The Mining Magazine

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

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

Branch Offices { New York: Amer. Inst. M. & M.E. / Chicago: 360, N. Michigan Blvd.

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

Vol. XLVI. No. 6. LONDON, JUNE, 1932. PRICE ONE SHILLING

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EDITORIAL

THE 1932 edition of Skinner's "Oil and Petroleum Year Book" was published last month. The book contains, as usual, up-to-date particulars of all the principal oil companies in the world and tends to become more and more an international work of reference.

A NEW tunnelling record on the Manchester Corporation's Haweswater scheme is claimed this month by the contractors, the François Cementation Company. The tunnel is stated to have been advanced 234 feet in one week, 14 feet in excess of the record announced in the MAGAZINE in October last.

MINING men will have noticed with pride that by the election of M. Albert Lebrun to succeed the late M. Doumer as President of the French Republic the Presidents of the world's two greatest republics, France and America, are both members of the profession, M. Lebrun's early training, like that of Mr. Hoover, having been as a mining engineer.

OF more than local interest is a remark made by Mr. Richard Hamilton, president of the Chamber of Mines of Western Australia, in his address at the annual general meeting in March last. Mr. Hamilton notes that intensified prospecting by the old methods during the past two years has not been as successful as had been hoped and he looks forward to the joint help of trained geologists, airmen, and geophysicists in the location of new ore-bodies.

A NOVEL method of allocating mine claims appears to have been recently tested in South Africa. Inspired no doubt by a somewhat larger project in another dominion, the Union officials decided the ownership of fourteen claims in the Sabie district by means of a lottery, the cost of a ticket—2s. 6d.—being the price of a prospecting licence. It is stated that there were no fewer than 6,000 ticket holders in the "sweep" and the idea was generally voted a complete success.

THERE are several names of interest to the profession in the Birthday Honours list. Lord Buckmaster, chairman of the governing body of the Imperial College, has been made a Viscount; Dr. Robert L. Mond, president of the Faraday Society, is created a Knight Bachelor; and Mr. F. H. Wynne, H.M. Deputy Chief Inspector of Mines, receives the C.B.E., while the O.B.E. has been awarded to Mr. A. M. Henshaw, formerly central examiner to the Board of Mining Examinations, Mines Department, and to Mr. R. L. Layfield, H.M. Inspector of Horses in Mines.

AN important move in connexion with the steel industry was made early this month, when it was announced that an agreement to co-operate in general policy had been concluded between Stewarts and Lloyds and the United Steel Companies, who between them control about 20% of the steel output of the United Kingdom. It is stated that a new plant is to be built at Corby, near Kettering, designed for the large-scale production of basic Bessemer steel, a type which has bulked largely in the imports from the Continent in recent years. The move embodies two important principles in the reorganization of the industry—a closer co-operation between producers and finishers and the development of the Midland ore field.

The Institution's Annual Meeting

The attendance at this year's annual general meeting of the Institution—held, according to custom, in May—was unusually large, for which present conditions in the profession were, no doubt, mainly responsible. Nevertheless, an interested audience paid a just tribute to the work of the retiring president, Mr. Pellew-Harvey, and welcomed his successor, Dr. Sydney W. Smith. The presentation of the annual awards was also an item of the proceedings which attracted many of those present, and members showed their usual willingness to bear generous witness to the work of the recipients.

In presenting the annual report of the council, Mr. Pellew-Harvey had no choice but to refer to the existing depression, which is bearing hardly on so many of the members. In this connexion he particularly mentioned the appointments information register kept at Cleveland House and pointed out that the number of vacant posts brought to their notice during the past year was the smallest since its establishment in 1922. Among other matters to which he made

special reference was their position with regard to income tax. This question has now been settled—happily in favour of the Institution—and contributions to the State made since the suspension of the exemption in 1926 have been refunded. Coming to the awards, the president, after commenting on the decision to present the gold medal in duplicate this year, announced that he would take the recipients in order of seniority, as both Dr. T. A. Rickard and Sir Harold Carpenter were present. To Dr. Rickard Mr. Pellew-Harvey spoke as to a fellow Cornishman, who had done yeoman work for the profession throughout his career. Dr. Rickard, in reply, thanked the council for the honour done him, and made happy reference to other medallists with whom he has become listed. To Sir Harold Carpenter the president spoke as to a fellow member of the council and a vice-president of the Institution and he welcomed the award to so distinguished a metallurgist, who was already a Bessemer medallist of the Iron and Steel Institute, and who, it may be noted, is the only holder of the highest award of the two bodies. In reply Sir Harold referred to the somewhat unique manner in which he had entered his profession, for he had come by way of physical chemistry. Leaving Oxford a chemist, his early work had been in connexion with the physico-chemical aspect of metallurgical problems, his experience growing with the growth of metallographical study. As to the other awards, both Mr. P. J. Crowle and Professor B. W. Holman were present, the former receiving the Consolidated Gold Fields of South Africa, Ltd. gold medal with a few appropriate words, while the latter suitably acknowledged the receipt of the same company's premium. The William Frecheville prize was accepted by Mr. H. L. Sulman on behalf of Mr. G. F. Hatch, who is at present abroad. The motion for the adoption of the report and accounts was seconded by Mr. E. T. McCarthy, who referred with appreciation to the financial stability of the Institution, while, in moving the vote of thanks to the retiring president, Mr. Carl Davis spoke warmly of the vast amount of work which Mr. Pellew-Harvey had carried out during his term of office.

The final business of the evening was the induction of the new president, Dr. Sydney Smith, and the delivery of his inaugural address, in the course of which he reviewed the history of the Institution and the achievements of many of its members, drawing attention to the directions along along which he considered further progress might be made. He referred to the status of the Institution and the work that body was able to do for the individual member, but at the same time he indicated how much this depended on the member himself. Dr. Smith pointed out that the Institution's membership list showed that there was hardly a part of the mineralized world that had not been visited by some of them and he was conscious of an uncomfortable feeling that much valuable experience still remained unrecorded, a feeling with which we confess to being in full sympathy. Referring to the review of Imperial mineral resources, which is being actively prosecuted through the Imperial Economic Committee (on which Sir Thomas Holland represents the Institution), the new president pointed out that it was equally important to take stock of our resources of individuals, the men with experience of the vital problems confronting the mineral industry to-day, and he was disposed to think that much good might accrue from closer association with the Institution of Mining Engineers or from joint discussions with that body on common problems. It was also emphasized that there were other important institutions with common interests, such as the Institution of Civil Engineers, the Institution of Mechanical Engineers, the Iron and Steel Institute, the Institute of Metals, the British Non-Ferrous Metals Research Association, as well as Government departments, with whom discussion on certain points could not fail to have profitable results. Another point of interest arising from the address—embodying a view we have expressed on more than one occasion—is the suggestion that the manufacturers of mining and metallurgical machinery should make more extensive use of the technically-trained salesman, a man able not only to keep abreast of current progress, but to be actively engaged in advancing it. Dr. Smith also spoke feelingly of the generation lost in the War, the men who should now be available to carry on the traditions of the profession, and stressed the necessity of making provision for the bridging of the gap between older and younger members. The address, representing as it did a rapid survey covering the past, present, and future, bore testimony to the

broad views held by the Institution's new chairman, which should stand them both in good stead during what promises to be a trying year of office.

Oil Production Methods

The fact that the output of the world's oilfields is so much in excess of current demands has tended somewhat to obscure the high degree of perfection which is being reached in modern engineering practice on the field, except, perhaps, to those actually engaged on the production side. The competition which exists among producers is so great that new conditions are forcing upon them the adoption of new policies, while increasing mechanical difficulties are rapidly met by improvements in both plant material and design. A paper recently read before the Institution of Petroleum Technologists by Mr. A. Beeby Thompson serves to throw light on the problems of modern oil production and many of the points dealt with seem worthy of closer examination. Before briefly reviewing the author's conclusions, we would point out that in a recent issue of the MAGAZINE, in commenting on a presidential address to the Institute of Metals, the rapidity with which the engineer makes use of new metallurgical products was emphasized and it is, therefore, interesting to find Mr. Thompson, speaking on behalf of oil production engineers, stating that "No unbiased observer can feel anything but admiration for the metallurgists and engineers who have so quickly evolved and put into usage metals and alloys which allow depths of 10,000 ft. and pressures of 5,000 lb. to be handled with as much safety as those of a third of these a few years ago." This remark serves to show clearly one trend of oilfield development—the opening up of the deeper horizons.

Probably the most striking advance in thought and practice of late years—even if actuated primarily by motives of self-interest—is the widespread acceptance by producers of the principle of unit operation of oilfields. The evils of uncontrolled offsetting have long been evident, in spite of its virtual enforcement in the United States, and a recent resolution passed by the directors of the American Petroleum Institute will show how the present-day attitude to this question is changing. In this resolution the institute endorses the principle that each surface-owner is only entitled to his fair share of the recoverable oil and gas in the common pool—in other words, that it is desirable that a system of prorationing under unit operation should do away with much of the legalized piracy of the past. Operators in the future, particularly when concerned with deep sources, will of necessity be forced to arrange for controlled output, a system rendered more easy of attainment by the fact that deep drilling, with its attendant difficulties, is itself compelling a degree of co-operation never known before. A few fields have already been successfully developed on a unit plan—notably Persia—and serious efforts are being made to evolve a scientific scheme for the allocation of oilpool contents to the interests concerned. The difficulties to be faced in the development of such a plan are enormous, especially when the relationship of particular areas to the structure must be determined. If it is generally held that the most valuable land will be located at points intermediate between the edge-water and the gas, the value of the latter as propulsive energy and the danger to the field when the former is allowed to rise too rapidly are factors for which allowance must be made. It would seem, however, that the most cogent reason in favour of unitization becomes apparent only in the declining phase of a particular field, when it becomes necessary to apply a system of air, gas, or water drive to improve the output, for, as Mr. Thompson points out, such methods can only be employed on a large unbroken block of ground to which energy can be applied.

Other important problems connected with modern practice can only be touched upon here, but most of them are connected with the high and often unexpected pressures encountered in deep wells. It is often necessary in such practice to drill with a heavy circulating fluid to which high surface pressure must be applied, provision being made for the insertion and withdrawal of tools through some sort of control head. Once the well is in production the use of bottom-hole chokes to control output appears good practice, although it has its attendant difficulties. Another factor in certain fields arises from the freezing of wells as the result of rapid gas expansion, although freezing in the well itself is even more serious. This condition seems also manageable by the use of bottom-hole control. Sufficient has been said to show some of the difficulties encountered in deep holes, where pressures

are often erratic, but it may be added that the reducing proportion of crooked holes tends to lighten the task of engineers in this respect. As regards declining wells, the use of gas or air lifts seems to have been revived, while the action of the plunger lift is also being examined in certain fields. Of paraffination and other conditions arising after long periods of exploitation, where clogged channels leading to the well have to be re-opened, little can be said here, although these factors, as well as those encountered in new fields where surplus gas must be conserved, are subjects of close study, and it is evident that the development of economic policies of exploitation must go hand-in-hand with the advances in mechanical engineering.

The University of Witwatersrand, Johannesburg.

A Worthy Appeal

The disastrous fire which occurred at the University of the Witwatersrand just before Christmas had far more serious consequences than the actual damage to the fabric itself, as the books and documents housed in the Gubbins Library of Africana, in the Hoernle Anthropological Museum, and in the Leonard Memorial Law Library were all destroyed. A recent meeting held in this country, at which the late Governor-General of the Union, the Earl of Athlone, presided, has drawn attention to the efforts which are being made to repair the University's severe loss. Immediately after the fire a fund was opened in the Transvaal having as its object the collection of books to replace those lost. At the meeting referred to it was decided to form a committee, under the chairmanship of Lord Athlone, to co-ordinate efforts in this country to the same end, Dr. William Cullen—whose offices are at No. 4, Broad Street Place, E.C.2.—acting as honorary secretary. It is recognized, of course, that some of the loss cannot be repaired, as the Gubbins Library, presented to the University only a few months before the fire, contained a unique collection of books, reports, pamphlets, and letters, brought together during many years, illustrating all phases of South African life and culture, while the Law Library contained rare volumes on Roman and Roman Dutch law. It was not only rare volumes and manuscripts which were destroyed, however, but the reference libraries of almost all the departments, including the rapidly-growing collection of scientific and other journals. The appeal for books to replace those lost has, happily, met with a whole-hearted response, but it is realized that in certain directions the stream of books to the Cape can only be augmented by the special efforts of the committee, especially with regard to books and documents relating to the early history of the settlement. The growth of a university so intimately connected with a wealthy mining field has always been watched with interest, especially by those of our readers who were among the pioneers. Some of these may, perhaps, be in possession of documents concerning the early colonization of the Cape and to these we would say—What more fitting home could such papers have than the Library of the Witwatersrand University ?

REVIEW OF MINING

Introduction.—The trend of business during the past month continues to reflect the confusion which obtains in International affairs. It is hoped that the findings of the conferences at Lausanne and Ottawa will be sufficiently decisive as to lay secure foundations for a return towards normal conditions. The metal markets have been adversely affected by the failure of an old-established firm of brokers, but all difficulties are stated to have been satisfactorily overcome.

Transvaal.—The output of gold on the Rand for May was 919,223 oz. and in outside districts 46,421 oz., making a total of 965,644 oz., as compared with 949,796 oz. in April, the May total representing a new monthly record. The number of natives employed on the gold mines at the end of the month totalled 215,926, as compared with 214,334 at the end of April.

A fall of rock in the Robinson Deep mine last month entombed a number of native miners, several of whom were rescued alive.

The report of the Central Mining and Investment Corporation for 1931 shows a realized profit of £445,553, making, with the sum of £27,267 brought in from the last account, an available total of £472,820. Dividends equal to 6s. per share absorbed £127,500, while £200,000 was transferred to reserve and £16,500 appropriated for income tax, leaving a balance of £128,820 to be carried forward. The reserve fund of the corporation now stands at £729,099 and the depreciation reserve at £996,720.

During 1931 the General Mining and Finance Corporation made a profit of £55,821, to which must be added the unappropriated balance from the previous year, equal to £19,037. The total available profit was, therefore, £74,858 and to this amount £300,000 was added from reserve. Depreciation on share values absorbed £359,537 and after making minor allowances a balance of £14,797 was carried forward.

A circular to shareholders of the Rooiberg Minerals Development Company, issued last month, showed that it had been decided to reopen the Nieuwpoort section of the mine and to extract the high-grade ore developed there. It was anticipated that the plant would be in working order in about two months' time and that during that period mining at Nieuwpoort would be carried on to provide a reserve of broken ore for the mill.

Cape Colony.—The accounts of the Cape Asbestos Company for 1931 show a profit of £13,141, making, with the balance of £21,165 brought in from the previous account, an available total of £34,306. Of this amount dividends equal to 4% on the ordinary shares and 9% on the preference shares absorbed £16,250, leaving a balance of £18,056 to be carried forward. It is stated that asbestos sales continue to contract.

Diamonds.—The accounts of the Koffyfontein Mines, Ltd., for 1931 show a loss of £28,998. The balance brought in from the previous year was £29,125 and this, together with the value of diamond stock in hand (£32,621), a sum of £46,691 transferred from Blue-Ground Replacement Account, and sundry receipts, gave an available total of £110,903. From this amount the loss for the year must be subtracted, while £33,225 is transferred to Suspense Profit Account as representing the value of diamonds on hand. Dividends declared during the year absorb £23,095, while £23,889 has been written off investments, leaving a balance of £1,696 to be carried forward. During the year 940,238 loads of blue ground were hauled and deposited on the floors, but, in view of the depression in the industry, these operations ceased on July 23 last, work being confined thereafter to removing reef from the edge of the mine. No washing of ground was done during the year.

Southern Rhodesia.—The output of gold from Southern Rhodesia during April was 46,487 oz., as compared with 47,239 oz. for the previous month and 43,776 oz. for April, 1931. Other outputs for April last were: Silver, 6,592 oz.; coal, 42,759 tons; chrome ore, 2,897 tons; asbestos, 1,740 tons; mica, 1½ ton; tin, 1½ ton.

