dried on a steam-plate drier to permit oxidation. It is then leached with the electrolyte from the electrolytic cadmium cells. All of the cadmium is not oxidized, and the remaining undissolved metallic portion serves to remove small quantities of copper which may not have been precipitated in the leach, and also tends to keep other impurities from building up to their full extent in the solution. After being dissolved, the cadmium, in the form of neutral solution, is sent to the storage tank and is ready for electrolysis. The electric cells are of the stationary cathode type and are in most respects similar to the standard cells used in the zinc plant. The chief points of difference are in the cell reagents and in the use of a lower voltage and much lower current density. After the electrolysis of the cadmium, the spent electrolyte is returned to the re-solution tank, where the acid generated during electrolysis is used to dissolve the cadmium sponge, which is again returned to the cells as neutral solution. The electrolysis is not very sensitive to impurities in the electrolyte, so they gradually build up, and it becomes necessary eventually to discard part of the solution; but before this is done the solution is passed through a stripping cell, which removes practically all of the cadmium.

The purification of the solution from the cadmium precipitation boxes constitutes one of the innovations in the cadmium plant. This solution is rich in zinc and contains cobalt, a very objectionable impurity in electrolyzing zinc, the greater part of which must be removed before the solution is returned to the zinc circuit in the main zinc plant. This is done by means of an additional purification process by which the cobalt and nickel are precipitated from the solution.

ZINC PLANT: SULLIVAN MINING COMPANY.

Because cadmium oxidizes at low temperatures, in order to prevent excessive drossing of the metal, the cadmium cathodes are melted under a thin layer of fused caustic soda or heavy gravity oil. After the cadmium is melted it is cast into pencils, slabs, balls and anodes of various shapes to meet the requirements of the trade.

The tanks throughout the plant are lead-lined and equipped with steam coils to permit temperature control of the solutions at any stage of the process. A motor-generator set supplies the cadmium with its own source of direct current independent of the zinc plant generators. The entire cadmium plant is so arranged that any unit can be temporarily shut down without affecting the operation of the rest of the process. In general, the plant resembles the zinc unit, but on a smaller scale, and embodies those features of design which experience with the zinc plant has proved to be desirable.

THE TESTING OF CHROME ORE

The sampling and assaying of South African chrome ore are discussed by L. Weinberg in the *S.A. Mining and Engineering Journal* for June 20 and full extracts from his article are given here. The writer says that the way in which chrome ore is usually mined and handled for export in Rhodesia, combined with the low margin of profit which it yields to the producer and exporter, makes the sampling and assaying of the ore a matter of great importance. A minimum grade of 48% or 49% of chromium sesquioxide has to be guaranteed to the overseas users and, in times when competition from other countries is severe, the penalties exacted for deficiency in grade are so serious that the local exporter cannot afford to take any risks of this happening. Nevertheless, it is surprising that, apart from the large organizations, nothing like the amount of care necessary is bestowed on the important question of sampling.

The Sampling of Chrome Ore.—The usual method of handling chrome is that the producer mines the ore under contract to supply the exporter, and settlements are effected before the ore is actually shipped, the basis of settlement being often decided on before the ore has been loaded into trucks for export. The mine is more often than not at a considerable distance from rail-head and the ore, after mining and collecting in dumps at the mine, is transported by ox wagon to the rail-head, where it is dumped ready for loading into trucks. Samples are usually taken for assay from the reefs, before mining is undertaken, then from the mine dumps, and finally from the station dumps. In some instances the trucks are sampled and, finally, the ore, after lying on dumps at the sea port, is sampled as the ore is loaded into lighters or steamers.

The sampling at each stage presents its own problems and the test of accurate sampling is, of course, the manner in which the assay results of shipments conform with the assay results of the mine dumps, station dumps, trucks, etc. It is, of course, essential to have correct assay results of the samples taken, but no matter how accurate analyses are, they are useless if the samples themselves do not accurately represent the dumps, truckloads, etc., from which they were taken. Chrome ore is affected by the conditions to which it is exposed, such as rain, wind, dust, contact with the earth, etc. Roughly speaking, there are two classes of ore—massive, fine-grained ore, and friable, coarse-grained ore. The massive ore is fairly homogeneous and does not cause anything like the trouble caused by the friable ore. The friable ore consists of crystals of chromite which are embedded in matrix which very often is a light and soft substance such as serpentine. Friable ore crumbles easily, especially after exposure to the weather and forms fines. Dumps of friable ore are readily contaminated by the soil on which they rest. This is particularly the case in wet weather. In this case, when dumps are loaded on to wagons, soil is likely to be shovelled along. This can be prevented only by keeping the ore dumps on prepared surfaces, such as galvanized iron sheets, or in petrol tins. During the crumbling of friable ore, chromite crystals become separated from the gangue. The light gangue may be blown away by wind, causing a concentration of chrome in the fines. It is clear that the chrome content of the fines may be very different from that of the lumps. In sampling chrome of this nature, great care must be taken so that the sample will contain the same proportion of lumps and fines as the dump itself.

It should, of course, not be necessary to point out that the sampling of dumps or truckloads should not consist of merely taking a few pieces here and there off the surface. Thus, as pointed out, there is the possibility of fines collecting on the bottom of the dumps. Again, it is useless to sample a dump, no matter how thoroughly, if one cannot be certain that on transporting the dump some soil is not shovelled along with the ore. And even in the best of cases one cannot assume that the chrome is evenly distributed throughout the dump. In general, it is clear that the best procedure in sampling would be to do so actually at the time when the ore is being shifted from one place to another, rather than to sample stationary dumps or full truckloads.

Assay Methods.—As regards the assaying of chrome ore, it is a well-known fact that there is not that close agreement between results of different analysts that there might be. The reason for this lies not so much in the methods employed or the skill of the analyst, but in the preparation of the sample for analysis.

(*a*) *The Preparation of the Sample for Analysis.*—A sample of chrome ore representing, say, 100 tons may weigh as much as 25 lbs. This has to be crushed and quartered until a quantity weighing only a few grams is left ground to the finest powder. This process, although an every-day one to the analyst, has its pitfalls, especially in tropical countries, where the analyst has to depend on the native for the greater part of this work, for no matter how well trained the native is liable to periods of slackness. A way of avoiding this is to use machinery throughout. Jaw crushers reduce the ore to ¼ in., and the quartered sample is put through a disc crusher. Disc crushers have several disadvantages, particularly the difficulty of keeping the dust from blowing away (which, as in the case described above, will cause a certain amount of concentration). Also the disc crushers will not give a fine product without the introduction of an excessive amount of iron, which means removal by a magnet subsequently. If the second stage is to produce a product passing a 40-mesh sieve, as usually done, no disc crusher which has seen any wear will do it in one operation. The usual method is the pestle and mortar. The ore after every few minutes is sieved, and the plus 40 portion returned to the mortar, until the whole of the sample passes the sieve. This is a process heartily disliked by the native, as the plus 40 portion becomes smaller as the crushing goes on, and is difficult to handle at the end. So the native, after the crushing is half or three-quarters finished, is tempted to discard the plus 40 portion and offer the minus 40 portion as the crushed sample. As regards the introduction of iron from the pestle and mortar, the oftener the ore is sieved during the crushing process the less iron is introduced. Experiments show that ordinarily not more than 0·2% of iron is introduced. The crushing of the last of the plus 40 portion is best done on a bucking board. This saves time and has the added advantage that it ensures complete crushing with

the minimum of supervision, for when the native can be seen (and heard) using the bucking board, there can be no doubt that the last portions of the sample are reduced. This matter may seem very elementary, but its importance cannot be exaggerated. Faulty crushing can be prevented (*a*) by continuous personal supervision; (*b*) by using mechanical crushing throughout; (*c*) by weighing the sample before and after crushing and noting any discrepancy; (*d*) by isolating the native in such a manner that the discarding of any portion of the plus 40 portion is immediately detected; (*e*) as explained above, by the use of the bucking board to finish off. The last stage is the grinding of the sample in an agate mortar to the finest possible powder. Here again the crystals of chromite resist grinding to a greater extent than the gangue. However, insufficient grinding is almost certain to give a low result, as some of the ore is then not decomposed by the peroxide fusion. Mechanical devices are said to give satisfaction, but the author finds it most satisfactory to grind only small portions of the sample at a time, each time spreading the ore over the whole surface of the agate mortar.