The report of the Lonely Reef Gold Mining Company for 1931 shows a profit of £85,139, which, added to the balance of £20,060 brought in, gave an available total of £105,199. Of this amount dividends equal to 20% absorbed £57,860, £10,000 was placed to reserve, and, after making other allowances, a balance of £17,180 was carried forward. During the year 83,100 tons of ore was milled, yielding 25,253 oz. of gold, while 172,500 tons of accumulated slimes re-treated yielded 13,044 oz. The total gold recoveries for the year were 38,297 oz., worth £179,942, produced at a cost of £97,452, as against 45,945 oz., worth £195,124, costing £101,899, for the previous year. The results of development

during the year were disappointing, no values being disclosed, and the mine is now dependent for its ore on reclamation work.

Development on the No. 25 level of the Motor mine of the Cam and Motor company is stated to have recently opened up rich values in mineralized schist in a cross-cut from the circular shaft.

At an extraordinary meeting of Rezende Mines, to be held in Salisbury in September, it will be proposed that the capital of the company be reduced from £131,250 to £82,500 by the return of 6s. 6d. on each 17s. 6d. share. The nominal value of each share will thus be reduced to 11s. The Caliph claims, adjoining the Rezende, have recently been acquired by the company and drilling has been commenced.

Northern Rhodesia.—The report of Loangwa Concessions (Northern Rhodesia), Ltd., for 1931 shows that an area of 12,662 square miles was systematically prospected during the year. Several occurrences of mineral values have been found and are being investigated, but so far nothing of definite commercial value has been proved. Arrangements have been made with the British South Africa Company whereby the amount to be expended on prospecting during the four years commencing May 1 last may be reduced annually from £125,000 to £45,000, provided £100,000 be set aside for the development of encouraging prospects and another £100,000 be allocated for purposes to be decided jointly by the two companies.

The report of the Rhodesia-Katanga Company for 1931 contains a record of the recent developments on the Kansanshi mine, where drilling is in progress. The reduced programme decided on for the current year will be carried out, the mine itself being on a maintenance basis. Recent drilling results are stated to confirm the estimates of ore and to show a slight improvement in grade.

The accounts of Rhodesian Anglo American, Ltd., for the year to March 31 last show a balance of unappropriated profit of £77,570, which was carried forward. Amounts paid up on shares during the year resulted in a credit to the share premium account of £149,044, which has been added to reserve, together with £50,956 from profit and loss appropriation, the reserve account being thus increased to £1,600,000. The whole of this sum has been applied to the depreciation of investments, reducing their book value to £4,849,083, against a market valuation of £4,407,932. The company's main interest is in the Rhokana Corporation, which has recently brought the N'Kana mine to the production stage.

Nigeria.—During 1931 the Associated Tin Mines of Nigeria, Ltd., made a profit of £28,082, which, added to the balance of £93,845 brought in, gave an available total of £121,927. Of this amount £27,337 has been written off the value of plant and machinery and £11,671 off development expenses, leaving a balance of £82,919 to be carried forward. The output of tin concentrates during the year was 2,643 tons, which realized £88 10s. per ton, working costs f.o.r. Bukuru being £56 13s. 2d. per ton. The increase in output was largely due to the operation of the new electrically-driven pontoon plants, brought into use at the end of the previous year, which were given a special quota.

Australia.—Elsewhere in this issue will be found the announcement of a dividend of 1s. 6d. per share declared by the North Broken Hill Company last month. It is stated that this dividend has been paid primarily out of income from investments and that unless metal prices improve the rate of dividend cannot be maintained.

The report of the Sons of Gwalia, Ltd., for 1931 shows a profit of £57,697, making, with the balance of £8,111 brought in, a total profit of £65,808. After making allowances for depreciation and other items and transferring £20,000 to reserve, a sum of £16,704 has been carried to the balance sheet. At the annual meeting, to be held this month, it will be proposed that the capital of the company be reduced to £187,500 by writing off 10s. from each of the issued shares and that the unissued 25,000 shares of £1 each be subdivided into 50,000 10s. shares. If this is approved it is further proposed that on confirmation of this reduction by the Court the capital be increased to £350,000 once more by the creation of 325,000 new shares of 10s. each. In the event of the capital reduction being approved at the meeting it is proposed to distribute £8,125 of the balance of profit as a dividend, equal to 6d. per share, leaving a balance of £8,579 to be carried forward. During the year under review 121,368 tons of ore was treated by the mill, together with 28,916 tons of accumulated sands and slimes, 41,442 oz. of bullion being recovered, worth £195,263.

Recent developments at the Great Boulder Proprietary have been very favourable, work on the X lode on the 1,650-ft. level in section 53 showing the ore-body to have a full width on the western drive of 27 ft. and an average assay value of 16 dwt., while on the eastern drive assays ran 21 dwt. over 17 ft. Later advice concerning the Perseverance lode states that a winze on the 1,100-ft. level, sunk to a depth of 84 ft., is in ore averaging 20 dwt. over 6 ft. In the annual report for 1931, covered elsewhere in this issue, it is stated that the developments on the X lode are the most promising for many years.

It is proposed to reduce the capital of the Golden Horse Shoe (New) from £220,000 in 4s. shares to £165,000 in 3s. shares by the return of 1s. per share to holders.

New Guinea.—The first return from the Bulolo Gold Dredging Company shows that during the 28-day period ended April 25 243,700 cu. yd. of gravel was dredged for a return of $57,000. The indicated value of the ground treated was 21 cents per cu. yd. It is stated that the run shows the capacity of the dredge to be greatly in excess of the estimate.

Malaya.—Shareholders of Malayan Tinfields, Ltd., have been informed that the directors have disposed of the £49,100 8% debenture stock of Teja Malaya Tin Dredging Co., Ltd., which had cost the company £46,645.

Panama.—A circular to debentureholders of the Panama Corporation intimates that the new certificates are not yet available. Owing to difficulties in connexion with the liquidation of the British, Foreign, and Colonial Corporation, it is also announced that the interest due on June 1 could not be met. The company is taking steps in other directions to obtain finance.

Mexico.—The report of the Mazapil Copper Co., Ltd., for 1931 shows a loss of £56,288, increasing the debit balance brought in to £92,673. A small tonnage of selected ore was mined during the year in order to reduce overhead expenses, but the company has now exhausted its cash resources and it is feared that its existence cannot be prolonged beyond a few months.

Brazil.—The urgent need of the Itabira Iron Ore Company for additional funds was announced in these columns last month. It has since been stated that debentureholders had agreed to the creation of further debentures ranking pari passu with those already issued and that the full amount offered for subscription had been taken up.

Sinai.—The accounts of the Sinai Mining Company for 1931 show a profit of £6,345, increasing the balance brought in to £28,720. Of this amount preference dividends absorb £3,500, leaving a balance of £25,220 to be carried forward. Arrangements have been made to keep the company's properties on a maintenance basis until conditions improve.

Yugoslavia.—The capital of Kapaonik Mines has been increased to £175,000 by the creation of 150,000 5s. ordinary shares, ranking equally with those in existence.

British-American Tin Corporation.—At a meeting of the British-American Tin Corporation held this month it was resolved that the corporation should be voluntarily wound up. It was also agreed that the 749,680 unissued 1s. shares in Tin Holdings, Ltd., should be consolidated into 37,384 preference shares of £1 each and that the capital of the company be increased by £12,500 in similar preference shares, carrying interest at 6%. These shares are to be offered to the present shareholders.

Chemical and Metallurgical Corporation.—The report of the Chemical and Metallurgical Corporation for 1931 shows a profit of £8,831, subject to depreciation on buildings and plant, as compared with £8,003 for the previous year. Accompanying the report are details of a reorganization scheme providing for the reduction of the capital to £548,298 10s. by the cancellation of 10s. on each £1 preference share and 1s. 8d. on each 2s. ordinary share. When the reduction has been confirmed the preference are to be re-consolidated into £1 shares and the ordinary into 2s. shares, and later on it is proposed to increase the capital to £1,100,000 by the creation of 5,517,015 new 2s. ordinary shares.

Tin.—At a meeting of the International Tin Committee held last month new proposals for the restriction of tin production were announced. These provide for a further reduction of output to 54,056 tons per annum, being 33⅓ per cent. of the standard output of 1929, and for two months' cessation of output, the scheme to come into force on July 1. Nigeria, Bolivia, and the Dutch East Indies have agreed to the proposals and it is believed that the Malayan Government will fall into line, subject to certain provisions suggested by the Malayan Chamber of Mines.

THE ASHANTI GOLDFIELDS CORPORATION

By G. W. EATON TURNER, M.I.M.M.

A brief history and description of the property of the corporation, which is situated in the districts of Bekwai and Adansi, Ashanti, Gold Coast Colony.

A short account of the Ashanti Goldfields Corporation from its inception in 1897 up to the year 1915 was written for the MAGAZINE by W. R. Feldtmann in 1916 and published in the May issue of that year. The purpose of the present article is to bring that story up to date, but, as many readers may not have had the opportunity of seeing Mr. Feldtmann's description, a brief outline of the corporation's early and strenuous youth may be of interest.

The history of gold mining in Ashanti remains to be written. It would appear probable, however, that gold was almost unknown to the Ashanti kings in the earliest years of their dynasty, and that their first supplies came from the spoils of their successful wars with the Denkeras, who had long known and practised the art of calabashing for alluvial gold on the banks of the Offin River, south and west of the original Ashanti kingdom. It is indeed doubtful whether the Ashantis as a race ever seriously undertook mining operations themselves and there is certainly no evidence to show that either they or the Denkeras made any attempt to obtain the precious metal from the unbroken reefs where these were found. It is known, however, that near Obuasi, where the corporation's mine is situated, the outcrops of the reefs, the gold-bearing detrital matter from their denudation, and the reef formations themselves where encountered by the myriad native prospecting pits that literally honeycomb the environs of Obuasi, had been worked for many years, and possibly for generations, by the Appolonians.

These people, inhabitants of the coastal area round the mouth of the Ancobra River, were the miners of the country, and probably the only natives who knew how to win ore from the solid rock—an art which their forefathers had learned in the sixteenth and seventeenth centuries from the Portuguese adventurers. In any event, we have it on excellent native authority "that before the White Man came to Obuasi the Appolonians used to sink pits until they found the hard rock, when they pile firewood in the pits and set fire to this. When the fire is wasted, then they carry water in big pots and pour down into the pits until the fire goes out. They wait for a day or two until the pit gets cool before they go down again and with hammer or something of the kind they break the walls, then having become quite loose and very easily broken up owing to the fire they burned. Then they bring all the stone up and divide them into three parts, one of which is given to the Chief of that land." [1]

It was on Christmas Eve in the year 1897 that the first European expedition arrived in Obuasi to work the concession that now belongs to the Ashanti Goldfields Corporation. Since August, 1895, when the three native traders had handed over the concession that they held from the kings of Adansi and Bekwai to Cade's Cote d'Or Syndicate, much troubled water had flowed from Ashanti to the sea. The destoolment and deportation of Prempeh, king of all Ashanti, in 1897 profoundly changed the political situation there, and it was only after considerable delay that an agreement with regard to the concession was finally arrived at, with the result that in 1897 the Ashanti Goldfields Corporation was formed, and acquired, direct from the Government, mining, trading, and agricultural rights, for a period of 90 years over the 100 square miles of territory concerned.

The expedition of 15 Europeans was led by E. A. Cade, with whom came, as mining engineer, John W. Daw, another born pioneer, to whose courage, enthusiasm, and administrative foresight his successors must stand for ever indebted. With them also came a large force of native carriers recruited on the Coast, prophetically enough, with the help of the corporation's present chairman, Mr. J. H. Batty, then at Cape Coast in business. These carriers were engaged to head-load something over 40 tons of machinery and stores, in loads not exceeding 150 lb. weight, for a distance of 120 miles

[1] The above is quoted from an account dictated by an extremely old man, who worked in these pits many years before Cade reached Obuasi. The system of "tribute" is interesting and is a characteristic of the Ashanti, who, a man of war by instinct and tradition, has beaten his sword into a ploughshare and his spear into a miner's pick for *someone else* to use on his behalf. It is a common practice to this day for the Ashanti cocoa farmer to employ aliens to cultivate his land in return for one-third of the crop.

along the bush paths of the forest—a transport operation that cost over £60 per ton. Many of the packages never reached their destination at all, being dumped in the bush by weary carriers, who felt better able to endure the loads on their consciences than on their heads. Such losses were considerable and if to these are added those already incurred in landing on the surf-bound beaches, some idea may be gathered of the initial difficulties under which these pioneers laboured in an evil climate and an undeveloped country where, as Mr. Feldtmann dryly observes, "the sanctity of human life was, in the native mind, subservient to a number of other considerations."

The site for the camp had been chosen on a low spur where the manager's bungalow stands to-day. Cade and his advisers had, seemingly, a genius for the selection of sites, as the location of the camp and of the concession area itself, in which the present mine occupies almost exactly the central point, bear witness. From this time development of the property commenced, but it was not until 1910 that a patient and resolutely-conducted campaign to increase the ore reserves and to solve the difficult metallurgical problem presented by the ore below the oxidized zone in Ashanti mine met its due reward. From that time on, thanks in large measure to the careful nurture and wise technical and financial control then exercised, the history of the corporation has been one of unbroken success, if we except a short period in 1922–1923, when the accumulated difficulties of the War and immediate post-war years made themselves felt with unhappy results.

The nominal capital of the corporation was, until last year, £250,000 in shares of 4s. each, fully paid. In February, 1931, a bonus issue of one fully paid share for each two held, brought the capital to £375,000, while in January, 1932, a further bonus issue increased the capital to £500,000.

In Table I are given details of tonnage, extraction, value of output, and ore reserves for the years 1910–1931. Up to the year 1918, a varying but considerable tonnage of ore was derived from the outlying mines, and the ore reserves include 50,000 tons of 9 dwt. ore at Ayeinm, and 65,000 of 11 dwt. at Justice's mine. Since that date, however, the entire output has come from the Ashanti mine alone, and the reserves given refer exclusively to it.

TABLE I

Year.	*Tonnage.*	*Extraction.*	*Fine Gold (oz.)*	*Value (£).*	*Reserve (tons).*	*Reserve Grade (dwt.).*
1910	101,763		72,115	306,323		
1911	124,554		100,783	428,129	508,200	15·6
1912	153,554		115,011	488,597	392,840	17·7
1913	148,447		110,770	470,659	365,300	19·4
1914	117,867		104,316	443,276	432,500	19·5
1915	131,236		105,283	447,257	433,900	21·5
1916	136,994	92·4	112,003	475,958	436,600	24·9
1917	112,853	93·5	112,017	476,322	534,100	24·4
1918	105,452	93·4	109,051	464,102	526,200	24·5 [1]
1919	85,566	93·2	98,220	418,057	414,500	27·3
1920	71,411	93·3	77,049	410,227 P.[3]	395,100	26·8
1921	62,259		69,050	383,168 P.	396,400	26·2
1922	108,506	71·9	98,567	486,419 P.	397,100	26·2 [2]
1923	88,509	74·7	72,040	323,895 P.	387,400	25·6
1924	83,479	80·9	76,253	359,736 P.	306,500	25·0
1925	91,924	89·8	90,613	393,031 P.	247,630	24·0
1926	100,246	91·4	92,220	392,080 P.	326,700	22·9
1927	100,312	92·5	95,725	406,971	419,700	24·2
1928	102,985	93·2	104,752	445,508	549,400	24·2
1929	108,007	92·2	118,136	502,441	590,200	25·2
1930	124,200	93·4	144,547	614,605	607,600	24·7
1931	142,910		169,360	730,644 P.	667,400	23·1

[1] After the year 1918 the ore blocked out in Ayeinm and Justice's is omitted from the reserves. The figures for these mines at this date were as follows :—

Ayeinm . . 50,000 tons — 9·00 dwt.
Justice's . . 65,000 tons — 11·00 ,, .

[2] The tonnage figures shown for the year 1922 really cover a period of 15 months, as at that time the corporation's financial year was changed so as to end on September 30, instead of June 30.

[3] Included in the figures marked "P." is the amount received in respect of premium on gold.

The ore-bodies on the concession occur as quartz and graphitic schist filling three main, and more or less parallel, fissures. These fissures cut through the phyllites and sericite and carbonaceous sericite schists of pre-Cambrian origin, which are the predominating rocks of the area. The three lodes now being worked from the Ashanti mine are the "Ashanti," the "Obuasi," and the "Cote d'Or." In the earlier years of the corporation's history and indeed as late as 1918, one or more of the smaller mines, which had been opened on lenses in the main line of fissuring to the S.W. of Obuasi, were in operation. These were Ayeinm, Justice's, Old Chief, Big Blow, Tom Collins' and Blackie's, with, further

General View of the Ashanti Mine and Surface Buildings.

to the west, the Sansu mine. All of these mines, of which Ayeinm and Justice's were the largest contributors, produced a certain amount of good-grade ore, and at one time Ayeinm had its own stamp mill and cyanide plant, but for the most part the ore was in short and shallow lenses, which were soon exhausted.

The Ayeinm shoot is in the line of the Ashanti fissure, about $1\frac{1}{4}$ miles S.W. of Obuasi. It is some 700 ft. in length and from 4 to 60 ft. in width, with an erratic gold content averaging 9 dwt. per ton. It was worked in the early days from adit levels, the lowest of which, No. 4, was the Main or Battery level. Later, a shaft was sunk from a point on the hill some 220 ft. above this adit and ultimately reached No. 9 level, 500 ft. below it. The Ayeinm ore-body is more easily worked than the Obuasi reef, but it is heavy and requires careful handling, owing to a tendency, which it shares with the Obuasi vein, to break in heavy blocks horizontally from wall to wall. It is, however, far less graphitic, and does not break also along vertical planes, as the Obuasi reef does.

Justice's deposit, about $\frac{1}{2}$ mile S.W. of Ayeinm, was named after its discoverer, J. N. Justice, who, in 1908, found that an impregnation deposit, which on the surface had a rather unpromising schistose gossany appearance, showing hardly any gold on panning, gave values of from 15 to 30 dwt. by assay, the gold being apparently entangled in the iron sulphides and arsenical pyrites, which were abundant in the matrix. This discovery came at a most opportune moment, to eke out the not-very-satisfactory ore discoveries then being made on the Ashanti lode prior to the sensational location of the downward extension of the Obuasi reef at No. 3 level far to the S.W. in the Ashanti mine. By open-cast working, 200,000 tons of oxidized ore was quickly and cheaply produced, and yielded £2 per ton. Below the oxidized zone, development on the sulphide ore opened up, above the level of No. 3 adit, some 65,000 tons of ore, averaging about 11 dwt. per ton. Later a winze was sunk a distance of 100 ft. and No. 4 level was driven exposing a run of ore 250 ft. in length and 20 ft. wide, assaying over 15 dwt.

Very little of the gold in this sulphide zone is free, the majority of it occurring as an arsenide and its recovery presents a

rather complicated metallurgical problem. For this reason, further work in this mine was suspended during the War, it being considered that the corporation's resources would be concentrated to better advantage in operating the high-grade Obuasi mine. This consideration also dictated the cessation of work at Ayeinm, for it is to be borne in mind that the supply of skilled mining labour, so essential to the working of the Obuasi reef, was never much above requirements. The same conditions, to all intents, apply to-day, but it is satisfactory to realize that in these two mines the corporation has very useful, even if not particularly rich, reserves of ore, which at the appropriate time can be drawn upon, and doubtless considerably developed.

The three main lodes at Obuasi all strike in a general N.E.–S.W. direction—the Ashanti at about 30°, the Obuasi at 45°, and Cote d'Or at about 35°—but, while the Ashanti has an underlie varying from the vertical to 80° to S.E., the Obuasi and Cote d'Or dip to N.W., the former at about 67° and the latter at 25°. The pitch of the Obuasi shoot is singularly uniform at 45° to N.E. which roughly corresponds with the angle made by the trough of its intersection S.W. with the Ashanti vein. The pitch of the Cote d'Or reef, at any rate from the 18th to 22nd level, appears to be at the extraordinarily flat angle of 15° N.E.

In width, the reefs vary from 3 ft. to 50 ft. with selvages of highly graphitic schist, from 1 in. to several feet in thickness, on one or both walls. This, coupled with the presence of floating "horses" of graphitic schist in the body of the reef itself, has made the mining of these veins, and particularly the Obuasi vein, a difficult and relatively costly business.

The Ashanti reef had an average length of 850 ft. down to No. 7 level, below which point the shoot shortened to 160 ft. at No. 9 level, and was proved for a length of 300 ft. at No. 11 level. During the past year, on the advice of Dr. Malcolm Maclaren, the long contemplated proposal to explore this reef at depth, a project which was held in abeyance, first during the exploitation of the more attractive Obuasi vein after its re-location at No. 3 level, and later owing to the unexpected cutting of the downward extension of the Cote d'Or reef in the Main Shaft at No. 22 level, has been put in hand. A cross-cut from the N.E. Sidetie on No. 16 level was put out about 300 ft. N.E. of the Main Shaft and cut the Ashanti fissure about 300 ft. to the west of the Obuasi reef. Development is still proceeding along the vein.

The Obuasi reef, fairly long at the surface, pinched about No. 8 level, but opened out again and attained its greatest extension between Nos. 13 and 19 levels, where it had an average length of 1,300 ft. Below that point it appears to have shortened to some extent, probably due to its proximity to, and its ultimate intersection by, the Cote d'Or fissure. So far as at present proved, the Cote d'Or reef attains its maximum dimensions on No. 21 level, where it is about 1,100 ft. in length.

Below No. 22 horizon, the characteristics and relationships of the three reefs are obscure and until the zone of intersection is passed through their definite features cannot be recognized with certainty.

The Ashanti mine is worked from two shafts, known as the Main shaft and the Timber shaft, the former of which is now 2,500 ft. deep at No. 26 level. The Timber shaft, so named from its having been originally designed for sending timber and material into the mine, is down to the random of No. 23 level. This shaft is now the principal ore-hoisting shaft, and is equipped with a powerful geared hoist, double-decked cages, and a fine steel lattice-work headgear, capable of working down to 5,000 ft. if necessary. Both shafts have three compartments, and their overall internal dimensions are 15 ft. 4 in. by 6 ft. 6 in. They are secured with steel girder sets and corrugated iron lagging, which, in the lower levels, has been replaced with advantage by 12 in. by 3 in. Pitchpine boards spaced 3 in. apart.

The Obuasi reef, which for many years supplied all the ore sent to the reduction plant, and is still responsible for 80% of the 12,500 tons average monthly output, has always been a very difficult ore-body to work, owing to the graphitic nature of its walls and to the fact that the enormous stresses to which it has at some time been subjected have more or less shattered it "in situ." Development on the reef itself was long ago abandoned and it is now opened up by footwall drives or "Sideties" as they are locally called, and cross-cuts at 50 ft. intervals through the reef. Rises are put up in the footwall and the reef is attacked in blocks of 100 ft. length from stope drives placed 10 ft. above the cross-cut floor, with boxholes

at 25 ft. intervals connecting the stope drive with the cross-cuts and sidetie alternately. The difficulty has never been to break the ore, but to support it, and for many years this was a limiting factor to output. Eventually, however, a satisfactory method was evolved and from 12,500 to 13,000 tons per month is now being broken and hoisted with comparative ease, and at an all in production cost of 10s. 5½d. per ton. This cost, under the circumstances, cannot be considered excessive and, indeed, compares favourably with many low-cost mines. The details are therefore offered as being, perhaps, of interest (Table II).

TABLE II

Ore Production Costs

	s.	d.	s.	d.
Labour, Drilling and Blasting	1	1·26		
,, Timbering		8·56		
,, Shovelling and Tramming		9·53		
,, Filling		6·56		
,, General		3·11		
			3	5·02
European Supervision			1	0·86
Explosives				6·52
Lighting				2·35
Timber				7·38
Rock Drills and Compressed Air				1·02
General Stores				4·34
Power				1·02
Winding			1	7·53
Sand Haulage (Surface)				0·99
Surveying and Assaying				0·15
Sundry Debits			2	4·34
			10s.	5·52d.

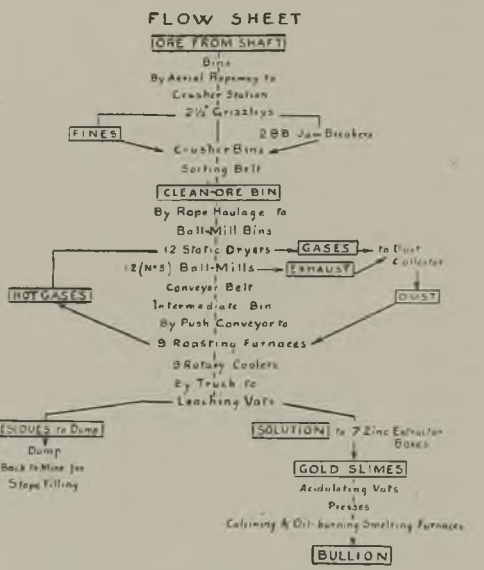
The stoping system in use is the overhand back stope with square-sets, reinforced where necessary with timber packs, and always by close back filling. For success it depends on rigid adherence to the rules for bracing and blocking properly constructed and erected king post square-sets, and to maintaining a continuous and adequate supply of filling. A relatively prodigious amount of timber has to be used, as sets must be kept right up to the face. Residues from the reduction works, free from cyanide, and supplemented with waste rock from development are used for filling, the sand coming from the surface via a sand pass with connexions at each level, from which it is drawn and transported to the rise from the stope concerned. From this point it is filled direct into buckets working on a monorail attached to the legs of the square-sets and run and tipped in the desired spot.

Ventilation is effected by means of a 72 in. Sirocco fan exhausting from the old Obuasi shaft. An elaborate system of doors and splits controls the distribution of air to the different workings. In recent years great benefit has been derived from the use of miners' electric hand-lamps of the storage battery type, which provide adequate illumination without vitiating the air, or appreciably increasing the temperature. All the stations, the shaft cross-cuts, and main ore passes are equipped with electric light, and in some of the largest and richest stopes clusters of powerful electric lamps are arranged to facilitate cleaning up operations, which are very thoroughly carried out. The pump stations are similarly lighted.

Pumping is fortunately not a serious problem in this mine, the relatively small quantity of water being dealt with by a system of electrically-driven three-throw ram pumps lifting in 500 ft. stages, with a series of air-driven plunger pumps as standby. An efficient alternating current electric bell-signalling system operates on all levels.

From the mine the ore is hoisted in trucks of 22 cwt. capacity by double-decked cages, and tipped into steel-framed bins feeding the aerial ropeway between the mine and the reduction works. This Central Treatment Plant, as it is called, consists essentially of the rock-breaker station, where the ore is reduced to pass a 2 in. ring by breakers of the jaw-crusher type, followed by ball-mills grinding dry to 25 mesh, Edwards' roasters, and the cyanide plant. The progress of the ore through this plant is briefly as follows :—From the rockbreaker bins, Ross feeders, now being installed, will pass the 2 in. ore to a sorting belt delivering to an aerial tramway bin. From here the tramway buckets carry it to the 12 ball-mill bins through which it passes via Static dryers to 12 No. 5 Krupp ball-mills. The drying of the ore is effected by passing the hot flue gases from the roasters through the Statics, and these as well as the ball-mills are equipped with fans exhausting any fine floating dust into cyclones. The ground product from the mills is borne by conveyor belt to a storage bin from which the ore is distributed by push conveyors to the battery of 9 Edwards' furnaces, where the refractory *bête noir* of the establishment, graphite, together with the 3% or so of arsenides and sulphides which the ore contains, is oxidized to harmlessness.

From the furnaces, the calcined ore is delivered to large rotary coolers, one of which works in conjunction with each roaster, and revolves in a bath of water pumped from a large concrete cooling pond nearby. The coolers feed the ore into trucks which are hand trammed—a mechanical conveyor system is under consideration—to the steel leaching vats, of which, at the time of writing, there are 60 of 120 ton capacity each. Leaching is carried on for from 12 to 16 days, as vat capacity permits, and results in an extraction of over 93%. The utmost importance is attached to attaining a sweet roast, otherwise, in the subsequent leaching,



Flow Sheet of the Central Treatment Plant, Ashanti.

the gold dissolved by the cyanide solution is promptly precipitated on any unoxidized graphite in a form insoluble in cyanide.

Following the leaching vats is the zinc box precipitation plant and the clean-up house, where the gold-zinc slimes are acid treated, calcined, and smelted into bars. The treated sands are shovelled through the bottom discharge doors of the vats into trucks, which are trammed to a cable way; this hauls them to a release point, whence they gravitate round the residue dump to be emptied on the way by the tipping gang, and finally find their own way back to the sub-vat floor.

This method of treatment, which has been in profitable and almost continuous use for the past 25 years, was the result of years of painstaking research and trial, and on its adoption in 1906 more than justified its comparative costliness by raising the percentage extraction of the original gold content of the ore from about 66% to over 92%. At the present time, extractions are over 93% and the all-in treatment cost amounts to 13s. 6·37d. per ton—figures which are by no means considered to represent the last word in the possibilities of this treatment under the present generally improving conditions. The fuel used for roasting is wood and the corporation's forest reserves are ample to ensure an adequate supply of this and also of mine timber and lumber, for many years to come.

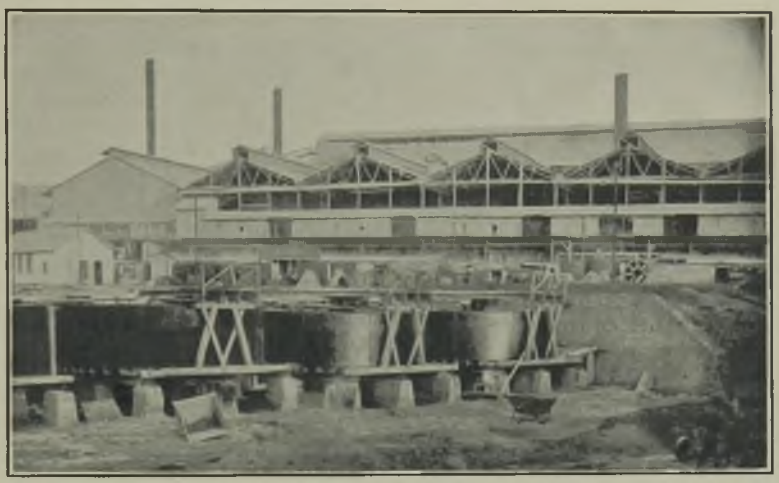
Shortly after the War, when the trade boom was at its height and wages and commodity prices soared to unprecedented and unmanageable heights, there was a period during which the scarcity of labour bade fair to paralyse the gold mining industry in this part of West Africa. This labour shortage—at any rate in the case of the Ashanti Goldfields Corporation—came just when an abundance of workers was most needed, not only to recover the leeway made during the War, but to fight against the rising tide of commodity prices. That the corporation kept going as it did through the difficult war years, when not only man-power but gold was so urgently needed, says much for those in London, who were able to ensure a supply of essential stores, when so many less fortunate concerns ran short; and also for the strenuous and unremitting efforts of those in charge at the mine, who carried on under many grave disadvantages, such as shortage of European supervision, much of which had perforce to be unskilled or otherwise undesirable, restless native labour and, finally, the terrible influenza epidemic of 1918, which played havoc with the staff, both European and native.

Faced with this post-war labour shortage and a calamitous firewood situation, it was considered advisable to revert to a wet treatment process in the expectation that the loss in extraction would be more or less balanced by a reduced working cost. This expectation was not realized in practice and the known disadvantages of the process, with its losses of gold both in the ore-dressing and the metallurgical-treatment stages, made themselves so conspicuous that the dry crushing and roasting process was very soon readopted. Fortunately, by this time it had been found possible to re-establish

the firewood cutting organization, and the change-over was carried out with comparative smoothness. With a view to providing against similar experiences in the future, however, experiments have since been made with pulverized coal as fuel to fire the roasters. These trials were at first quite unsuccessful, owing to mechanical difficulties in controlling the length and intensity of the flame, which caused sintering of the ore and destruction of the furnace parts on the one hand, or freezing and black roasting on the other. Both defects, of course, meant loss of output through low duty, and loss of gold owing to bad roasting of the ore. Eventually, however, the ingenuity and perseverance of the engineering staff prevailed over most of the difficulties and established the fact that, in an emergency, pulverized coal could take the place of wood fuel with no really prohibitive increase in cost or loss in efficiency.