(*b*) *Analysis.*—The shortcomings of the methods of chrome analysis in common use are probably known to all chemists and were summarized in a paper read before the S.A. Association of Analytical Chemists some years ago. In this paper a method was suggested which was free from objections, and from this the method used by the author has been developed. The ordinary method consists of fusing 0·5 gms. of the ore in an iron crucible with sodium peroxide, extracting the melt with water, boiling to destroy excess peroxide, filtering, acidifying the filtrate, and estimating the chromium oxide in the solution, either by adding potassium iodide and titrating with thiosulphate, or adding a known excess of Mohr's salt (ferrous ammonium sulphate) and titrating the excess with permanganate or bichromate.

Apart from chemical considerations, this method has two grave faults: (1) The filtration and washing of the precipitate is a long and wearisome business, and even the most thorough washing will not dissolve out all the chromate. (2) It is easy for the fusion to have been incomplete without this fact being discovered. As regards (1) it has been suggested to avoid the filtration by collecting the mixture in a graduated flask, allowing to settle, and pipetting an aliquot portion for titration from the supernatant solution. This is obviously open to criticism, as the volume occupied by the precipitate is left out of account, and as each measurement introduces a source of error. As regards (2), incomplete fusion is much more common than generally supposed. Inferior sodium peroxide, too short a period of fusion, or insufficiently ground ore are the cause of incomplete fusion. Of course, incomplete fusion could be detected by dissolving the washed precipitate in acid, but when an iron crucible has been used, iron scale is usually present, which takes a long time to dissolve.

In the method used by the author, firstly the fusion is carried out in a porcelain crucible to avoid the introduction of too much iron. The melt is extracted with water and completely dissolved in dilute sulphuric acid (1 in 4). This avoids the filtration, and any undecomposed ore is immediately shown up. The treatment after acidification requires some explanation. The acid liberates hydrogen peroxide, which may oxidize some of the chromate to perchromate, which in turn decomposes, giving chromium salts. This action takes place more readily in the cold. The author consequently takes up the melt in only 80 cc. of water, and adds about 30 cc. of the sulphuric acid, using not more than 20 cc. of water for rinsing the crucible. The heat liberated by the reaction prevents the perchromate action to some extent. However, in order to re-oxidize any chromium salts, 3 to 5 gms. of potassium persulphate are added, the solution is brought to the boiling point, and then 30 ccs. of sulphuric acid (1 in 4) added. The boiling is continued for 40 minutes, and in the strongly acid solution the persulphate is destroyed. Water is added if the volume becomes too low. If any manganese is present, it shows itself as a dark precipitate of manganese dioxide. This can be reduced to manganous salt by adding a little benzoic acid at the end of the boiling period, and continuing to boil until the solution is quite clear. The solution is cooled and titrated by the excess ferrous ammonium sulphate method. This method has been used for over seven years; it has been tested against most known methods by using standard chromium compounds and has been found most reliable. This method is strongly recommended as a standard method for chrome assay.

MILL RETURN VALUES

In the *Proceedings* of the Australian Institute of Mining and Metallurgy for March 30 C. C. Freeman deals with the determination of relative economic values of mill returns and full extracts from his paper are given here. The author says that in concentrating-mills, where several minerals are recovered for realization in more than one product, various systems are used to express the relative economic value of the work done, and the writer describes a system which, in his opinion, is more complete than any other that he has seen published.

The controlling factor in all mill work must be based on the economic result represented by the greatest margin possible between the realizable value of the products and the cost of obtaining same. From a mill-man's point of view these are affected by the following factors: (1) Metal contents of ore; (2) grade of products; (3) recoveries; and (4) working costs.

The grade of ore milled is usually outside the mill-man's control, but this may exercise a considerable influence on the grade of his products, metal recoveries, and revenue per ton of ore. Higher grades or recoveries may be obtained by using a more expensive process, or by additional grinding or reagents, and the economic comparison can only be arrived at by obtaining an analysis showing the monetary value of each variation within the possible limits.

In the system to be described, the value of unit variations of metal contents of the ore, grade of

products and recoveries are calculated in terms of a monetary unit per ton of ore with the returning charges ruling, and any suitable metal prices. To do this it is necessary to assume what, for convenience, is termed a "standard" set of results from the mill, preferably representing about average conditions and, having calculated the effect of unit variations in respect to the first three of the above factors, comparison between any actual result and this common standard is made by summing the results of the variations multiplied by the unit rates. As the value of each set of results for different periods, or mills, is obtained in reference to the common standard, the comparison between each of these sets is established. To obtain a full economic comparison, the operating costs per ton of ore are finally included so as to correlate all the factors.

The advantage of the system is that, apart from showing the total economic position, an accurate analysis is obtained which clearly shows in a monetary unit the incidence of any of the variations in the mill results.

The easiest way to describe the system will be to take an example, assume returning charges and metal prices, calculate the necessary tables for unit variations, and then show the application of these tables. Taking a lead, silver, and zinc ore, and a mill producing a lead-silver concentrate and a zinc concentrate, with the market prices of lead, silver, and spelter at £16 per ton, 1s. 6d. per oz. (fine), and £16 per ton respectively. The following are taken for returning charges f.o.r. smelters :—

Lead concentrate 47s. 6d. per ton with payment for 95% of the lead and 98% of the silver.

Zinc concentrate $\frac{P\ (T-8)}{100} - 78s.$

Freight mine to smelters in each case, 55s. per ton net dry.

Assume for calculations the following standard results :—

	% Pb.	*Oz. Ag.*	*% Zn.*
Grade of ore	14·0*	3·0*	10·0*
,, ,, lead concentrate	70·0*	14·2	5·0
,, ,, zinc concentrate	1·5	1·0	52·0*
Recoveries in lead concentrate %	95·0*	90·0*	9·5
Recoveries in zinc concentrate %	1·6	5·1	80·0*

As there would be no penalty or premium for lead and silver in zinc concentrate or for zinc in lead concentrate, only the eight figures marked thus * are required for the calculations.

The revenue per ton of ore derived from the foregoing would be as follows :—

	s.	*d.*
In respect to lead	20	11·484
,, ,, silver	3	11·628
,, ,, zinc	1	2·400
Total revenue	26	1·512

Calculating the effect on revenue of variations from the standard of one unit and expressing this in terms of pence per ton of ore, the following tables are obtained :—

(1) 1% variation in Pb content of ore—

% Pb in lead concentrate.	*Pence per ton ore per unit Pb in ore.*
68	17·47
69	17·72
70	17·96
71	18·20
72	18·43

(2) 1 oz. per ton variation in Ag content of ore—

15·88 pence per ton of ore.

(3) 1% variation in Zn content of ore—

% Zn in zinc concentrate.	*Pence per ton ore per unit Zn in ore.*
50	·27
51	·87
52	1·44
53	1·99
54	2·52

Note.—Although the above 1, 2, and 3 are calculated at the recovery taken in the standard, the above unit variations are applied irrespective of the recovery in the set of mill results to be studied, as 4, 5, and 6 take care of this factor.

(4) 1% variation in Pb recovery—

% Pb in ore.	12	13	14	15	16
% Pb in lead concentrate.	*Pence per ton ore per 1% recovery of Pb.*				
68	2·21	2·39	2·57	2·76	2·94
69	2·24	2·42	2·61	2·80	2·98
70	2·27	2·46	2·65	2·84	3·03
71	2·30	2·49	2·68	2·87	3·06
72	2·33	2·52	2·72	2·91	3·10

(5) 1% variation in Ag recovery—

Oz. Ag. per ton in ore.	*Pence per ton ore per 1% recovery of Ag.*
2	·35
3	·53
4	·71
5	·88
6	1·06

(6) 1% variation in Zn recovery—

% Zn in ore.	8	9	10	11	12
% Zn in zinc concentrate.	*Pence per ton ore per 1% recovery of Zn.*				
50	·03	·03	·03	·04	·04
51	·09	·10	·11	·12	·13
52	·14	·16	·18	·20	·22
53	·20	·22	·25	·27	·30
54	·25	·28	·32	·35	·38

(7) 1% variation in Pb in lead concentrate—

From.	*To.*	*Value in pence per ton ore.*
68	69	3·49
69	70	3·39
70	71	3·29
71	72	3·20

(8) 1% variation in Zn in zinc concentrate—

From.	*To.*	*Value in pence per ton ore.*
50	51	5·97
51	52	5·74
52	53	5·52
53	54	5·32

Note.—Each of these last two tables must be used cumulatively ; that is, 52/54% Zn would give a variation of 5·52 + 5·32 = 10·84d. per ton ore.

Application of the System.—Having compiled the foregoing tables they may be easily applied to any combination of mill results within the range to which they are calculated, and will hold for the returning charges, freights, and metal prices taken. Suppose, for example, a comparison is required of the two following results :—

A.	*% Weight.*	*Assay. Pb.*	*Assay. Ag.*	*Assay. Zn.*	*Metal distribution. Pb.*	*Metal distribution. Ag.*	*Metal distribution. Zn.*
Ore milled	100·0	12·0	5·0	11·0	100·0	100·0	100·0
Lead concentrate	16·0	69·0	29·375	5·0	92·0	94·0	7·3
Zinc concentrate	16·5	1·8	1·0	54·0	2·5	3·3	81·0
Tailing.	67·5	1·0	·2	1·9	5·5	2·7	11·7

B.	*% Weight.*	*Assay. Pb.*	*Assay. Ag.*	*Assay. Zn.*	*Metal distribution. Pb.*	*Metal distribution. Ag.*	*Metal distribution. Zn.*
Ore milled	100·0	15·0	4·0	8·0	100·0	100·0	100·0
Lead concentrate	20·0	72·0	18·6	4·5	96·0	93·0	11·2
Zinc concentrate	12·0	2·0	1·0	50·0	1·6	3·0	75·0
Tailing.	68·0	·5	·2	1·6	2·4	4·0	13·8

These are compared with the standard result as follows :—

A.	*Variation from standard*	*Value of unit variations under ruling conditions in pence per ton ore.*	*Total value of variations per ton ore.* Plus	Minus.
Grade of ore—				
12% Pb.		17·72		35·44
5 oz. Ag	−2·0	15·88	31·76	
11% Zn	+2·0	2·52	2·52	
Recoveries—	+1·0			
92% Pb.	−3·0	2·24		6·72
94% Ag.	+4·0	·88	3·52	
81% Zn	+1·0	·35	·35	
Grade of concentrate—				
69% Pb.	70/69			3·39
54% Zn	52/54		10·84	
		Total	48·99	45·55
		Net	+3·44d. per ton ore.	

B.	*Variation from standard.*	*Value of unit variations under ruling conditions in pence per ton ore.*	*Total value of variations per ton ore.* Plus	Minus.
Grade of ore—				
15% Pb	+1·0	18·43	18·43	
4 oz. Ag	+1·0	15·88	15·88	
8% Zn	−2·0	·27		·54
Recoveries—				
96% Pb	+1·0	2·91	2·91	
93% Ag	+3·0	·71	2·13	
75% Zn	−5·0	·03		·15
Grade of concentrate—				
72% Pb	70/72		6·49	
50% Zn	52/50			11·71
		Total	45·84	12·40
		Net	+33·44d. per ton ore	

The revenue per ton of ore can be obtained by adding the net total to the revenue from the standard, namely, 26s. 1·51d.

Thus revenue from—

A would be 26s. 4·95d. per ton ore.

B ,, ,, 28s. 10·95d. ,, ,,

Revenue from each metal may be obtained separately by picking out the total value of variations as affecting each metal and adding or subtracting these to or from the revenue in respect to each metal. An analysis may be made to show up any phase of the work. Thus the revenue from B is 30d. per ton greater than in A.

By summing the variations under headings as below we obtain the following comparisons with the common standard :—

	A.	*B.*	*B.—A.*
Due to grade of ore.	−1·16	+33·77	+34·93
Due to grade and recoveries of Pb and Ag in lead concentrate	−6·59	+11·53	+18·12
Due to grade and recoveries of Zn in zinc concentrate	+11·19	−11·86	−23·05
	+3·44	+33·44	+30·00

This clearly shows that the improved revenue was entirely due to the grade of the ore milled and that the net metallurgical results were better in A than B.

To complete the economic picture it is only necessary to include the item of any variations in operating costs which are already in terms of the monetary unit per ton of ore.

From the calculations the analysis may be taken out in various ways to show up any particular point desired.

In conclusion, it may be added that while the above tables and examples have been calculated to whole units, where fractions occur a *pro rata* allowance may be made without loss of accuracy.

THE SLACK-LINE ROPEWAY

The application of the slack-line cableway to excavating, conveying, and elevating material is dealt with by M. Moore in the *Chemical Engineering and Mining Review* of Melbourne for June 5. The author says that the slack-line arrangement has proved to have many advantages over the ordinary arrangement of the taut rope and the flying bucket which can be raised or lowered at any point.

The essential parts of a slack-line cableway are a double drum friction-driven winch similar to that supplied for the drag scraper, except that it is necessary that the drums should be fitted with effective brakes capable of holding a load equal to the full pulling power of the winch and also for most large and important plants the hauling drum operates at two speeds. The lower speed gives about double the pull and is used during the excavation part of the operation cycle. As soon as the bucket has been filled and lifted clear of the material, the higher speed is put into operation and the bucket is thus hauled to the tower at a fast speed.

The tower consists of a mast varying in height according to the conditions. The mast may be up to 100 ft. or more in height for large plants where the level at which the material is to be delivered is considerable. The mast is arranged with guy ropes in the manner shown, and on the head of it rope blocks are attached usually on revolving collars so that they can take any alignment in relation to the mast.

The winch is usually located to one side of the mast, a position being selected so that the driver is able to command a good view of the bucket at all times. The tail anchorage is generally similar to those previously described for the drag scrapers, except that no return sheave block is required. The slack-line consists of a locked coil or other strong wire rope which is secured to an adjustable anchor clamp at the tail end and is shod with a clevis at the mast end. To this clevis is attached a treble or fourfold rope block, which mates with another treble block attached to the head of the mast, forming a powerful pulley system by means of which the slack-line cable is tightened or slackened.