The supply of firewood, mine timber, and lumber, necessitates the construction and maintenance of many miles of narrow gauge railway and hand tramming lines, which incidentally serve a useful purpose in opening up the country. The West African native is quick to seize an advantage and wherever these lines have penetrated, cocoa and food farms spring up in the shade of the sufficiently numerous forest trees, which were either too hard to cut or too soft for fuel; the old tramline formations serving admirably as roads for bringing their products to market. Fifteen or sixteen years ago, experiments were made in re-afforestation and several small teak plantations were started. Some of these were very successful and of recent years new areas have been planted out, the programme being gradually extended. Quick-growing neam and cassia trees were also planted with the idea of providing fuel for the gas producers, but these plantations were but indifferently successful.

Haulage is done partly by the Government railway, and in part by a fleet of 12 small locomotives, to which has recently been added a motor caterpillar-tractor and trailer which feeds the main line from areas too far from the rails for hand carriage. In all, about 6,000 cords of firewood are cut and hauled each month in addition to about 1,000 trucks of mine timber and 120 lumber logs for the sawmill, where a fine modern bandsaw has recently been installed.



PART OF THE CENTRAL TREATMENT PLANT, ASHANTI.

Run in conjunction with the sawmill are the inside and outside carpenters' shops. In the former are manufactured furniture for the bungalows, bullion boxes, mine ladders, ventilation doors, and the hundred and one similar requirements of the mine. Outside carpenters deal with ordinary building construction and repairs and work in association with the masonry gangs. A fitting shop, well equipped with the necessary machines, a small foundry, electric welding plant, boiler making plant, locomotive and electrical repair shops complete this side of the establishment, and are all manned by native artisans with a minimum of European supervision. In this connexion it is satisfactory to reflect that for over 30 years the corporation has played no insignificant

part in the development of Ashanti by training so many natives in useful arts and handicrafts.

With the exception of the hoisting engines and the standby air-compressor sets, which are steam driven, all power supplied to the works is electrical. The steam plant consists of six 100 h.p. Babcock & Wilcox multitubular boilers burning wood fuel, and one nominal 500 h.p. boiler of similar type, arranged for either wood or pulverized coal firing. The standby steam-driven compressors are coupled to a condenser and are, when necessary, used to supplement an electrically-driven Bellis & Morcam machine. A large gas-driven two-stage compressor arranged *vis-à-vis* with its engine is, however, shortly to be installed and will replace the Bellis and Morcam set.

The general power station comprises four 500 h.p. Premier horizontal gas engines direct-coupled to Mather & Platt generators. In addition there are two 400 h.p. vertical engines of an older type, with a 300 h.p. Diesel oil-driven set as an independent standby for essential services. Gas is derived from a battery of six 400 nominal h.p. Crossley producers burning wood fuel eked out with charcoal derived from the roasting furnace ashes. Distribution of the power is controlled by an elaborate switchboard in the power house, and a new sub-station feeding the central treatment plant, with a well-arranged system of mains carrying the 250 volt current from this station to the consumers. It is interesting to record that the all-in power cost at this station works out at the low figure of 0·411d. per unit.

Water for all works requirements is derived from three dams supplying suitably disposed storage tanks. Two of these dams deliver their quota by gravity and there is a powerful pumping station at the larger low level dam. Water for the gas producer scrubbers comes from the mine pumps.

The low cost figure for power, quoted above, is naturally reflected in the working costs as a whole, though its influence on underground costs is almost negligible since, as already stated, power for hoisting purposes is derived from a separate steam plant. On a tonnage of 142,910 short tons mined and treated during the last financial year, the working costs were as shown in Table III.

It is the long-standing policy of the corporation to make its monthly reports as explicit and as informative as possible. In these statements are given the tonnage and yield, with production costs at the mine shown separately from those incurred on development, London office, bullion charges, royalty and depreciation, and the estimate of nett profit shown is, to all intents and purposes, accurate. Details of development are given, immediately, exactly as cabled, so that shareholders may be in possession of all important information at the earliest possible moment.

TABLE III

	s	d
Ore Production (including winding)	10	5·52
Maintenance Shafts and Workings		9·75
Ore transport on surface		3·34
Pumping		8·44
Treatment charges	13	6·37
General charges	2	10·68
	28	8·10
Mine Development	4	7·79
Government Royalty (5% on output)	5	1·35
Freight and Insurance, Bullion	1	3·16
London Office Expenses	1	5·95
Depreciation (approx.)	4	7·80
	45s.	10·15d.

There are about 75 Europeans permanently employed at the mines, and upwards of 3,000 natives. The function of the European employee in West Africa is almost entirely a supervisory one, nearly all the manual work being done by African artisans and workmen. The art of handling the native labourer is not difficult to acquire, as, in general, the West African responds very readily to just, firm, and good-humoured leadership. Given the requisite technical ability, therefore, the value of the European employee varies directly with the degree to which he possesses and uses those three qualities. Assisted by the directors, the European staff runs a fine club, which has a library of 5,000 books, two billiard tables, and a well-appointed reading room. There are also two first-rate hard tennis courts, cricket, and football clubs, and a rifle range, all of which are well patronized. Cricket and football matches are regularly played between European and African sides, and do much to foster an excellent relationship, which is reflected throughout the works generally.

West Africa will never be a healthy country for Europeans to live in, but enormous strides have been made in recent years in rendering life at once more safe and more pleasant. Lack of continuity in supervision has always been a severe handicap to mining in this country, but the directors of the

corporation, by interesting themselves in, and supporting the social activities of the staff, and by their generous policy in the matter of gratuities and pensions for long service, have done much to minimize this disadvantage. The new Native Hospital recently built by the corporation is really admirably equipped, and is for its size certainly one of the best hospitals in the country. Here, all the native employees and their families receive free medical attention, and apart from its immediate practical value to the business, is proving a very real educative force in the district.

Obuasi was connected by rail with the Coast and with Kumasi, the capital of Ashanti, as long ago as 1903, but it has, as yet, no road communications with the outside world. On the mine and residential areas, however, motor roads have been constructed, and practically all transport of stores, building material, etc., is now done by motor lorry.

The sanitation of the native villages is controlled by a Sanitary Board composed of representatives of the Government and the corporation, with the Provincial Commissioner as chairman. The corporation as ground landlord and the principal employer of labour provides, directly and indirectly, the bulk of the board's revenue. The villages are well cared for with an excellent water supply, bath houses, drainage system, incinerators, covered and open markets, cricket and football grounds, etc., and a comprehensive programme for building improvements is being steadily carried on. The Obuasi of the jungle, with its forty crude mud-walled and palm-thatched huts, which Cade and his pioneers found in 1897, has vanished. Within the space of a generation, the present well-planned town, with its population of nearly 10,000 inhabitants, has risen as a vital monument to their courage and enterprise. Their preliminary crushing of 262 tons yielding £2,665, has been followed by a total output as at October 1, 1931, of 2,895,840 tons from which gold to the value of £11,081,828 has been recovered.

The ore reserve at September 30, 1931, in the Ashanti mine stood at 667,400 tons, valued at £3,274,558, with gold at £4 4s. 11½d. per ounce. Occurring as they do in rocks of archæan origin, it will be indeed surprising should the main fissures and values fail to persist in depth, and there is eminent geological authority for expecting that they will so persist to the limit to which practical mining is possible. Whatever the future may hold in store for this mine, however, when the history of gold in Ashanti comes finally to be written, the record of its achievements in the first generation of its life must surely provide a very notable chapter.

THE DISTRIBUTION OF ENERGY IN CRUSHING

By R. T. HANCOCK

The author examines work done by certain investigators on the energy consumed in crushing.

Since Dr. Geoffrey Martin first applied the method of measuring the surface exposed in a sample of crushed quartz by comparing the amount dissolved in a given time by a standard solution of hydrofluoric acid with that dissolved in the same time from a quartz cube, there has been no longer any dispute as to the correctness of Rittinger's Law of Crushing and the incorrectness of Kick's, concerning which so much ink has been spilt in the past. This was recorded in the MAGAZINE at the time, but as most of Dr. Martin's work has been published in the Transactions of the Ceramic Society (1925/6), it has not been readily accessible to mining men, who are more familiar with that of the American investigators, John Gross and S. R. Zimmerley, whose recent research is recorded in Technical Publications Nos. 46, 126, and 127 of the American Institute of Mining and Metallurgical Engineers, and in Report of Investigations No. 2,880 of the Department of Commerce of the U.S. Bureau of Mines.

It will be recalled that in Dr. Martin's earlier work, the results given for the finest sizes were somewhat discordant. This suggested that the comparison of amounts dissolved in a fixed time was misleading. It would be fatal to accuracy if, for instance, some of the finest particles completely dissolved during that time. Gross and Zimmerley submit crushed quartz to treatment with hydrofluoric acid under standard conditions for varying lengths of time,

obtaining from the results a curve relating amount dissolved per cent per hour to time elapsed, which, extrapolated to zero time, gives a value for the initial rate (I.R.) of solution before the system has undergone any change in the amount of surface exposed or in the concentration of the solution.

C. F. Wenzel (1777) propounded the law now called by his name, which is here quoted as "the reaction velocity between solids and liquids is proportional to the area of contact." Gross and Zimmerley consequently take the I.R. values to be directly proportional to the surfaces in sq. cm. per gram of the samples they investigate, making this surface equal to 170 × I.R. They present their results in the form of tables and graphs showing the I.R. values obtained for various sizes of particles, adopting as this size the arithmetical mean of the apertures of the Tyler series of screens through which the sample passed, and upon which it rested. This choice is somewhat arbitrary; they might have taken the aperture of the interpolated screen belonging to the same geometrical series, or the geometric mean. This would have given lower figures, and the difference between such sizes and the sizes they adopt becomes greater as the particles are larger, with the Tyler series of screens which they use. As a matter of fact the mean size is dependent on the manner in which coarse and fine are distributed in the original bulk sample and is not the same in any two cases. In particular it is governed by special considerations in the extreme sizes, especially in the "all through."

I.R. values were determined both for crushed quartz—a massive type from Utah—and for Ottawa River sand, the latter being a natural product well-known for its purity, freedom from internal cracks, and almost spherical shape. The values were found to differ widely for the two materials where the mean diameters, as determined by screening, were the same, and moreover the rate at which I.R. varied with diameter was very different for the two materials. In the case of the Ottawa sand, a logarithmic plot of the I.R. values against particle size gives very nearly a straight line, but for the crushed quartz this line is curved, tending to approach the Ottawa sand line as size decreases. No arithmetical expression is given for these curves, which are extrapolated to an incredible degree, even to the ultimate unit crystal of 0·0005 micron, where the two curves are stated to unite, this coincidence being taken as further evidence of the accuracy of the surface measurements.

It is natural that there should be a different relation of I.R. to mean diameter for the two materials. The sharply angular quartz exposes a greater surface in proportion to its diameter than does the smooth sand. If this were all, the rate of variation with size would be the same for both. But it was found that owing to the presence of cracks in the crushed quartz, into which the acid was able to penetrate, the acid measures not only the external surface, but what may be styled the interior surface. It was found by silver-plating the smooth sand, a method for which no great accuracy is claimed, that its actual surface in sq. cm. per gram was given by multiplying the initial rate by 170, an average figure. This same factor is adopted for estimating, from the initial rates found, the surface of the crushed quartz, and therefore gives for this material a measure of the sum of the external and internal surfaces. The external surface of the crushed quartz could also be measured by silver-plating, as the depositing solution did not enter the cracks. Approximately, the external surface of both the sand and the crushed quartz varied as the diameter. But the proportional amount of internal surface in the crushed quartz varied enormously with diameter, though quite regularly, the amount decreasing as the size of particle decreased, so that at no extremely small size the crushed quartz resembled the sand in its freedom from cracks. The tendency for the cracks to increase with particle size is obviously limited, otherwise automatic disintegration would occur. The approach to this limit is perhaps exhibited by the largest sizes of crushed quartz and accounts for the abnormality of their behaviour as compared with the general run of sizes which will be noted further on.

The values of I.R. obtained for each size depend on correct extrapolation of the curves obtained from the experimental data. Gross and Zimmerley state that many attempts were made to fit standard curves to these data and obtain the I.R. values from the tangent at the origin of such a curve, but that all were unsuccessful. Eventually they adopted the equation of a rectangular hyperbola. It is the case that there is a close superficial resemblance, over a limited range, between a rectangular hyperbola and an exponential curve, just as there is between

a parabola and a catenary, which latter is also an exponential curve of sorts. It may well be that the hyperbola gave satisfactory results on small weights, where the derived curve was fairly flat, and the I.R. values obtained appear to be reasonably accurate, but the method is basically wrong in itself, and its application may be questioned in cases where as much as 16 grams was taken, as was the case with the coarsest material. Naturally the task of forcing a fit involved an enormous amount of really unnecessary work and, what was much worse, it very seriously limited the scope of the laboratory work.

Data by Harcourt and Esson (1860) on the amount of a substance remaining in a reacting system after various periods of time can be equated to y = amount remaining = $a\epsilon^{-bt}$, where t is time elapsed and a = 100 where the data are expressed in percentages. This applies to substances in solution, and in this case, where a solid is involved, it becomes necessary to include a further constant, so that the correct equation to employ, and one which fits the data published quite well, is

$$R = a\epsilon^{-bt} + c$$

where R is percentage of silica dissolved per hour, t is time elapsed since zero time, and c is a constant whose determination offers the only difficulty, not a great one in this case, and for which standard methods exist. The constant b is known in physics as the "time-constant," and will probably be found to have important relations to the general data. When the constants have been found from the data and inserted in the formula, and t is put equal to zero, then R = I.R. = a + c. The advantage of an extra and correct set of data can be secured by working from the original weights dissolved, or rather, from the original weight taken minus these weights, and this provides a valuable check on the short-period determinations, which Gross and Zimmerley state are the least reliable.

Notwithstanding the enormous amount of work which must have been involved in obtaining the I.R. values by the method actually followed, and the final result that these values are in all probability reasonably accurate, it would seem desirable to place the determinations on a surer mathematical basis. Determinations made specially for the purpose showed that the initial rates on 100/150 mesh crushed quartz (the massive variety of the main tests), the Ottawa sand, also crushed for this test, and crushings from a large quartz crystal, were all substantially the same.

Suggested Formulation of the Values.—Apart from the logarithmic graph showing relation of measured surface to average particle size, no mathematical relation between I.R. and diameter is disclosed, but it will be found if the I.R. values for the Ottawa sand are plotted against the mean diameters that there results a rectangular hyperbola whose equation may be given as

(Initial rate − ·01244) (average size + ·00145) = ·17281.

Tabulated values for this sand as found and as derived from the formula are shown below, and show that over this rather limited range the agreement is quite good, and goes far to justify a belief that such a type of formula represents the observed facts.

Mesh Tyler.	*I.R. Initial Rate.*	*Av. size mm.*	*Av. size calc.*	*diff.*
20/28	0·255	0·711	0·71099	—
28/35	0·358	0·503	0·49864	− ·00536
35/48	0·497	0·356	0·35518	− ·00082
48/65	0·732	0·252	0·23871	− ·01329
65/100	1·020	0·178	0·17006	− ·00794
100/150	1·386	0·126	0·12436	− ·00164
150/200	1·923	0·089	0·08900	—

Adopting the same procedure in the case of the crushed quartz, the formula appears as

(Initial rate − ·19923) (average size + ·01538) = ·31555.

and a comparison of the figures actually obtained with those derived from the formula is shown below.