Slack-line Bucket and Attachment.—The heart of a successful slack-line installation is the bucket itself. Without an efficiently constructed bucket with its somewhat complicated chains and attachments, efficient work is impossible. As in the case of the drag scraper, the bucket must be designed for the material to be dealt with. The drag scraper bucket is the bottomless type, but the slack-line bucket is constructed with a long bottom which projects forward to prevent the material, once it has been filled into the bucket from spilling, whilst the bucket is being traversed from the material towards the head tower. Except when excavating very soft material, it is always essential to fit the bucket with digging teeth, somewhat similar to those which are used on steam shovels. In order to minimize the resistance to digging and

hauling the bucket through the material, it is usual for the slack-line buckets to be made long and narrow compared to what is usual with other excavating buckets. Certain makers make the rear of the bucket narrower than the mouth, so that the friction due to the dragging of the material on the sides of the bucket is reduced and to facilitate a cleaner discharge of sticky material from the bucket.

The bucket itself is carried by a trolley block which runs on the slack-line and the construction of this block is very similar to the flying fox or trolley block of an ordinary cableway. Intricate mechanism connected with a slack-line bucket is found in the arrangement of the chains or ropes which are responsible for the operations of filling the bucket, transporting it in a balanced position on the cableway and automatically discharging its load when it comes to the tipping point.

Various arrangements of rope gear have been used for achieving these results and have been the subject of a number of patents. In a commonly used arrangement the purpose of the chains is as follows :—A hauling or digging chain is attached to the bucket in positions which are adjustable in height so that the penetration power of the bucket can be varied in the manner described for the drag-scraper bucket. The chain for tipping the bucket operates as follows :—When the tipping block comes in contact with a stop, which is clamped to the rope, the tipping rope, which is attached to a block, is pulled round a small sheave and thereby gradually up-ends the bucket, as the other end of the tipping chain is attached to the tail of the bucket. A carrying rope which is attached to the front and rear of the bucket passes over two small sheaves in the trolley block. Thus, when the tipping rope pulls up the end of the bucket, the carrying rope simply runs over its two sheaves and allows the front of the bucket to fall. Another rope is added as an adjustment to increase the digging effect in hard material. It will be seen that if this rope is shortened slightly, being attached as it is to the arch across the mouth of the bucket, it has the effect of tilting the bucket forward and thus driving the cutting edge into the material. The first stop is simply clamped to the rope and can be adjusted so that it can be placed in any position at which it is desired to discharge the material.

The method of operation of a slack-line cableway is as follows :—Assuming the bucket has discharged its load, the hauling rope drum clutch is thrown out completely so that the bucket will rush back by gravity at a high speed. High speed is necessary for two reasons ; firstly, to save time, and, secondly, so that the momentum will carry the bucket some distance beyond the bottom of the sag of the rope and thus enable a longer span to be commanded. It will be seen that the height of the tower must be proportioned to the span to be worked, as it is essential to have a certain difference of level between the anchorage and the head of the tower in order that the bucket will run back to the full length of the span. For this purpose, it is necessary to use high quality ball or roller bearings in the trolley and to arrange the hauling rope so that it will run with a minimum of friction. A good trolley should run at least 100 ft. beyond the point of maximum sag in the cable. The sag in the cable with the loaded bucket in the centre of the span should be about 7% of the span. In extreme cases, this may be reduced to 5%, but the tension in the cable and the pull on the tensioning ropes, winch and anchorages becomes very severe.

The bucket having run back to the end of the span or to the point at which excavation work is being done, the second or slack-line drum of the winch which operates the tensioning rope which is reeved through the treble blocks is released. The effect of this is to drop the slack-line cable, allowing the bucket to fall into the material being excavated. The driver then usually takes up a little of the slack on the slack-line cable so as to lift it and the trolley block just clear of the bucket whilst allowing the bucket to remain with its chains slack bearing its full weight on the material to be excavated. He then throws the hauling cable drum into gear, pulls the bucket forward until it is full, at which point he again engages the slack-line drum and hauls the cable taut, thereby lifting the bucket high into the air. Immediately it is clear of the ground, he may throw his high gear into operation on the hauling drum so that the bucket can be hauled to the head tower. The digging speed on the hauling rope runs up to about 200 ft. to 250 ft. per minute and the traversing speed from 600 ft. to 700 ft. per minute.

As the excavation proceeds, the anchorage of the cable must be moved sideways to prevent the bucket digging deep trenches.

Applications of the Slack-line Cableway.—In general, the applications of the slack-line cableway are similar to those described for the drag scraper, except that the slack-line will operate over longer spans, elevate the material to much greater heights and will also excavate material and transport it over roads, rivers or other property which must not be interfered with or over spaces across which a bottomless bucket cannot be dragged. When spans are long, say, over 400 ft. or 500 ft. and where the height of delivery of the material is, say, over 20 ft. from the ground, or where there are obstructions between the point of delivery and the source of excavation, then the slack-line cableway will be installed in preference to the drag scraper. With regard to the capacity of the plant, buckets are built up to 5 cu. yd. capacity and speeds are such that on a span of 600 ft. it is possible to do about 20 trips per hour.

Cableway Drag Scraper.—In another application of the double-drum winch and drag-scraper bucket the bucket is lifted above the material. This is really a modification of a drag scraper rather than of the slack-line cableway. The return rope of the plant is led through a sheave arranged on the rear end of the drag scraper bucket, as shown. On the return journey of the bucket when the return rope is pulled tight, if a certain tension is also held on the brake of the hauling rope drum, then the return rope will lift the bucket clear of the material. This is often of considerable advantage in that it enables the bucket to be dislodged by lifting it clear of snags, etc., should it become stuck when dragging under water. Also, when digging down material from a high bank, quicker and better work with less effort on the winch and less wear and tear on the ropes and the scoop can be achieved by this rig.

[This arrangement was used both for unloading the flat-topped scows and also for excavating material from the high banks. Its advantages

will be evident in this instance, in that, when unloading material from the scows, the bucket was drawn a little too far forward and fell into the water over the edge of the scow, the tightening of the return rope in this manner lifted it up clear of the scow so that it could be returned for another load. This arrangement enables berms to be left along channels between the channel and the spoil bank. When dredging material from below water it enables the bucket to be returned above water to the point from which material is being removed and then dropped through the water, thereby getting a quicker return and saving the resistance due to pulling the bucket back through water.

A TASMANIAN STANNITE ORE

A stannite ore from the Oonah mine, Zeehan, Tasmania, is described by Dr. F. L. Stillwell in the *Proceedings* of the Australian Institute of Mining and Metallurgy, N.S. No. 81. The author points out that the ore from the " Stannite " lode in the Oonah mine, Zeehan, has a complex composition and contains an exceptional number of elements. Its chemical composition has been given by Twelvetrees and Ward as follows:

Silver	22 oz. per ton
Copper	5·5%
Tin	4·5%
Bismuth	0·4–0·45%
Iron	26–27%
Sulphur	29%
Silica	22–27%
Alumina	4·5%

An analysis of apparently pure stannite was made by J. H. Levings with the following result:

	%
Silver	0·298 = 97·3 oz. per [ton.
Tin	23·27 as sulphide ·64 as oxide
Copper	26·77
Iron	12·11
Bismuth	2·27
Antimony	0·505
Arsenic	trace
Zinc	0·475
Sulphur	32·10
Silica	1·40
Oxygen	0·14

These figures indicate the proportions of the main elements in the ore and show that even apparently pure stannite is contaminated by a number of minerals. The identity and the relationships of these minerals to each other are, therefore, an important basis for any experimental work upon the metallurgical treatment of the ore.

Mineral Composition.—The metallic minerals that have been observed in a sample of the ore are—pyrite, arsenopyrite, cassiterite, stannite, chalcopyrite, tetrahedrite, bismuthinite, and galena. The gangue minerals are chiefly quartz, with some siderite and occasional fluorite. Twelvetrees and Ward also record wolfram and antimonial lead.

The examination of polished sections of the ore shows clearly the existence of two generations of minerals. Pyrite, arsenopyrite, and cassiterite belong to the earlier generation with quartz. Stannite and chalcopyrite with the smaller included amounts of tetrahedrite, bismuthinite, and galena belong to a later generation. The earlier generation shows considerable replacement by the later generation, and the varying degrees of replacement partly account for the wide variations in mineral content in different specimens of ore. Wolfram is a common associate of cassiterite and, though not detected in the polished sections, would undoubtedly belong to the earlier generation.

Pyrite.—Pyrite occurs in seams and bunches of crystals which are generally associated with the siliceous portions of ore. Isolated crystals in quartz are often idiomorphic, but isolated crystals in stannite are generally corroded and often represent shapeless, unreplaced residuals. The edge of a mass of pyrite in contact with an area of the stannite group of minerals is often corroded and, in places, is transgressed by numerous veins of chalcopyrite, stannite, galena, and bismuthinite. Of these the replacement by chalcopyrite is the most prominent.

Arsenopyrite.—Arsenopyrite is much less abundant than pyrite, though in limited areas crystals of arsenopyrite may be more numerous. The crystals are often comparatively large and easily visible to the naked eye on the polished surface. They are generally idiomorphic in contact with quartz or pyrite, but are extensively corroded and veined by the invading areas of the stannite group of minerals.

Cassiterite.—Crystals of cassiterite occur within the main areas of pyrite, arsenopyrite, and quartz. They appear more abundantly as bunches along the margin of quartz and stannite and in areas of chalcopyrite. They also occur embedded in stannite. Large bunches of crystals may measure ·87 mm. × 1·15 mm., but many individuals in the residual groups in stannite may be as small as ·002 mm. in width. Inclusions of cassiterite in stannite tend to be more abundant in areas rich in chalcopyrite, and they are often surrounded by a thin sheath of chalcopyrite. The average amount of cassiterite is greater than that indicated in Levings' analysis of stannite, and approximates to his estimate that as much as 15% of the total tin occurs as oxide.

Cassiterite in polished sections is recognized by its hardness, grey colour in comparison with dark quartz, and by its resistance to all etching agents. Though recognizable in the polished sections, it is only identified with certainty by the preparation of a thin section and by examination in transmitted light. The cassiterite is then recognized by its high refractive index, high double refraction, straight extinction, uniaxial and positive character. These optical properties, combined with its hardness, which is similar to that of quartz and sometimes a little higher, establish the mineral as cassiterite beyond doubt.

Chalcopyrite.—Chalcopyrite is an abundant constituent of all sections containing stannite, and is readily recognized by its yellow colour. It is unevenly dispersed throughout the stannite as small inclusions of irregular shape and size.

While these are numerous they are not comparable in abundance with the myriads of minute particles of chalcopyrite that are a feature of many stannites from other localities. It may perhaps be that the excess copper in the stannite solutions of the Oonah deposit has been largely utilized in the replacement of pyrite and its conversion into chalcopyrite.

Some areas of stannite are comparatively free from inclusions of chalcopyrite, but there are other fields where the amount of chalcopyrite approximates to that of stannite. Others again are more accurately described as large areas of chalcopyrite honeycombed with irregular inclusions of stannite. These larger areas of chalcopyrite are often studded with cassiterite particles. Moreover, as many particles of cassiterite in stannite are surrounded with a thin coating of chalcopyrite, it would appear that cassiterite, belonging to the earlier generation of minerals, has been more stable in contact with chalcopyrite of the later generation than in contact with stannite. Chalcopyrite also contains inclusions of tetrahedrite, galena, and bismuthinite.

Stannite.—Stannite is the most abundant mineral in the specimens of ore, and is readily recognized in a polished section by its brownish white colour. It is a very brittle mineral, and the polished surfaces show pittings which appear as dark spots in the photographs. It is anisotropic, and frequently shows traces of an imperfect lamella twinning. It is attacked by HNO_3 with the development of an etched structure, showing the irregular outlines of the crystals, and also at times the intermittent and impersistent twin lamellae.

Like chalcopyrite, it frequently shows evidence of the replacement and veining of pyrite, arsenopyrite, cassiterite, and quartz. Residuals of these minerals appear as common inclusions in stannite. In addition, stannite contains numerous small inclusions of chalcopyrite, tetrahedrite, bismuthinite, and galena.

Tetrahedrite.—Tetrahedrite is the important silver mineral in the ore. It is also probably the source of all the antimony in Levings' analysis of stannite. Its greyish-white colour on the polished surface enables it to be distinguished from the brownish-white stannite of similar hardness. It is unattacked by the standard etching agents, and only affected by a mixture of HCl and CrO_3. Sometimes inclusions of tetrahedrite occur in chalcopyrite, while minute particles are often associated with the inclusions of bismuthinite and galena.

Bismuthinite.—Bismuthinite occurs as irregular veinings and replacements in quartz, pyrite, and arsenopyrite, and also as minute inclusions dispersed throughout the stannite. Isolated crystals are generally prismatic in shape, and some are as small as ·001 mm. in width. Bismuthinite in a polished section has a galena-white colour and is etched slowly by HNO_3 with the development of its prismatic structure. It resembles stibnite in being strongly anisotropic and pleochroic, but is distinguished from stibnite by its resistance to KOH. Its identification has been confirmed from areas surrounded by quartz from which it can be dissolved by concentrated HNO_3 without contamination. The drop of solution so obtained is transferred to a glass slide and tested for bismuth by microchemical methods.

Many of the areas of bismuthinite in both quartz and stannite are composed of several crystals associated with particles of tetrahedrite and galena. Some of the individual crystals may also contain thin films of stannite along the cleavage planes of bismuthinite, and at times a very intimate association of bismuthinite and stannite is presented.

Galena.—Minute quantities of galena occur in the ore as inclusions in chalcopyrite and stannite. It is often associated with the inclusions of bismuthinite, and is indistinguishable from bismuthinite in an untreated section. It is, however, readily distinguished by etching with HCl or $FeCl_3$, when the galena is rapidly tarnished. Galena is then seen in some cases to fill interstices between the prisms of bismuthinite and extends in other cases to amounts equivalent to, or greater than, the area of bismuthinite.

The minute inclusions in stannite may, therefore, be composed of galena, bismuthinite, tetrahedrite, or chalcopyrite, and many are minute composite aggregates of two or more of these four minerals. Galena is perhaps not so constant an associate of bismuthinite as tetrahedrite. It tends to be more frequently associated with chalcopyrite, and appears to find its greatest development in areas of chalcopyrite.

Composition of Stannite Ore.—The comparison of the mineral constitution of the ore with Levings' analysis of stannite indicates that the tin content is derived from cassiterite as well as stannite. The proportion derived from cassiterite is less in apparently pure stannite than in the average ore sample.

The copper content is derived from stannite, chalcopyrite, and tetrahedrite. In the apparently pure stannite possibly as much as 90% is derived from the stannite, perhaps 8% from chalcopyrite, and the remaining 2% from tetrahedrite. In the average ore the percentage of copper derived from chalcopyrite materially increases.

Bismuth is wholly derived from bismuthinite and the silver and antimony from tetrahedrite.

Iron is derived from pyrite, chalcopyrite, arsenopyrite, and stannite. The presence of arsenopyrite indicates that the average mine ore contains a small percentage of arsenic. Small quantities of lead are also present, being derived from the galena. Zinc blende has not been detected in the stannite, and it is probable that the zinc in Levings' analysis of stannite replaces part of the iron in the theoretical composition of stannite (Cu_2S, FeS, SnS_2). Zinc is sometimes present in the composition of tetrahedrite, but the proportions of tetrahedrite are insufficient to account for the estimated amount of zinc in the stannite analysis.