Mesh Tyler.	*I.R. Initial Rate.*	*Av. size mm.*	*Av. size calc.*	*diff.*
3/4	0·201	5·690	(178·1)	?
4/6	0·258	4·013	5·35285	?
6/8	0·307	2·845	2·91261	+ ·06761
8/10	0·351	2·007	2·06571	+ ·05871
10/14	0·425	1·410	1·38228	− ·02773
14/20	0·525	1·001	0·95235	− ·04775
20/28	0·632	0·711	0·71376	+ ·00276
28/35	0·823	0·503	0·49049	− ·01251
35/48	1·038	0·356	0·36082	+ ·00482
48/65	1·393	0·252	0·24895	− ·00305
65/100	1·851	0·178	0·17566	− ·00233
100/150	2·504	0·126	0·12153	− ·00447
150/200	3·219	0·083	0·08911	+ ·00411
200/270	4·287	0·063	0·06181	− ·00129

The agreement is reasonably good, especially for the finer sizes, but for the coarsest material it is extremely bad. The formula takes care of the change in the configuration factor, or ratio of total surface, both external and internal, to diameter,

but breaks down when this factor approaches a limit, as already explained.

A further check on the formula is given by integrating it between the limits 0·590 mm. and 0·052 mm., which are the limiting apertures of the composite sample of Table 2 (Tech. Publn. No. 127). This sample appears to have been artificially compounded in such a way that its grading analysis (limiting diameters vs. cumulative weights) is a straight line. It contains nothing below 270 mesh, and so is free from the disturbing influence of the very finest material, which will be referred to later. The integration gives the initial rate 1·48758, and the rate actually found on the composite sample was 1·487, which checked within 0·4% on the individual I.R. determinations of its components.

The formula for the crushed quartz predicts that at an initial rate of 20·716 the average diameter of the corresponding particle would be zero, but Gross and Zimmerley found an initial rate of 31·080 for particles rising in an upward current of 0·48 mm. per sec., and not rising in one of 0·12 mm., and a rate of 128·703 for particles rising in an upward current of less than 0·12 mm. per sec. The highest and lowest values of initial rates for minus 200 mesh material found by Gross and Zimmerley appear to have been 41·50 and 12·02, corresponding to 7055 sq. cm. and 2043 sq. cm. per gram respectively. Such values could never be predicted from the behaviour of particles of ordinary size.

Knowing what we do to-day about the surface energy residing on these very small particles, and recalling that Stoke's Law no longer holds for them, it may reasonably be doubted whether Wenzel's Law, upon which Gross and Zimmerley's deductions are based, really holds good for these extreme cases, in which case reliance upon it would have the effect of making these very small particles appear smaller than they really are, of increasing the apparent surface per unit of weight of such particles, and of assigning an unduly large proportion of the work expended in crushing to the production of such particles, this work being, in accordance with Rittinger's Law, in direct proportion to the new surface produced. Speaking before the Institution of Engineering Inspection in November, 1927, Mr. C. A. Klein, President of the Oil and Colour Chemists' Association, said: "In considering particle size, it was necessary to consider something more than change of surface or increase of surface. Many interactions were possible with material in a finely-ground condition which could not be obtained with comparatively coarse material, and by control of particle size it was often possible to control chemical changes to a degree hitherto unsuspected."

Gross and Zimmerley have quite convincingly shown that the surface per gram obtained by the hydrofluoric acid attack method is the same whether taken on a mixed sample, or on its components separated by screening and calculated accordingly. This is not in conflict with the suggestion made here that some of these components may in reality be coarser than they have been assumed to be.

Crushing Tests.—As the result of a number of concordant tests on material of varying initial size, Gross and Zimmerley obtain an average of 17·56 square centimeters of new surface for each kilogram-centimeter of energy applied. The crushed samples produced by these tests all contained a proportion of very fine particles and it will now be suggested that the effect of this fine material was to raise the solution rate unduly, and so much to overstate the surface produced. It is, in fact, probable that not more than about 7 sq. cm. of new surface was produced by this expenditure of work.

One of these tests is detailed in Table 5 of Report of Investigations No. 2880. 296 grams of 20/28 mesh (Tyler) were crushed in 4-gram lots by the single blow of a falling weight, the products mixed, sized into lots by screening, and the surface determined on each by the solution method, and checked on the bulk sample. If the cumulative weights of these products (100% = 1) be plotted against the limiting diameter of each screen size in mm., it will be found that a rectangular hyperbola passes very accurately through all the points, and in particular that it passes through the point where cumulative weight equals one and limiting size equals zero. So that a relation is exhibited of the progressive production of smaller and smaller particles in the crushing. The formula of

Tyler mesh.	*Limiting Aperture mm.*	*Cum. wt. found.*	*Cum. wt. calc.*
On 28	0·59	·42192	·42221
28/35	0·42	·68022	·65905
35/48	0·295	·78736	·78728
48/100	0·147	·90726	·90629
100/200	0·074	·95553	·95544
Through 200	0·000	1·00000	1·00000

this hyperbola is—

(1·80684 — cum. weight) (1·41388 — lim. size) = 1·14077.

The original feed contained particles up to a maximum diameter of 0·83 mm. None larger than 0·78252 mm. exist in the crushed product, according to the formula.

The mean diameter of the minus 200 mesh material is found by integration of the formula to be 37·7 microns, and it is of interest to calculate by the formula the cumulative weights remaining on imaginary fine screens of the Tyler series.

Mesh.	*Limiting aperture.*	*Cum. weight.*
200	0·074 mm.	·95544
270	0·052 ,,	·96920
400	0·037 ,,	·98034
540	0·026 ,,	·98489
800	0·0185 ,,	·98931
1080	0·0130 ,,	·99252
1600	0·0092 ,,	·99472

Gross and Zimmerley condemn the common practice of regarding 0·037 mm., or 37 microns, the mean between the aperture of the 200 mesh Tyler screen and zero, as the average size of the minus 200 mesh material. The lowest and highest values in sq. cm. per gram which they obtained by the solution method on this class of material were 2043 and 7055 respectively, the average size of such particles, which they take from their logarithmic chart, being 18 and 5 microns respectively. But it will be seen from the tabulation just given that the 4·447% of material in the crushed sample finer than 200 mesh was made up of 2·481% of material coarser than 37 microns, and 1·966% of material finer than this size, so that instead of 37 microns being much too large, as they allege, it was, in this instance at least, a little too small. Their conclusion is based on the high initial rates they obtain on this class of material and the present article is mainly directed to showing from their own data that the I.R. values may not be altogether reliable indices of particle size when these particles are very small. They calculate that 73·7% of the work done in crushing this sample went to the production of the minus 200 mesh material, and assign to it a mean diameter of about 10 microns.

It will be noticed both in the tabulation of the crushing tests and in the Table 5 referred to, that they have in some instances departed widely from the surface values for the various mesh sizes which were discussed earlier in this article, where an attempt was made to fit a formula to them. In spite of this they say: "Determinations made on a variety of samples, sized and unsized, with I.R. values ranging from 0·816 to 128·703 gave an average variation of 0·77% from the average; the greatest variation was 2·69% from the average." This statement avoids any reference to sizes larger than 28 mesh. It naturally makes a great deal of difference to the manner in which the work is distributed among the various grades produced, what I.R. values are taken, especially for the original material. The figures used in this case are shown below and compared with the earlier figures.

	Surfaces (Sq. cm. per gram.).				
Mesh.	20/28	28/35	35/48	48/100	100/200
Table 1	(111·0)	139·9	176·5	(260·8)	(460·1)
Table 5	113·2	120·4	164·6	283·7	566·3)

The figures enclosed in brackets are calculated by the formula given earlier from the means of the apertures of the limiting screens, as they are not given for these particular ranges in Table 1. Further, Table 1 gives 107·4 for 20/28 crushed quartz, whereas in Table 5, and in the general tabulation of the crushing tests, it is taken at 97·4. As is pointed out above, the crushed material remaining on 28 mesh contained nothing larger than 0·78252 mm., and the value assigned to it above is in harmony with that found by Gross and Zimmerley on this particular sample. But there is a good deal of variation in the other figures, especially for the 100/200 mesh material, for which no explanation is forthcoming. It is impossible to arrive at any other conclusion than that the minus 200 mesh material produced in this test was of a mean diameter not less than 37 microns and, assigning this value to it, calculating the I.R. by the formula suggested earlier in this article, and multiplying by 170, gives the resulting surface in sq. cm. per gram as 1058, whereas the solution test gave

	Proport. new surface per gram. sq. cm.		*Distribution of work input.*	
Mesh.	*G. and Z.*	*Suggested.*	*G. and Z.*	*Suggested.*
20/28	6·67	6·67	2·7	6·20
28/35	5·94	5·94	2·4	5·53
35/48	7·20	7·20	2·9	6·70
48/100	22·34	22·34	9·1	20·78
100/200	22·63	22·63	9·2	21·05
through 200	181·25	42·72	73·7	39·74
Totals	246·03	107·50	100·0	100·00

4173·2 sq. cm. Taking the rest of the figures recorded in Table 5 as they stand, we get the re-arrangement of the work input given in the previous table.

The suggested distribution of work input finds some degree of support from the fact that the cumulative figures, plotted against limiting apertures, yields a hyperbola fitting the limiting values and conforming tolerably with the rest, no difference exceeding one and a half per cent. The formula of this hyperbola is—

$$(\text{Cum. work} + \cdot 18257)\ (\text{lim. apert.} + \cdot 14286) = \cdot 16894.$$

Connecting this with the formula given previously for relating cumulative weight with limiting aperture, gives a formula connecting cumulative weight with cumulative work.

$$(\text{Cum. work} + \cdot 07403)\ (1 \cdot 07403 - \text{Cum. weight}) = \cdot 07951.$$

This hyperbola is symetrically disposed about its co-ordinate axes.

Relative figures conforming to these three equations are given below.

DATA OF TABLE 5. TECHNICAL PUBLICATION No. 127.

Lim. Aperture.	*Cum. Weight.*	*Cum. Work.*
·78252	·00000	·00000
·59	·42221	·04795
·42	·65905	·11757
·295	·78728	·20326
·147	·90639	·40026
·074	·95544	·59646
·000	1·00000	1·00000

15·04 kg. cm. of work per gram went to this crushing, and if the new surface per gram produced was only 107·50 sq. cm. instead of 246·03 sq. cm., then instead of belonging to a concordant series averaging 17·56 sq. cm. of new surface produced per kg. cm. of work expended, the figure found is only 7·15 sq. cm., and in the same way it is suggested that all the figures of the concordant series of values given in Table 4 of Tech. Publn. No. 127 are much too high. So that, by relying on Wenzel's Law to the extent they do, and not checking it up by their own most careful and accurate work, Gross and Zimmerley appear much to overstate the amount of energy which goes to the production of the finest sizes, most of it uselessly as far as the aims of the metallurgist are concerned. The larger the proportion of fines which a machine is making, the more efficiently it is stated to be employing the energy supplied to it, to the detriment of the relative efficiency of primary crushers not making so large a proportion of fines.

The kilogram-centimeter is equal to 0·072329 foot-lb., and the square centimeter to 0·1550 sq. inches. So that in British units 17·56 sq. cm. per kg. cm. is equivalent to 0·02692 foot-lb. per square inch of new surface. Dr. H. A. White has given the Rand performances as—

	Foot-lb. per sq. in. of surface.
Crushers . .	1·66
Stamps . .	0·69
Tube-mills . .	0·39

More recently Dr. Sydney W. Smith, writing in the MAGAZINE relative to the Empire Mining and Metallurgical Congress in S. Africa in 1930, gave the most efficient tube-mill figure as 0·3 ft.-lb. per sq. in of surface produced. It is not in evidence how these figures are obtained, presumably by taking the widely accepted Gross and Zimmerley figures and applying them to the screen analyses. If this is so, the difference in the efficiencies of these machines is much exaggerated. The tube-mill, making the finest product, is credited with much more surface than it actually produces, if Gross and Zimmerley's figures for the very fine sizes do not conform to the same relationship as prevails with the general run of sizes.

It has been suggested—indeed, it follows from Gross and Zimmerley's conclusions—that to obtain an expression of the work done in grinding, and thereby rate efficiency under varying conditions, all that is necessary is to determine the I.R. values on the bulk samples of the feed and the product and so ascertain the new surface produced. In view of the evident abnormality of the behaviour of the finest particles, this is impracticable, but it would seem to be a safe course to make screening analyses down to 200 mesh, estimate the average size of the minus 200 mesh material from the curve, and apply the suggested formula relating mean aperture to I.R. to the figures obtained. Naturally the mean diameter of the minus 200 mesh material depends among other things on the amount of grinding which the whole material, subject of the run, has undergone. How it may be estimated in suitable cases has already been indicated, but only if the screening has been very carefully done, with every precaution to avoid dust losses, and the whole effect has

not been ruined in the summation to one hundred per cent, can any degree of accuracy be expected.

The quite remarkable concordance of the figures given in the papers which are being discussed with those given by theory, is undoubtedly due to the use of the standard method of screening proposed by Gross to the Milling Committee of the A.I.M.M.E.

As recorded in Technical Publication No. 375 of the A.I.M.M.E., Fahrenwald and Lee obtained various efficiencies in wet grinding in a laboratory ball-mill, the highest being equivalent to 0·234 ft.-lb. per sq. in. These workers state :—

Surface conversion figures for material smaller than 200 mesh are given by Dr. Geoffrey Martin, but this conversion table is limited to fine material. When surface measurements of coarse grains are desired, we must turn to the conversion factors offered by Gross and Zimmerley. In other words, when an attempt is made to study the effect of variations in ball size upon mill efficiency no single table of conversion factors is available ; two tables must be used. The only point common to both tables is found at $-150+200$ mesh (mean diameter 0·0089 cm.). The surface per gram of material at this point is given by Dr. Geoffrey Martin as 315 sq. cm., and that given by Gross and Zimmerley is found to be 493 sq. cm.

As a matter of fact, Gross and Zimmerley give 326·9 sq. cm. per gram as the surface of uncrushed Ottawa sand of this mesh size, and the figure 493 is that which they obtained by estimating the external surface of the crushed quartz sample by silver-plating it, the acid attack figure, which they use in their own work, being 547·2. So that it is not clear what system Fahrenwald and Lee follow. But in a later paper (Tech. Publn. No. 416) they describe their method of evaluating surface. "This was accomplished by screening the products to 400 mesh, and applying Gross and Zimmerley's surface data. The average diameter of the — 400 mesh material was obtained microscopically, and the surface of this material by use of the factor suggested by the investigators mentioned for particles of the determined diameter." In a footnote below they refer to Perrott and Kinney's paper on "The Meaning and Microscopic Measurement of Average Particle Size" in the Journal of the American Ceramic Society, Vol. 6, p. 417, and state that the formula used gave average size comparing closely to that given by the use of the solution method.

This would seem decisive, except that Gross and Zimmerley do not suggest any factor, but suggest scaling from their extrapolated logarithmic curve, and that Perrott and Kinney discuss no fewer than twelve different formulae for obtaining average diameter from microscopic measurement, giving results on the same sample ranging from 3 to 48, and that Fahrenwald and Lee select the one giving the smallest diameter in seeking to assimilate their results to Gross and Zimmerley's.[1] Calculating in this manner, they rate the performance of a laboratory ball-mill test as producing 1 sq. in. of surface for the expenditure of 0·0285 ft.-lb. of work.

No small part of the energy dissipated in grinding has been expended in futile investigations into ball-trajectories (subsequently discovered to be due to chicken-wire), the boiling point of silica, the angle of nip, and so on. The Principle of Least Action is never mentioned. As a matter of fact, the general law of crushing is a remarkably simple thing.

CONCLUSIONS.—Gross and Zimmerley's results for the minus 270 mesh material appear greatly to exaggerate the degree of fineness assignable to the finest portion of a crushed rock ; greatly to exaggerate the amount of energy which is applied in producing this portion ; and greatly to exaggerate the efficiency of fine-grinding machines which make much of this fine material, to the disparagement of coarse crushers.

Nevertheless, it appears that there is an harmonious relation between initial rates of solution, as they determine them, for the general run of sizes, and average particle diameter which can be expressed by a formula which takes care of progressive small changes in configuration ; and that such a formula can probably be used with safety for the small amount of extrapolation necessary in dealing with the minus 270 mesh.