Sampling Cyanide-Gold Bullion.—The dip sampling of cyanide-gold bullion at the Sons of Gwalia gold mine in Western Australia is described by C. O. A. Thomas in the *Proceedings*, N.S. No. 81, of the Australian Institute of Mining and Metallurgy. The author says that the difficulty of accurately sampling cyanide gold bullion for valuation is well known, and nothing new or original is claimed in presenting his paper, but it was thought that a record of differences found in the composition of bullion bars might be of interest to others and perhaps helpful to those who have to do with the evaluation of cyanide bullion.

A method was in use at Gwalia of boring each ingot in two places and mixing the two borings for the sample. More accurate values were obtained, however, when the bullion was sampled in a molten condition immediately before casting into the ingot; the sample being so taken as to preclude oxidation of base metals before solidification of the sample. In all, samples from 32 ingots were assayed and comparisons made between the existing boring sample and the proposed dip sample. Assays were also made of two other portions of the borings from each ingot and the results show that in the majority of cases the borings sample assays higher in gold than the dip sample of the same ingot.

Ingots are cast in C.I. moulds $\frac{5}{8}$ in. thick, smoked, and heated, and the largest ingot cast weighs approximately 920 troy ounces.

Method of Taking Boring Samples of Bullion Bars.—The bar is cleaned from adhering slag and drilled in two places only, to a depth of $\frac{1}{2}$ in., one hole on the top near one end and the other in the bottom at the opposite end of the bar. The borings from the top $\frac{1}{8}$ in. of each hole are rejected, and the borings from the next $\frac{1}{8}$ in. are mixed together and comprise the assay sample of the ingot. About 5 grm. of borings are taken. For the purpose of comparison the rejected borings were assayed separately.

Method of Taking Dip Samples of Bullion.—A graphite rod having a hollow at one end is heated red hot and immediately before casting the ingot the rod is grasped in a pair of light tongs and the hollow end plunged well into the molten bullion in the crucible, the metal stirred round until thoroughly mixed and the bullion sample withdrawn in the rod and cast beneath castor oil in a hot iron mould. When cool or solid, the button, weighing about 5 grm., is cleaned from slag and from oil with methylated spirit and comprises the dip sample of the bullion.

The gold content of the rejected borings from the tops of the bars was in most cases higher than any other sample taken, whilst the gold content of the bottom rejected borings was usually the lowest.

The boring sample proper (a mixture from the top and bottom of the bar) usually had a gold content between the rejected borings and generally slightly above that of the dip sample.

Observations made as to the relative conditions of casting the ingots, e.g., temperature, did not appear to yield any satisfactory explanation of the variations in value of the different parts of the bar.

The table summarized here sets out :—

(1) The period of the mint return.

(2) The bars melted together by the mint and assayed.

(3) The ounces of fine gold estimated by the mine using boring sample figures.

(4) The ounces of fine gold estimated by the mint which employs a method of dip sampling bullion, and whose results are final.

(5) The ounces of fine gold estimated by the mine using dip sample figures.

The mine estimate using dip sample figures is closer to the mint estimate than when using boring sample figures. Bore sampling of ingots was discontinued as from February 3, 1930. A second table sets out and compares the various samples taken from the bars, which are tabulated in order of their increasing gold content on the dip sample.

An analysis of a sample of an ingot of average fineness was as follows :—

	Fineness.
Gold	825·3
Silver	66·6
Copper	74·5
Lead	26·4
Zinc	5·3
Iron	2·3
	1000·4

The bullion is a mixture of several constituents and, due to segregation on cooling, would present difficulties to correct sampling in the solid state. This is borne out by experience. Upon comparing the samples taken from the outside top of the bar, the outside bottom of the bar and the dip sample, the bottom section usually contains more base, the top section least base, and the dip a quantity in between, pointing to liquation of base metal to the bottom of the bar and the enrichment of the upper central portions of the bar. The dip representing the true composition is in between the extremes.

	Fine Gold.			
	Bore sample estimates.		*Dip sample estimates.*	
Period.	Under-estimated oz.	Over-estimated oz.	Under-estimated oz.	Over-estimated oz.
June–July, 1929		2·156	0·001	
Aug.–Sept., 1929		2·621		1·217
		2·774		2·657
		2·675		1·851
		2·446	0·926	
Oct.–Nov., 1929		4·157	0·451	
		3·776		1·408
		1·800		1·096
Dec., 1929	3·482		1·886	
Jan., 1930	2·131			1·264
	1·643		3·326	
	oz.	oz.	oz.	oz.
Total	7·256	22·405	6·590	9·493
Less under-estimated		7·256	Less under-estimated	6·590
Fine gold over-estimated		15·149		
			Fine gold over-estimated	2·903

Fine gold for the whole period :—

Boring estimate.	Dip estimate.	Mint estimate.
oz.	oz.	oz.
17,020·387	17,008·141	17,005·238

Ore Leaching.—Technical Paper 498 of the United States Bureau of Mines by J. D. Sullivan and E. O. Ostrea is a continuation of Technical Paper 441 of the same Bureau in which was presented evidence to show that the solubility of the gas within the ores was one of the most important factors that determined the ingress of solutions, notwithstanding the fact that capillarity has at times been considered almost the only important factor involved. This phase of the study was continued and the authors summarize the results of their present work as follows :

1. Solutions penetrated more rapidly into small-bore or capillary glass tubes when the tubes were filled with sulphur dioxide than when filled with air.

2. Glass tubes containing air and at 3° 50′ from the horizontal filled with water in 15 seconds when both ends of the tubes were open, but virtually no penetration took place in 144 hours when the upper ends of the tubes were closed.

3. Water rose 6·7 millimeters in a vertical glass tube with a bore of 0·191 millimeter and filled with air when both ends of the tube were open, but rose only 0·2 millimeter when the upper end was closed.

4. When the glass tubes were horizontal and filled with air slightly greater penetration took place in tubes of small bore.

5. When the glass tubes contained air boiled distilled water penetrated more rapidly than distilled water saturated with air.

6. When the glass tubes contained sulphur dioxide distilled water saturated with air penetrated more rapidly than distilled water saturated with sulphur dioxide.

7. Ethyl alcohol penetrated a glass tube at virtually the same rate as distilled water.

8. Replacing the air in the voids within pieces of Warren unweathered ore with sulphur dioxide increased the rate at which distilled water permeated the ore.

9. The time required for a given percentage penetration increased with increases in sizes of particles of ore.

10. Ethyl alcohol penetrated the voids of Warren ore more rapidly than distilled water.

11. The effect of the solubility of the gas within the voids on the rate of penetration of solutions and the ability of solutions to wet the surface of ore particles has been discussed.

12. A study has been made of the rise of distilled water in glass columns of Warren and El Tiro ores crushed to various sizes.

SHORT NOTICES

Mechanical Loading.—In the *Canadian Mining and Metallurgical Bulletin* for July, R. S. Bigelow discusses progress in mechanical loading in both coal and metal mines.

Asphalt in Cuba.—A. E. Northey describes the mining of asphalt in Cuba in *Engineering and Mining World* for July.

Machine Drilling.—The use of specially designed carriages for machine drills in the Flin Flon mine is described by M. A. Roche in the *Canadian Mining Journal* for July.

Felspar Mining and Milling.—To the *Canadian Mining and Metallurgical Bulletin* for July, N. B. Davis contributes a paper on felspar mining and milling in Canada.

Flotation of Native Copper.—E. Koepel describes the flotation of native copper at Freda, Michigan, in *Engineering and Mining World* for July.

Leaching Oxidized Copper Ore.—The description of an experimental plant, designed to show the advantages of the removal and separate treatment of slime, by W. J. Loving, appears in *Engineering and Mining World* for July.

American Metallurgy.—An abstract of the report on modern American metallurgical practice by W. D. Jones, holder of an "Arthur S. Dwight" Post-Graduate Travelling Grant, is given in the *Bulletin* of the Institution of Mining and Metallurgy for July.

Zinc in British Columbia.—In *Engineering and Mining World* for July, G. J. Young describes the zinc, acid, and fertilizer plants of the Consolidated Mining and Smelting Company of Canada.

Lead Refining.—H. Lauterbach discusses the refining of lead by the Harris process in *Metall und Erz* for July 1.

Electrolytic Copper.—In *Engineering and Mining World* for July, L. C. Fopeano describes the fire-refining and casting of electrolytic copper.

Asbestos.—Some of the uses of asbestos are described in a paper by J. S. Hancock and C. W. M. Furniss, which appears in the *Journal* of the Chemical, Metallurgical, and Mining Society of South Africa for May.

Ore-Deposits in the Westerwald.—The stratigraphy and tectonic position of the iron-stone and ore-deposits between Betzdorf, Altenkirchen and Hachenburg in the Westerwald are discussed by H. Quiring in *Glückauf* for July 18.

Salt in South-West Africa.—T. W. Gevers and J. P. van der Westhuyzen in a paper read before the Geological Society of South Africa on May 4 describe the occurrences of salt in the Swakopmund area, South-West Africa.

Copper in the French Congo.—The occurrences of copper at Niari in the French Congo are described by L. Duparc in the *Bulletin Suisse de Minéralogie et Pétrographie*, vol. x, part 2.

Indian Copper Corporation.—R. B. Woakes describes the properties and operations of the Indian Copper Corporation in *Engineering and Mining World* for July.

RECENT PATENTS PUBLISHED

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

36,182 of 1929 (349,432). U. C. Tainton, East St. Louis, Illinois. Improved electro-deposition of zinc is obtained by employing an anode consisting mainly of lead, which has alloyed with it a small proportion of a metal or metals standing below it in the electro-chemical scale, such as silver, arsenic, bismuth, etc., and carrying out the electrolysis in the presence of an inorganic colloid.

36,650 of 1929 (349,563). National Processes, Ltd., London and A. R. Gibson, Bristol. Oxidized ores are leached by a solution of ammonium sulphite, with or without excess of ammonia or sulphur dioxide, in order to extract the desired metals they contain.

3,374 of 1930 (349,591). Minerals Separation, Ltd., H. Lavers, and A. H. Higgins, London. A differential froth flotation process characterized by the presence of a compound of arsenic in the ore pulp; one compound which has given improved results being sodium arsenate.

6,840 of 1930 (349,625). Doherty Research Company, New York. Apparatus for and a method of heating and melting electrically conducting material, such as a metal reduced from its ore, which comprises feeding the material upwards in a column towards the hearth of the furnace, utilizing the top of the column as an electrode from which to cast an arc to an electrode in the furnace and controlling the temperature by varying the rate of feed to the column.

9,166 of 1930 (350,086). O. Saladin, Basle, Switzerland. Sulphur ores are roasted in mechanical multiple-stage roasting furnaces, using the counter current principle and a by-pass arrangement which permits of the roasted substance being carried into an intermediate cooling zone.

10,245 of 1930 (350,625). Patentaktiebolaget Grondal-Ramen, Stockholm. Pyritic ores, to which solid fluxes and reducing means have been added if required, are smelted in a blast furnace provided with means for drawing off gaseous products, the reducing means being added in

such a proportion that a pyritic or a partial pyritic smelting takes place in the lower part of the furnace.

10,883 of 1930 (350,124). D. Tyrer, Norton-on Tees, and Imperial Chemical Industries, Ltd., London. Sulphur is produced from sulphur-dioxide containing gases by reducing the sulphur dioxide with carbonaceous materials at elevated temperatures.

16,590 of 1930 (349,313). Berzelius Metall hütten G.m.b.H., M. G. Freise, and H. Masch meyer, Germany. Material containing tin is reduced at an operating temperature which is below the melting temperature of the furnace charge, the working temperature at the close of the reduction period being raised to such a degree that the pasty or sintered slag formed protects the reduced tin from oxidation.

18,632 of 1930 (350,728). Deutsche Gas-glühlicht-Auer, G.m.b.H., Berlin. Zirconium ores are decomposed by a process which involves the use of much less alkali than has heretofore been necessary.

18,759 of 1930 (349,342). Standard Oil Development Company, New Jersey. Process for the hydrogenation of heavy oils.

26,075 of 1930 (350,828). Metallgesellschaft A.-G., Frankfort-on-Main, Germany. Pulverulent ores having a high sulphur content are roasted and sintered in a furnace burning similar ore instead of coal dust in suitable burners.

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.

Mining Electrical Engineering. By Dr. H. Cotton. Cloth, octavo, 307 pages, illustrated. Price 15s. London: Chapman and Hall.

A Practical Handbook of Water Supply. By Dr. F. Dixey. Cloth, octavo, 571 pages, illustrated. Price 21s. London: Thomas Murby and Co.

Secondary Aluminium. By Dr. R. J. Anderson. Cloth, octavo, 563 pages, illustrated. Price 45s. Cleveland, Ohio: The Sherwood Press.

Useful Information about Lead. Cloth, octavo, 104 pages, illustrated. Price 50 cents. New York: Lead Industries Association.

Engineering Geology. 4th edition. By Dr. H. Ries and Dr. T. L. Watson. Cloth, octavo, 708 pages, illustrated. Price 25s. London: Chapman and Hall.

Gmelins Handbuch der anorganischen Chemie. 8. Auflage, Teil B- Lieferung 4. Iron. Paper covers, pp. 657-872. Price 35 RM. Berlin: Verlag Chemie.

Microscopic Determination of the Ore Minerals. By M. N. Short. United States Geological Survey Bulletin 825. Paper covers, 204 pages, illustrated. Price 60 cents. Washington: Superintendent of Documents.

Pressures Produced on Blowing Electric Fuse Links: The Effect on the Surrounding Atmosphere. By G. Allsop and P. B. Smith. Safety in Mines Research Board Paper No. 67. Paper covers, 19 pages. Price 6d. London: H.M. Stationery Office.

The Ignition of Firedamp by the Heat of Impact of Coal Cutter Picks against Rocks. By M. J. Burgess and R. V. Wheeler. Safety in Mines Research Board Paper No. 70. Paper covers, 21 pages, illustrated. Price 9d. London: H.M. Stationery Office.

The Barnsley Seam: The Yorkshire, Nottinghamshire, and Derbyshire Coalfield; South Yorkshire Area. Department of Scientific and Industrial Research, Physical and Chemical Survey of the National Coal Resources No. 18. Paper covers, 70 pages, illustrated. Price 2s. London: H.M. Stationery Office.

Abandoned Mines, Catalogue of Plans of; Supplement to Vols. I, II, III, and IV. Price 9d. London: H.M. Stationery Office.

Southern Rhodesia: A. Geological Traverse down the Lower Inyantue Valley, Wankie District. By H. B. Maufe. Geological Survey Short Report No. 26. Paper, 10 pages, illustrated. Salisbury: Geological Survey.

Southern Rhodesia: The Geology of the Country around the Norah, Molly, and Umboe Copper Claims, Lomagundi District. By A. M. Macgregor. Geological Survey Short Paper No. 25. Paper, 10 pages, illustrated. Salisbury: Geological Survey.

Gold Coast: References to Occurrences of Economic Minerals in the Gold Coast, Recorded in Annual Reports of the Director, Geological Survey. By Sir A. E. Kitson and W. J. Felton. Geological Survey Bulletin No. 5. Paper covers, 35 pages. Price 1s. London: Crown Agents for the Colonies.