Royal School of Mines' Dinner.—The 55th annual dinner of the Royal School of Mines (under the auspices of the Old Students Association) will be held on Thursday, June 16, at Gatti's Restaurant, Strand, London, W.C. (King William Street entrance), at 7.45 p.m., with Mr. G. W. Gray (president of the association) in the chair.

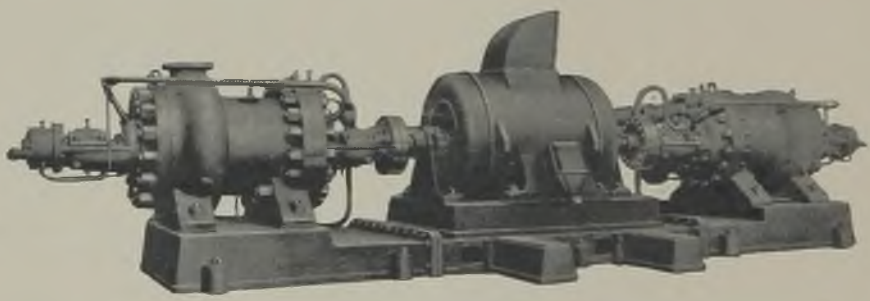
[1] *Vide* THE MINING MAGAZINE, January, 1931, p. 52, for an instance of the use of Weigel's formula.

MODERN MECHANICAL EQUIPMENT IN MINES

By F. J. GARLAND

The author describes some of the advances in mechanical equipment design that have been utilized in mining operations.

As mining men are aware, many important and far-reaching changes have taken place in the art of mining as practised in all the chief mining centres of the world to-day. The universal use for instance of the steel wire rope, high-speed rock drills, high explosives, electric surface and underground pumping plant, ventilation and winding machinery, as well as the general employment of automatic machinery for the concentration of ores, has in fact completely revolutionized former methods. The collaboration of the mining, mechanical, and the electrical engineer in the equipment of modern mines has largely contributed to make the industry what it is to-day in many instances, which is one of enterprise and efficiency. In the brief notes, which follow, the writer draws attention to some salient mechanical features which have come within his experience and which have gone a long way to make modern mining successful.



Electrically-Driven Multi-Stage Centrifugal Pump installed on a Rand Mine.

Electric Pumps.—The electric mine pump has come into its own and within the limits usually available below ground the electrically-driven multi-stage centrifugal pump possesses qualities specially fitting it for mine drainage. On the Rand, where high lifts and corrosive water are conditions often met with, it has proved an efficient unit. One such recent installation comprises two units, each of 42,000 g.p.h. against 2,840 ft. at 1,470 r.p.m., each unit having 16 stages, 8 on either side of the motor. Each unit is driven by a 50 cycle motor, 3 phase, 1,200 b.h.p. machine, with pump castings of cast steel and fitted with suitable hydraulic balance disc. Then the 5-bearing 3-throw ram pump is a substantial and suitable pump for heavy mine work and with double reduction gear and interchangeable ram cases and clack boxes, alleviator and large air vessel is reliable, steady, and quiet in working. A recent test of a 3-throw mine pump for a 1,880 ft. lift gave 94·7% efficiency, which may be considered satisfactory. It is customary for some large firms to-day, before delivery, to test all centrifugal plant against a, say, 50,000 gallon tank and venturi meter—a test motor being provided for this purpose.

Steam Pumps.—Many will recollect the steam pump of 50 years ago as a most wasteful and extravagant consumer of steam, especially as it was usually operated non-expansively and non-condensing. To-day, however, great advance has been made and steam pumps of various makes are more efficient and economical, and those of the compound and triple condensing type, duplex or otherwise, can give a good account of themselves. Moreover, they can, in some conditions in confined positions, where it is difficult to convey away exhaust steam, be so planned that a condenser may be usefully attached to form part of the suction pipe, the exhaust steam being conveyed into it and then condensed by the water which is drawn into the pump. With brass valve seats and interchangeable valve boxes they can be well adapted for "dip" workings and for inclined shafts.

Although the usual designs of multi-stage centrifugal are excellent for deep mines,

Headgear at Bullen's Shaft, Ooregum, Kolar Goldfield.

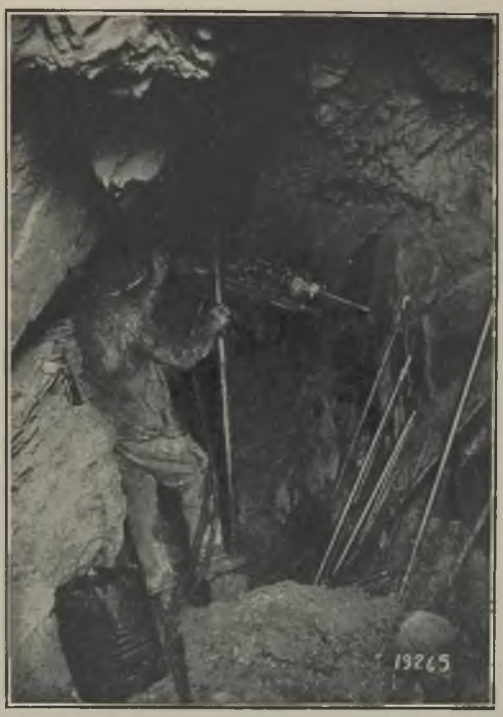
where large volumes are concerned, a type of pump is now being introduced which is more especially suitable to low-lift work. This is the "Helivane" and the "Contra-whirl" pump which has been so designed to overcome certain disadvantages that exist in the ordinary centrifugal. In the new type the pump is constructed so that in working the "flow" or "whirl" of the water takes place in a much more efficient manner. These pumps are simple in construction as well as effective in use and are applicable to many conditions including "dip" workings in mines.

Winding Engines.—Winding can, in these days, be carried out successfully at very considerable depths, and some of the difficulties that hitherto existed have been overcome by the use of electric winders. Many mines such as Ooregum, Morro Velho, and Village Deep are over 6,000 ft. down and the use of electricity for winding and general haulage is now generally applied in our chief mining centres.

At the Champion Reef Mine, Kolar, is a d.c. geared electric winder with a net load of 5,333 lb. winding from 4,400 ft., the drum being of the bi-cylindrical type, and at the Crown Mines are two d.c. units direct-driven for 16,000 lb. net load, having two cylindro-conical drums for 3,540 ft. depth of wind. These are two typical types of electric winders. Where electric power is cheap or where a generating station is a practical proposition the electric winder is undoubtedly the more economical winding method.

In steam winding, plant pressures of 200 lb. and 600° F. superheat make modern

Modern Drill Equipment in an American Mine.



MOUNTED DRILL OF JACKHAMMER TYPE IN OPERATION AT A MINE IN IDAHO.

winding an easy operation especially as present practice in providing against overwinding and overspeed is now in the best work general. In steam winders overwinding prevention gear is combined with speed governing gear and driven from the drum shaft, but in electric winders the actuating gear operates on the main motor power circuit instead of the steam engine throttles. The drums of steam winders may be driven by a duplex cross-compound or double tandem compound steam engine coupled direct to the drum, or through gear in a small plant, and where practicable the exhaust may be used in low pressure or mixed pressure steam turbines driving electric generators or compressed air plant.

VENTILATION.—Mine ventilation also is having serious attention, the plant being often electrical. One mine may be referred to in South Africa, 5,400 ft. above sea level, where the ventilating installation has a huge metal fan with a maximum load of 900,000 cu. ft. per minute 7 in. water guage and driven by a compound condensing engine —the whole plant forming an effective unit.

SHAFT METHODS IN CORNWALL.—Cornwall has, of course, been pre-eminently a tin producing county, but that feature to-day is unfortunately at a very low ebb. Reference may be made, however, to some of the Cornish mining methods which have been in practice and are still employed where active mining still lingers. The pit cages usually carry 10 to 16 men, and the large skips 6 to 8 men, and these are the recognized means of conveying men to and from their underground work. These appliances are also used for the ore. When cages are used there are usually two decks carrying a 16 cu. ft. truck of ore in each deck, and in the case of skips these are usually self-dumping, and carry from two to three tons per skip.

In most mines, the shafts are vertical with double winding roads and high speed winding up to 2,000 ft. per minute. The headgears generally are wood or steel; at Dolcoath of steel, and South Crofty, wood and steel. Wire ropes are best plough steel, $1\frac{1}{8}$ to $1\frac{1}{4}$ in. diameter, but the kibble for shaft use is a thing of the past, except for preliminary sinking purposes. The modern steel wire ropes with its high safety factor is comparatively safe and it is easy to discover any sign of weakness in it.

ELECTRIC MINING IN INDIA.—The application of electrical power to mine operations has been successful particularly in India, New Zealand, and Canada, and in countries where water power exists and can be harnessed for distant transmission. At Kolar, electric power has been applied most

BULLEN'S SHAFT, OOREGUM, KOLAR GOLDFIELD.

effectively and with a great reduction in working expenses, and after 30 years' experience has shown itself to be a notable example of what can be achieved by its use in mining.

The falls are 450 ft. high and ½ mile wide. Power was first applied at 32,000 volts, and now at 73,000 volts through 2 parallel lines on the 3 wire system.

At Kolar, which, by the way, the writer visited, the reef runs for some miles, and one passes along the electrically lit high-way through the various mines. The mining methods are essentially up-to-date and in its metallurgical features the history of the field has been one of steady progress and continued development.

Modern Dressing Plant.—Naturally the elaborate and scientific methods of to-day are not to be compared to the primitive practices of 100 years since, which involved repeated handling of the stuff and a great deal of manual labour, and modern methods may be summarized on general lines as follows :—

The crude ore, having been hoisted through the vertical shaft with great speed and little friction to the surface, is trammed direct to the dressing floor and automatically discharged to a grizzly. The large lumps pass direct to the stone breaker and thence to the crusher. The modern crusher, by the way, is capable of great crushing power, and large output. A 24 in. by 12 in. size may crush say 15 tons per hour road metal at 220 r.p.m. The smalls go into a washing trommel where it is cleaned of adhering clay and dirt. Thence to the sizing trommel, which grade the ore ; the larger pieces go to the revolving picking table and there sorted into milling rock and waste rock. Each grade below this is then conveyed to its proper set of jiggers where it is concentrated and cleaned. The very fine grained and slime water are conveyed to a revolving table which effectively separates automatically the ore from the waste material. The whole system it will be seen is thoroughly automatic, with practically little or no handling except that which is essentially mechanical.

These brief notes on a few features of the mechanical side of present-day mining are illustrated by several recent photographs taken on the Kolar goldfield, South Africa, and America.

The I.M.M. Benevolent Fund

The following further subscriptions to the Benevolent Fund of the Institution have been received during the past month :—

H. A. Titcomb . . .	£10 10s. 0d.
G. W. Gray . . .	5 0s. 0d.
Elbof Geophysical Co. and H. Bertram Bateman . .	3 3s. 0d.
Previously acknowledged .	£148 0s. 0d.
Total . . .	£166 13s. 0d.

LETTERS TO THE EDITOR

Prospecting for Alluvial Deposits

Sir,—Mr. A. F. Skerl's article in the April issue contains one or two points which call for remark. The classification of alluvial deposits given there is suitable enough for the orthodox geological textbook, but as a means of giving a comprehensive summary of the Nigerian deposits from a prospecting point of view it is not the best to adopt. Considering Nigerian deposits from the viewpoint of practical prospecting rather than that of academic geology, there seems to be no particular reason to stress a distinction between deposits related to the present river system and those unrelated to it. This statement may appear a somewhat strange one to make concerning a region where ancient stream beds and so-called "deep leads" are typically preserved, but this fact in itself is an argument in its favour. The geological history of the Plateau is such that nowadays anyone having any acquaintance with the country realizes the possibility of tinstone existing under almost any portion of the superficial cover, independent of the courses of the present streams. There are numerous indications for the trained prospector to work upon, of course, such as the nature of the soil, the appearance of the lateritoid crust which frequently exists at surface, the physical characters of adjoining solid outcrops, etc. All these yield a certain amount of information, but as a general rule it may be taken for granted that no area on the Plateau, which is not actual bare rock, should be passed over as barren until it has been definitely proved to be so.

The following scheme, based primarily on topographical considerations, with subdivisions on a more or less genetic basis, is suggested as a suitable one for presenting a clear summary of Nigerian deposits for prospecting purposes. It has been drawn up from an analysis of some 50 to 60 localities, both on and off the Plateau, with which the present writer has had a somewhat intimate acquaintance :

1.—Watershed Deposits : (*a*) Detrital, (*b*) Alluvial, (*c*) Fluvio-volcanic.

2.—Valley Slope Deposits : (*a*) Detrital, (*b*) High Terraces, with bedrock above present stream level, (*c*) Old tributaries, (*d*) Fluvio-volcanic.

3.—River Deposits : (*a*) Gravels on bedrock in present stream bed, (*b*) Low Terraces, with bedrock more or less at same level as present stream bed, (*c*) Valley Flats, with bedrock below present stream level, (*d*) Fluvio-volcanic, (*e*) Recent Gravels, not on bedrock.

The terms low and high terraces and valley flats are those used by Dr. Falconer in his classification of the Plateau deposits. In the above summary it will be noted that no mention is made of deposits which may exist under the recent volcanic rocks. Comparatively little work has as yet been done to prove such areas, as the basalt is generally extremely hard, unlike the interbedded flows of Fluvio-volcanic age.

Mr. Skerl's suggestions for a formula to indicate the probable limit of lateral displacement of a secondary alluvial deposit of mineral from its primary source are interesting, but, I should imagine, rarely, if ever, applicable in practice. So far as the vast majority of Nigerian deposits are concerned, the prospector who can locate with any degree of certainty the original position of the primary deposit from which the concentrates in alluvial deposits have been shed must be something of a diviner.

The subject of drilling is only briefly touched on by Mr. Skerl, but I must question his statement that "where, however, hard boulders occur in the alluvium and where there are very hard beds the ordinary hand-operated drill is useless, often misleading as to bedrock, and power drills are necessary." So far as I am aware, the only power drills which have been operated to any extent on the Plateau are Keystone machines, and where they are employed it is not on account of the hardness of the ground, but on account of the depth of hole to be attained.

Mr. Skerl's theory of desert conditions having prevailed in Northern Nigeria during geologically recent times and of a protracted period of desiccation during which the river channels were buried under aeolian deposits has little evidence to support it. The superficial ground mantling the valley slopes, and extending from the solid outcrops to the river zones of true alluvium, is exactly what Dr. Falconer has described it to be—an accumulation of rain wash and residual material resulting from the decomposition of the solid rocks. It varies considerably in appearance and composition, but for the most part it consists of a stiff sandy or gritty clay, and anyone who has insisted on his drill boys washing the whole of this material pulled out of a drill-hole would never class it as being of aeolian origin. The evidence of the alluvial deposits themselves points to a gradually decreasing rainfall since the elevation of the Plateau, and far from the area having emerged from a recent period of desiccation it is more likely that the desert is encroaching southwards from the Sahara.

W. C. GRUMMITT.

Loose, Maidstone,
May 8.

Arbitration Procedure

SIR,—Many members of my profession have, I think, an idea that arbitration is a simple and fair method of settling disputes with their employers and therefore request the insertion of an arbitration clause in their employment agreements, which, in addition, generally embody a specific reference to the Arbitration Act of 1889. From a recent experience in arbitration procedure I venture to suggest to my fellow engineers that it would be to their best interests that in any such employment agreements no reference should be made to the Arbitration Act of 1889, so as to allow the arbitrator or arbitrators a perfectly free hand in arriving at his or their decisions.

EDWARD HOOPER.

5, London Wall Buildings, E.C. 2.
June 3.

[This presumably refers to Mr. Hooper's association with the Way and Ariston Company case.—ED. *M.M.*]

BOOK REVIEWS

Markscheidekunde. Part II. By Dr. P. Wilski. Large octavo, 270 pages, illustrated. Price RM. 34. Berlin: Julius Springer.