Gold Coast: Minerals of Concentrates from Steam-Gravels, Soils, and Crushed Rocks of the Gold Coast. By Sir A. E. Kitson and W. J. Felton. Geological Survey Bulletin No. 6. Paper covers, 50 pages. Price 1s. London: Crown Agents for the Colonies.

Tanganyika Territory: Some Salt Lakes of the Northern Rift Zone. By D. Orr and Dr. D. R. Grantham. Geological Survey Short Paper No. 8. Paper covers, 21 pages, with maps. Price 4s. London: Crown Agents for the Colonies.

South Australia: Report on the Geology of the Region to the North and North-West of Tarcoola. By R. Lockhart Jack. Geological Survey Bulletin No. 15. Paper covers, 31 pages, with map. Adelaide: Department of Mines.

The Kaolin Minerals: By C. S. Ross and P. F. Kerr. United States Geological Survey Professional Paper 165-E. Paper covers, 30 pages, illustrated. Price 15 cents. Washington: Superintendent of Documents.

Idaho: Annual Report of the Mining Industry, 1930. Paper covers, illustrated. Department of Mines.

Mineral Resources of the United States, 1929. Part I, pp. 275–332, Manganese and Manganiferous Ores, by L. A. Smith. Part II, pp. 359–371, Sand and Gravel. By E. R. Phillips. Washington: Superintendent of Documents.

Mineral Resources of the United States, 1928. Part I, Metals, cloth, 910 pages. Price $1.50. Part II, Non-Metals, cloth, 801 pages. Price $1.25. Washington: Superintendent of Documents.

The Wasatch Plateau Coalfield, Utah. By E. M. Spieker. United States Geological Survey Bulletin 819. Paper covers, 210 pages, illustrated, with maps and sections. Price $1.30. Washington: Superintendent of Documents.

Congrès International des Mines, de la Métallurgie et de la Géologie appliquée: June 1930. Proceedings, Mining Section. Paper covers,

484 pages, illustrated. Liége: Société Géologique de Belgique.

Coal-Mining Wages. Principles and Methods of Wage Determination in the Industry: An International Survey. Studies and Reports of the International Labour Office, Series D, No. 20. Paper covers, 104 pages. Price 2s. 6d. Geneva: International Labour Office.

COMPANY REPORTS

Rhodesia Broken Hill.—This company was formed in 1910 and works lead-zinc-vanadium properties in Northern Rhodesia. The report for the year 1930 shows that the output was increased to 17,907 tons of electrolytic zinc, as compared with 12,121 tons in the previous year, but low prices have since compelled the company to suspend production of this metal. The plant for the production of fused vanadium oxide was completed by the end of the year, commencing production in January last, this plant being still running. The operations for the year resulted in a loss of £38,485, which has been met by transferring the sum of £38,121 from reserve.

Otavi Mines.—This company was formed in 1900 in Berlin and works the Tsumeb copper mine in South-West Africa. The report for the year ended March 31 last shows that the production of the smelter amounted to 15,036 tons of copper matte, containing on an average 44·8% copper, 22·8% lead and 763 grammes silver per ton, in addition to 3,661 tons of lead, containing on an average 96·3% lead and 1,147 grammes silver per ton. The ore output was 215,000 tons, as compared with 184,000 tons in the previous year, but deliveries decreased from 53,000 to 43,000 tons. The operations of the ferro-vanadium works were less than those of the preceding year, but were on the whole satisfactory. The net profit for the year was £11,479, which was carried forward.

Ex-Lands Nigeria.—This company, formed in 1912, operates alluvial tin properties in the Bauchi Province, Northern Nigeria. The report for the year 1930 shows that the output of tin concentrates was 495 tons, as compared with 655 tons in the previous year, the average price per ton obtained being £88 12s. 9d., against £123 7s. 2d. Production costs showed a reduction of approximately £10 10s. per ton. The accounts show a loss for the year of £2,626, which reduces the balance brought in to £27,101. The ore reserves at the end of the year were estimated to be 7,547 tons, of which 3,582 tons are proved and 3,965 tons partly proved.

Tin Properties.—This company was formed in 1912 and since 1924 has worked alluvial tin properties in Northern Nigeria. The report for the year ended September 30, 1930, shows that 178 tons of tin concentrates was recovered during the year at a cost of £95 per ton, the year's working resulting in a loss of £4,297. Owing to the price of tin metal and the restriction imposed on the company, the properties have been closed down for the time being. The ore-reserves at the end of the year were estimated to be 3,572 tons.

Ipoh Tin.—This company was formed in 1913 to acquire alluvial tin properties in the State of Perak, F.M.S. The report for the year ended March 31 last shows that only No. 2 dredge was working during the period under review, the yardage treated being 827,500 cu. yd., the tin concentrates recovered amounting to 449½ tons. The net profit for the year was £9,261, which was carried forward. The erection of a dredge on the company's property near Ayer Etam in the state of Selangor is approaching completion.

Kent (F.M.S.) Tin.—This company was formed in 1926 to work alluvial tin property in the F.M.S. The report for the year 1930 shows that 1,555,960 cu. yd. of ground was treated and 379·44 tons of tin concentrates recovered, which realized £30,242. The working profit for the year was £10,909 as compared with £44,256 in the previous year. The profit available after making various allowances was £9,829, of which £5,250 was distributed as a dividend, equal to 5%.

Kramat Pulai.—This company was formed in 1907 to acquire alluvial tin property in the State of Perak, F.M.S. The report for the year 1930 shows that 100 tons of tin concentrates was produced, as compared with 224½ tons in the previous year, the output realizing £9,755, equal to £86 16s. 2d. per ton, as compared with £121 4s. 11d. per ton in 1929. Scheelite ore sold during the year realized £46,447. The net profit for the year was £28,911, of which £20,000 has been distributed as dividends, equal to 20%.

Peña Copper.—This company was formed in 1900 and works copper properties in the Huelva district, Spain. The report for the year 1930 shows that 127,539 tons of ore was mined, as compared with 120,999 tons in the previous year. Of the amount won, 106,940 tons was added to the leaching dumps, while 20,599 tons was exported. The output of cement copper for the year was 900 tons. The net profit for the year was £27,984 and, after making various allowances, a balance of £22,549 was carried forward.

DIVIDENDS DECLARED

Angola Diamond.—1s., less tax, payable July 23.

Consolidated African Selection Trust.—1s., less tax, payable August 4.

Hongkong Tin.—3d., less tax, payable July 22.

Kramat Pulai.—6d., less tax.

Taquah and Abosso.—3d., less tax, payable July 22.

NEW COMPANIES REGISTERED

Clunes Goldfields (1931).—Registered as a public company. Capital: £25,000 in £1 shares. Objects: To acquire certain mining leases in the parish of Clunes, the county of Talbot, Victoria, Australia. Directors: Sir George R. Hill, D. Barron, H. D. Richardson and W. A. Campbell. Office: 11, Queen Victoria Street, E.C. 4.

English Petroleums.—Registered as a public company. Capital: £40,000 in £1 shares. Objects: To adopt an agreement with Sir Francis Caradoc Price; to carry on the business of producers and distributors of oil, petroleum products, etc. Directors: Sir Francis Caradoc Price, Dr. W. G. Burns, and C. D. H. Wemyss. Office: 19, Basinghall Chambers, E.C. 2.

Salman-Essuawah (Gold Coast) Alluvial Gold Areas.—Registered July 24. Capital: £1,000 in 5s. shares. Objects: To acquire the interests of Sierragold Trust, Ltd., in two contracts relating to mineral and other rights in Salman Chiefdom, Salman Sub-Chiefdom Extension, and Essuawah Chiefdom, on the Ancobra River, Gold Coast Colony. Directors: E. R. Hoad, E. E. Maynard, F. W. Dove.