The second and concluding part of this work has now at last appeared, some two-and-a-half years after the publication of Part I, which we reviewed in November, 1929. Unfortunately the author does not appear to have made use of the interval to extend his knowledge of mine surveying in other countries and the complete work is likely to be of as little real use to practising mine surveyors in this country as was the first part. The scope of this part may best be understood by the following list of sections into which it is divided: I, Connexion between underground and surface surveys; II, Tacheometry, including its application to the Plane Table; III, Setting out dams, water courses, roads and railways; IV, Magnetic Measurements; V, Measurements of Heights by Trigonometry; VI, Measurements of Heights by Angles of Depression; VII, Measurements of Heights by the Barometer; VIII, Photographic Surveying from Stations on the Surface of the Earth; IX, Photographic Surveying from the Air; X, Route Surveying; XI, Cartography; XII, Mine Plans. It will be seen that methods of importance to mine surveyors, such as the setting out of a true North line, are omitted, whereas the largest section of the book is that devoted to Cartography, which is a matter of but very secondary importance to the great majority of mine surveyors.

The great defect of the book is that it is written throughout with true Germanic self-sufficiency; the author appears to feel no shame in admitting, for example (p. 7) that he is not familiar with English mine surveying literature, though a perusal of his book makes it quite clear that he would have benefited considerably had he known something of the state of the art in other countries. Thus from his description of the tacheometric plane table, it is evident that he is utterly unacquainted with Dr. Jeffcott's auto-reduction tacheometer, which automatically shows both correct elevation and distance derived from inclined sights, and which has the advantage of being applicable to the tacheometric theodolite as well as to the tacheometric alidade of the plane table. The author is equally unacquainted with the reviewer's device of specially graduated proportional compasses, by which it is possible to at once set out on a plane table the reduced distance (see *Proc.* Inst. C.E. 1916, vol. cciii, p. 359), but he certainly ought to know the Swedish device of Ljungström for attaining the same object, which is comparatively old and has been described in Swedish textbooks as far back as 1876 ("Geodetisk Matningskunskap." By G. O. Andersson, p. 210). An example of the author's limitations is to be found in the method he recommends for determining altitudes above sea level by taking the angle of depression from the height he wishes to measure to the sea shore. He appears to have adopted this method in mapping a portion of the sea coast in Asia Minor, and hence, because it answered in his case, he appears to think it universally applicable. He forgets that he was working on the shores of the "tideless" Mediterranean, where mean sea level does not vary very much, total tide range being under 2 ft., and does not appear to realize that the same method might involve very serious errors in other parts of the world where the level of the sea at a given moment and sea level may be two very different things, as e.g. in the Bay of Fundy, at the head of which the tide range is over 50 ft. His opening chapter would also have benefited very considerably had he been familiar with the paper by the late Professor L. H. Cooke on "Underground Orientation by Exact and Approximate 'Alignments' of Plumbwires in One Shaft" (*Trans.* Inst. Min. Met. 1925, vol. xxxiv, p. 391). Again under plane tabling, he surely ought to have mentioned the circular plane table, which has been in successful use in Sweden for over a century and a half, and which has been repeatedly described in literature, as for instance by Professor G. Nordenström (*Journ.* Iron and Steel Inst., 1898, vol. liv, p. 62) even if he is unacquainted with its more modern Cornish copy, Henderson's Rapid Traverser.

Of positive errors there are not many to be found, though exception may well be taken to the author's description on p. 131 of rays of light travelling *from* the telescope *to* the object sighted. The real difficulty is that the work applies essentially to German conditions only, and deals far more with the theory than with the practice of the art; thus the author gives at some length the mathematical reasoning for calculating the cubic parabola as a transition curve for connecting the

straight portion of a railway line with a circular arc (of course he knows nothing of the Canadian method of setting out such curves), but he says nothing as to how the results obtained should be applied in the field. Altogether the same criticism may be applied to the complete work as we gave in reviewing the first part, namely, that the work "is of decided interest to the student of the history and theory of the subject, but . . . will not prove of any great assistance to the practising British surveyor."

HENRY LOUIS.

Deep Borehole Surveys and Problems. By M. H. HADDOCK. Cloth, octavo, 296 pages, illustrated. Price 21s. London: McGraw-Hill Publishing Co., Ltd.

This is an interesting book dealing with the subject of "crooked holes" and one can only regret that it will probably not come to the notice of those who stand in need of the information. The field covered includes bore-holes drilled by the mining industry as well as by the oil industry and in this latter connexion the author acknowledges information and data supplied to him by the several bodies of oil-field investigators centred about Oklahoma and the Gulf Coast in America, and the Roumanian companies on this side. It will probably come as a surprise to many to learn that it is established beyond any doubt that all deep bore-holes deviate—and by deep bore-holes all those over 1,000 ft. in depth are implied. The extent to which they deviate may be illustrated by referring to some 22 deep bore-holes on the Rand surveyed by Joseph Kitchin. In these bore-holes, with an average total depth of 3,370 ft., he found an average horizontal displacement of 1,165 ft. with an average lowest depth of survey points of 3,015 ft.

The author traces the history of bore-hole surveying and describes the more important methods used for this purpose. A criticism, and not a serious one, is that the reader is left, after finishing the book, with the wonder in his mind which of the various methods described is the most economical and, at the same time sufficiently accurate method, for him to employ at the present day, should he desire to find out what any particular bore-hole under his charge has been doing.

MURRAY STUART.

German - English Geological Terminology. By Dr. W. R. JONES and Dr. A. CISSARZ. Cloth, octavo, 250 pages. Price, 12s. 6d. London: Thomas Murby and Co.

British geological students and English-speaking geologists in general are commonly handicapped to a really serious extent by the unfortunate fact that in most of the schools of Britain and America German occupies a very subsidiary place in the curriculum as compared with French. To the geologist, however, a knowledge of German would be far more useful professionally, for the output of geological literature which appears in German is enormously greater, and as a rule much more stimulating, than that which is published in French, or indeed in any language other than English. Moreover, honours students are required to have at least a reading knowledge of German, and it is a common experience that this has to be acquired during the University years. It is not found difficult as a rule to pick up the fundamental principles of the language, but the first attempts at reading are often painfully discouraging. The authors of this book have taken a very important step towards ameliorating this very genuine difficulty, and they will undoubtedly earn the gratitude of a long procession of struggling students.

The book consists of fourteen chapters dealing systematically with all the chief branches of geology: Physical and structural geology; stratigraphy and palaeontology; crystallography and mineralogy; petrology and ore-deposits. Quoting from the preface: "To avoid the irritating and time-consuming necessity of frequently consulting dictionaries, the chief terms with the explanatory text, are here arranged side by side. Every German paragraph has directly opposite to it the corresponding English paragraph. Moreover, the corresponding paragraphs, represent close translations one of the other, for the authors felt justified in sacrificing, to some extent, literary style in order to maintain close connexion between the German and English texts." The further advantages of this method are obvious. In the first place the exact meaning of all technical terms can be grasped at once. Even the most voluminous dictionaries often fail to be of assistance where geological technicalities are involved. Secondly, the arrangement of the book (with everything

in English on the left-hand pages reproduced in German on the right) ensures that the work will be equally useful to the German learning to read English. Thirdly, the book is itself a valuable summary of the leading ideas and terminology of geology as a whole.

The authors are to be congratulated on having carried out their enterprise with conspicuous success. Nothing comparable has hitherto been attempted and similar volumes devoted to physics, chemistry and other sciences would certainly be equally welcome.

ARTHUR HOLMES.

Handbuch der Geophysik. Edited by Professor Dr. B. GUTENBERG. Band I, Lief. I, paper covers, 308 pages, illustrated. Price RM. 54 (subscription price RM. 36). Berlin: Gebrüder Borntraeger.

This handbook is intended to give an exhaustive account of the state of knowledge in all branches of geophysics, as well as in other subjects related thereto. The work is arranged to include a complete survey of the theory and practice of geophysical instruments, written by leading experts in the subject, while special consideration is given to modern developments, and wherever possible the results of the experiments and investigations of the collaborators are to be incorporated. The whole subject will be dealt with in ten volumes, each of which will be published in several parts. Certain portions of this "Handbuch" have already appeared and have been reviewed in the MAGAZINE. The part now under review forms Part I of Vol. I, and deals with "The Earth as a Planet." As might be expected from the introductory part of such a treatise, it opens with a preliminary section on general geophysics by the Editor, in which the object of geophysics is explained, the position of the subject in exact science is discussed, and the significance of the results obtained is indicated.

This is followed by a section by Nolke, on "The Evolution of the Solar System and the Earth," in which he discusses the cosmic forces of evolution, and outlines the various hypotheses concerning the origin and evolution of the planets and their satellites. The views of Kelvin, Jeffreys, Goldschmidt and Linck as to the condition of the earth in pre-geological times are clearly set out.

The next section by Milankovitch deals with the position and motion of the earth in the Universe. In this chapter he outlines the gradual development of knowledge on this subject, from the time of the Chaldeans, leading up to the laws of Kepler and Newton, after which he discusses the fundamental problems of Celestial mechanics.

The main portion of the book is devoted to a section by Hopfner on the Figure of the Earth, and the density and pressure of its interior. In this section a complete historical survey is given of the development of knowledge on this subject, and all the more important measurements and investigations are mentioned. The various processes of determining the geoid are discussed at considerable length, and the methods employed in higher geodetic processes are expounded. The section concludes with a chapter on the density, pressure, and gravitation of the interior of the earth, in which all the important theories and hypotheses are outlined.

This part is undoubtedly a complete and up-to-date exposition of the subject, which will be welcomed by those interested in this branch of geophysics.

H. SHAW.

☞ 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

April 20.

Mount Isa.—Official reports available for March show that good progress is being made at Mount Isa with the erection of the new portion of the reduction work. The first of the additional sintering machines in the new section has been put in operation during the past week. Further development plans for opening up sulphide ore-bodies in the deeper ground have been prepared, and work will begin at an early date. In underground work at the mine last month, the seven glory-holes on the Black Star section were operated continuously. In the same section at No. 3 level, exploration to the south has been discontinued, and a winze was started to connect with H 40 lode in No. 4 level. A further cross-cut west in G 50 section was stopped over I 51 rise from No. 4 level, and a winze is being sunk to meet it. At No. 4

level chute construction was completed on the main lode and stoping was commenced. I 51 rise is still in progress. On the foot-wall lode at G 40 the sub-level has been commenced north and south, scraper loading being utilized. G 42 cross-cut is still in progress. In the Rio Grande section the drawing of the main lode south stope at No. 1 level was continued without interruption. Stoping, with filling, is in full operation in the middle lode stope. At No. 2 level the connexion of the pyrite lode was completed. A further south drive on the middle lode was commenced in order to connect with the stope rise from No. 4 level. At No. 4 level the foot-wall north stope was completed. The foot-wall south stope was operated continuously. Chute construction is in progress on No. 1 hanging-wall south stope. The development of the pyrite lode continues north and south. The G 24 rise holed through to No. 2 level. The diamond drill at No. 2 Crystalena bore-hole is now down 455 ft.

Cloncurry Copper Mines.—The strike which has lain idle for six months three of the principal mines in the Cloncurry district has been officially declared off. The leases involved are those of Mount Oxide, Dobbyn, and Orphan, owned and let on tribute by the Mount Elliott Company. If a statement published by an official of the Australian Workers' Union is correct, the agreement come to is in favour of the men. Notwithstanding that the price of copper still continues to drop to unprecedentedly low levels, the minimum rate of wages now decided upon are 2s. a day higher than the rates offered by the employers and recommended by the local mining warden prior to the stoppage. The rates for wood-cutting and cartage have been increased by 25% over those paid before the attempted reduction in wages. The minimum to be paid for the cartage of ore from Mount Oxide to the rail-head at Dobbyn, a distance of some 80 miles, is the same as existed before the dispute, subject to the proviso that 50% of any increase in the value of ore is to be paid to the carriers until such time as the price equals 33% increase on the previous rates. Moreover, the position as regards the hours of labour that were previously regarded by the miners as unsatisfactory have been rectified.

Mount Wandoo.—The Queensland Mines Department has obtained from a competent and reliable official (Mr. C. G. Rutledge, General Manager of the Chillagoe State Smelters) a report on the recent find of gold at Mount Wandoo, which is about 20 miles from Chillagoe. Mr. Rutledge did not go below, but was informed that the principal shaft was 130 ft. deep, and that the last 20 ft. of sinking was on a 3 in. to 10 in. foot-wall vein highly mineralized. The assay book showed that concentrates from this foot-wall assayed from 20 to 200 oz. of gold to the ton, while specimens of hard and soft ore given to Mr. Rutledge assayed from 5 oz. to 7 oz. per ton. The average value of the ore, however, was not indicated. Summed up, Mr. Rutledge's opinion is that the results are most encouraging, but that considerable work must yet be done before appreciable quantities of ore are assured. At the time of his visit, shortly after the discovery was reported, no reserves worth speaking of had been blocked out. The Minister for Mines (Mr. A. E. Atherton), who has a good knowledge of mining in North Queensland, and who visited the mine early this month, says it has great possibilities as to gold production, but could not assent to one of the exaggerated reports which had been circulated—that it would prove a second Mount Morgan. The Minister explained that a material factor was the extent to which values are likely to be definitely established, sufficient to allow of the mine being worked on a large scale, and of ore of both a high and low grade being mined and treated economically. As yet, however, he said, sufficient data are not available as to what maximum width the ore could be profitably mined. A small battery is being erected on the field and a dam is being built for the storage of water. Mr. Alexander Macdonald, the holder of the Mount Wandoo leases, is now on his way (for a second time) to Great Britain, where he hopes to interest overseas capitalists further in his Queensland ventures.

Sulphide Corporation.—Arrangements have been made by the Sulphide Corporation to re-open the Central mine at Broken Hill this month. The preference now accorded Empire production in the United Kingdom through the new British tariff is undoubtedly the important factor that led to the decision to resume production. Operations are expected to be on the same basis as in 1930, when the company was treating 2,800 tons of crude ore weekly and employing 600 men. Local Union officials warn men from other parts not to go to the Barrier in search of work, as there are at Broken Hill 5,000 unemployed who should receive preference for work.

Wiluna and Lake View and Star.—Mr. H. E. Vail, consulting engineer to the Wiluna and Lake View and Star companies, Western Australia, on a recent visit to the Eastern States gave an assurance that enough work had been done to prove that the expectation of the management would be realized at both mines. About the underground position at Wiluna, he said, there was no cause for anxiety. The recent uneasiness had been caused by the shoots of ore having pitched to the south sufficiently for the cross-cuts at the 600 ft. and 800 ft. levels to miss them. It had, therefore, been necessary to drive south before the ore-body could be picked up again. Nothing in the upper levels had indicated that the ore-body pitched to the south. Since this had been discovered the ore-body had responded very well to development work. Referring to the Lake View and Star mine, Mr. Vail said that several old mines had been taken over and a modern central plant was being constructed to make low-grade ore profitable. Extensive development work had proved the continuation of several of the important ore-bodies and had revealed new shoots.

Great Boulder Proprietary Mine.—Activities at the Great Boulder Proprietary mine, according to reports from Kalgoorlie, Western Australia, are proceeding satisfactorily. The ore reserves have increased by about 50% since last year. The ore-bodies being developed at a depth between the Hamilton and Lane shafts are opening up well, while considerable development work is being carried on at the cross lode between the 1,600-ft. and 1,800-ft. levels. The south end of the workings on these bodies is now showing the ore to be well sheared and more favourable in appearance, while the values are improving.

New Guinea Gold.—No. 1 dredge of Bulolo Gold Dredging, Ltd., was started on March 1, driven by a hydro-electric power plant. The company, which is registered at Vancouver, British Columbia, reports that the cost has proved to be within the original estimate, that nearly the whole of the material for the second dredge is on the ground, and that it appears likely that that dredge will, like the first, begin working about the date estimated for starting. The New Guinea Goldfields, Ltd., expects that its mill will be ready for ore treatment in May next. In this section of the company's property a flat ore-body has been opened up, carrying very cheaply mined ore, the value of which is given as 110s. per ton. The general manager (Mr. G. A. Harrison) sees no reason why the company should not begin paying small dividends next year. He says that prospects are good, but that they depend entirely on developments at depth. It is estimated that the cost of production will be about 22s. a ton, and the value of the ore not less than £5 a ton. The chairman of the company (Mr. Frank Hambridge) lately stated that on the Edie Creek section shafts had been sunk to water level in readiness for the campaign of development at depth. The Golden Ridges plant was designed to treat 100 tons of ore per 24 hours, and the present ore reserves there are enough to keep the mill in operation for more than three years. He added that the directors would be disappointed if operations at the Ridges failed to yield £100,000 a year. The alluvial tributes, which yielded £34,600 net revenue during the past year, have expired, and the company is staffing the ground with its own men. This ground is expected to yield £70,000 net revenue in the next twelve months.

JOHANNESBURG

May 5.

Swaziland.—Many claims have been pegged in Crown Mineral Area No. 7 in Swaziland which was thrown open for prospecting and mining for precious and base metals on March 24. The area lies eastward and adjacent to the great Ingwenya Range that is so prominent a feature in the landscape along the Swaziland border, between Oshoek and the Komati River. On the Swaziland side the area is bounded, roughly, by granite, and the whole is occupied by rocks of the Swaziland System which extend in this direction southwards from the Barberton Mountain Land. The gold occurrences, where opened up, are found as impregnations in the schist, without definite foot or hanging-walls, the mineralization being shown occasionally in the form of quartz stringers and pyritic bodies, and generally speaking the impregnations appear to be associated with fissures or zones of fracture without showing any continuous body such as is usually understood by the term "reef." The hills give evidence of abundant prospecting activity at various times during the last 40 years or so, and there is no doubt that the area in question is highly mineralized. In addition to gold, which has been mined along the

Forbes Reef line from time to time, and which is likely to occur in other localities within the area, there are other minerals of economic importance. Cassiterite is reported as existing in pegmatite off-shoots from the granite mass, and scheelite and monazite are said to exist in similar geological conditions.

Vredefort Goldfield.—It is reported that active gold mining is being commenced on the farm Elandslaagte, in the Vredefort district, about two miles below Schoemanspont, on the Free State side of the Vaal River and at Nooitgedacht on the Transvaal bank. A five-stamp battery has arrived at Elandslaagte and is in process of erection. The two places will be connected by cableway across the river. Elandslaagte is about five miles downstream from Virginia, where encouraging assays were reported a few months ago.

Zululand Gold.—Sixty-one ounces of gold recovered from 100 tons of rock has been received at the head office of the Nondweni G.M. Co. in Johannesburg. This is the first output of a Zululand property since it was closed down 36 years ago.

Mineral Rights in Rhodesia.—The Premier of Southern Rhodesia (Mr. H. W. Moffat) has laid on the table of the Legislative Assembly a letter addressed to the members of the Committee that has been appointed to advise the Minister of Mines regarding the steps which should be taken to test the British South Africa Company's claims to mineral rights. It reads as follows :—

> In view of the resolutions received from public bodies, particularly from those representing the mining industry, and also in view of the widespread feeling throughout the country that the question of the "ownership of the mineral rights" should be settled through the law courts and if possible, by the Judicial Committee of the Privy Council, the Government (very reluctantly on the part of the Premier, whose views on the matter are well known) has decided to initiate proceedings with a view to obtaining a decision which the public must accept as final.
>
> Ministers consider it desirable that a committee representing the three parties of the House of Assembly should be appointed to advise the Minister of Mines : (1) As to what steps be taken to ascertain whether this question can be so submitted ; (2) the best method of submitting it ; (3) on the general conduct of the case, or whatever process may be adopted. The Premier trusts you will consent to serve on this committee. The following have been nominated by the Government : Mr. Walsh (Chairman), Mr. Eickhoff, Mr. Gilchrist, and Mr. Davies.

Messrs. Walsh and Eickhoff are of the Rhodesian Party, Mr. Gilchrist is leader of the Reform Party, and Mr. Davies is leader of the Labour Party.

Witwatersrand Deep. — A pocket of quartz carrying visible gold has been struck on the 17th intermediate level of the Witwatersrand Deep Mine. The total weight of five specimens which were all part of one original body is 1,232 oz. and it is estimated that the gold content equals 75% of the whole. The gold occurs mainly in connected flakes and thin films of considerable superficial area. Geologists are investigating the occurrence.

Vlakfontein.—On Vlakfontein No. 21, one of the farms lying between the Daggafontein and Sub Nigel Mines, the drilling which is being carried on by the Union Corporation has proved that the Main Reef Series will be encountered at an easily workable depth. Two bore-holes have been completed and a third has recently begun south-east of the second, which was in turn south-east of the first. These bore-holes have yielded important evidence of the dip and depth of the Main Reef Series and have, therefore, abundantly justified the outlay incurred in sinking them. On the adjoining property, Marievale Nigel, on which the Union Corporation also holds an option, surface prospecting is in progress. It is expected that the two headings which are being driven from the East Geduld will reach the Grootvlei Proprietary Mines' boundary in about two and a half years. No shaft sinking will be done on Grootvlei until the results of the exploratory work from East Geduld are known.

IPOH

May 12.

Restriction.—On April 30 there was issued from Singapore, under the authority of the Governor, notice for publication of the decision to increase by 7% the already heavy proportion (60%) of restriction to which all producers here have been subject during the present and two previous quota periods. This was naturally regarded as a very serious but probably necessary decision, but on May 2—the same day on which the above decision was published in Perak—there was also published another proposal, said to aim at consumption of surplus stocks, involving a complete shut down of all mining for tin ore for two months. This proposal was put forward with very influential backing, and with the expectation that it would reduce

visible supplies by some 15,000 tons. At the end of that period of two months the F.M.S. miners would resume operations with a quota for this country of only 33%, and it was anticipated that production would then be about 2,000 tons per month below the present rate of consumption. Such a scheme as this is clearly advantageous for certain interests, especially for certain dredging companies, but its applicability to other methods of working is very doubtful and it would involve great loss and hardship to the smaller open-cast mines and to the stores and engineering firms from whom the smaller and locally organized mines chiefly draw their supplies. It was proposed that Government should subsidize all who could not themselves cover costs during the period of stoppage. Excluding dredging companies, which are not affected in quite the same ways, the rest of the mines would then be in the following situation :—(*a*) Owing two months' subsidy to the F.M.S. Government, or having two months' outlay on necessary work and pumping with no revenue from production ; (*b*) ready to resume production, but with only a 33% quota ; (*c*) the peace of the country might be endangered by enforced idleness of 30,000 to 40,000 out of the total of labourers on the mines ; (*d*) there would be much unemployment and loss in other businesses connected with the mines. The above proposal is conveniently referred to as the Byrne Scheme, and to meet some of the difficulties of the Chinese mines a modification has been proposed which would allow only the Chinese to continue working, but to produce only 32% of their assessment, the tin won being kept off the market by a scheme of purchase and regulated release to be financed by the F.M.S. Government. At the time of writing it appears unlikely that the Byrne Scheme can be generally applied here without modification to suit local conditions. There are a large number of small open-cast mines in Malaya, as well as a number of large open-cast and a few underground mines, in each of which categories there is a considerable proportion worked and owned by Europeans and it is obvious that their case is not identical with that of dredges in relation to such a scheme.

Survival of the Fittest.—This expression has been often used by opponents of restriction as applied to low-cost producers which are generally dredges, but it is not correct to assume efficient recovery of tin ore in the case of all low-cost producers. In certain types of ground, and generally on any pinnacled limestone bottom, very impressive figures of yardage treated, area worked, and cost per cubic yard may be correctly declared, but the percentage saved of the actual values down to bedrock may be as low as from 50% to 70%, and there are cases known where a dredge has gone a second time over the same ground and won almost as much ore as the first time. There is often, though not always, a valuable proportion of values in stiff clay, which tends to form balls and not only carries away ore originally in the lumps but conduces to loss of ore as the balls go through the sluice boxes. There are extensive swampy areas where no method except dredging would be economically practicable, but where the ground will stand and pumping costs are not too heavy there is opportunity in this country for use of improved methods of working open-cast, and several instances can be seen even now of successful open-cast mining in progress on ground previously dredged and covered with 40 to 60 ft. of tailings.

Gold.—The Raub Gold Mines in Pahang continues to report satisfactory and increasing production. In the Batang Padang district of Perak, where the gold is generally won in the course of working tin ore, the tendency has been for the rate of output to decrease. The following are particulars of past and recent production :—

	1931 *Total* oz.	1931 *Av. p. month.*	1932 *March.* oz.
Raub Aust. Gold Mines	24,727	2,060	2,561
Batang Padang . .	2,294	191	109

The depressed state of the tin industry has naturally stimulated activities in relation to search for gold and a number of parties have gone prospecting in Pahang and Kelantan where, especially in the latter state, gold is known to occur in the mountainous country running northwards into South Siam. It has recently been proposed to form a prospecting and development company with headquarters in Kuala Lumpur to investigate potential gold-bearing areas in this peninsula and in the Dutch East Indies. The proposed capital to be authorized is $1,000,000 of which $100,000 would be called up.

Coal.—The Malayan Collieries, Ltd., Selangor, remains the only company producing coal. The mines started production in July, 1913, and the total amount of coal

won has been 5,663,000 tons up to the end of December, 1931. The colliery is equipped for a monthly production of 75,000 tons, which could be increased ; but the monthly sales of coal have fallen from about 37,000 tons in March, 1931, to 27,000 tons in March, 1932, being necessarily affected by the state of the tin mining industry.

VANCOUVER

May 10.

Pioneer Gold.—The report of the managing director, David Sloan, which accompanies the 4th annual report of Pioneer Gold Mines of B.C., Ltd., supplies up-to-date information of the remarkable progress that is being made at the Pioneer mine. The programme of development and construction work that was outlined in the previous yearly report, for completion within a period of 18 months, is well ahead of schedule and it is indicated that four new levels at 125-ft. intervals will be under development during the month of June, by which time ore reserves will be more than doubled. It is expected that by the end of the year the shaft will have reached the 2,125-ft. level, making available nine new levels below the 1,000-ft., which represents the extent of present depth development. The gross value of the 37,324 tons of ore mined during the fiscal year is given as $736,456, total recovery being valued at $680,798, and receipts being further augmented by $44,882, in respect of premium on bullion. The new mill unit adjoining the existing plant, with the grinding ends together, will include the best equipment available and will have a tank capacity for cyanidation considerably in excess of twice that of the present unit, which has handled an average amount of 102 tons per day throughout the year. The new Rand hoist will be installed before the end of June and all new equipment is expected to be completed by the late summer. The hydro-electric plant will also be duplicated, thus ensuring against any further power shortage. The balance sheet shows cash and bullion assets amounting to $137,619, and from the financial statement it appears that total operating costs were $7·34 per ton, total costs before depreciation, depletion, and Dominion and Provincial taxes, amounting to $8·38 per ton. After all deductions, the net profit for the year, carried to surplus account, was $207,685·95.

Sheep Creek.—A satisfactory solution of the matter of provision of a treatment plant for the Reno mine, to replace the mill destroyed by fire a few months ago, has been reached in the acquisition by Reno Gold Mines, Ltd., of the existing all-cyanide plant at the Motherlode mine, as an adjunct to the purchase of both the Nugget and Motherlode properties, adjoining the Reno, in the Sheep creek area. This mill was erected in 1914 by the Merrill engineering firm of San Francisco and represented, at that time, the best efforts of technical skill. The plant is operated by water power, and is situated at an elevation some 3,000 ft. lower than the Reno workings. Ore will be transported by means of an aerial ropeway, about 12,500 ft. in length, which is now under construction. The mill is in a comparatively good state of repair, and can be put into shape at small cost, while its nominal capacity of 100 tons per day can be increased without much difficulty. Both the Nugget and Motherlode mines present opportunities in regard to ore supply, more particularly in view of the discovery of primary ore of good grade in the lower levels of the Reno mine. The Motherlode was developed extensively down to the 500-ft. adit level, but operations were suspended owing to disappointing results from work conducted from a winze below that level, which did not offer encouragement, at that time, for the driving of a long cross-cut tunnel such as would have been necessary for further depth development. It is expected that the new equipment will be ready for operation in September, and production will be resumed on a larger scale than heretofore.

Boundary. — The Dividend - Lakeview mines near Osoyoos in the Boundary district have been reopened by Lakeview Mining Company of Vancouver and active operations are in progress with a view to milling the considerable reserves of low-grade gold ore that are indicated. The property has been idle for several years following the exhaustion of available ore of shipping grade, of which about 16 carloads were treated at the old Granby smelter at Grand Forks, having an average grade of around $20 per ton. The ore occurrence is represented by contact-metamorphic deposits, in limestone, of irregular lenses of magnetite, pyrrhotite, and arsenopyrite, and surface exposures indicate a considerable tonnage. A thirty-stamp mill has been installed.

Lardeau.—It is reported that high-grade gold ore has been uncovered recently on the

Burnière group of claims near Camborne in the Lardeau district. The property was bonded recently by Hercules Mining, Smelting, and Power Company. The ore occurrence was described by H. C. Gunning of the Canadian Geological Survey as a gold-bearing quartz vein about 5 ft. wide., in which visible gold is found associated generally with a green chrome mineral, resembling mariposite. The vein has been traced on surface for some hundreds of feet, and occurs in an altered and fractured greenstone dyke. The claims are owned by Cory and Stanley Menhenick of Camborne.

Smithers.—Local capital is being subscribed by Smithers residents for the further development of the Jessie property, which is located near the town. The property has been favourably reported upon as a good prospect, gold values being associated with arsenopyrite in an intersecting series of veins, one of which reaches a width of five feet. The mineralization is irregular and appears to be more pronounced near the intersections.

Radium Legislation.—Legislation has been enacted recently with a view to encouraging prospectors to look for radium ore. The immediate cause of this action appears to have been the withdrawal of certain private interests from prospecting work on Quadra Island, owing to the definite discouragement to such investigation, by Government, conveyed in the previous regulations, whereby a 50% interest in any radium discovery was vested in the Crown, in addition to royalties payable. Under the present regulations the Crown interest is reduced to 10%, while a reward of $5,000 is still offered for discovery of commercial ore-bodies. At the same time, sweeping powers are conferred upon the Government to take all such steps to conserve radium resources in the public interest as may be found desirable. As a result of this measure it is stated that prospecting operations on Quadra Island and Vancouver Island will be resumed.

Phillips Arm.—Development work at the Alexandria mine, which was initiated under the auspices of Eastern interests, with which Alexandria Gold Mines, Ltd., had concluded a provisional arrangement for more extended operations at the property, has been stopped, and the parties concerned have withdrawn from the agreement.

Big Bend.—French Creek Development Company, Ltd., has resumed hydraulicking operations on the placer property in the Big Bend district. After making a good clean-up in the early part of last year, washing had to be discontinued in order to make a 500-ft. rock-cut for drainage purposes, a section of old channel having been exposed high up in the hydraulicking pit, which could not be followed for any great distance owing to its downward slope. This work was completed in the fall and there is every indication of a successful season's work this year. With advices just received of the intention of the Government to complete the construction of the highway round the Big Bend of the Columbia River at an estimated cost of $272,000, there are prospects of a considerable renewal of activity in this country, where mining operations have been greatly handicapped by lack of transport facilities.

Omineca District.—There is a renewal of activity on Dome mountain in the Omineca district, where in 1923 and 1924 extensive development operations were carried on by Federal Mining and Smelting Company, under their subsidiary organization, Dome Mountain Gold Mines, Ltd. The work was stopped and the properties were relinquished owing to failure to prove continuity in depth for the several ore-bodies that outcrop over a wide area on the mountain. The development work that is now proposed is sponsored by interests identified with Great Falls, Montana.

Wallace Mountain.—At the recent annual meeting of the Wellington Beaverdell Syndicate that was held in Greenwood it was decided to instal further machinery to provide for more extended development at the Wellington mine on Wallace mountain in the Kettle River valley. This mine has been continuing to make shipments of high-grade silver-lead ore and, in common with its neighbours the Bell and the Sally mines, has been able to maintain profitable operation during the existing depressed state of the silver market. Among other improvements a new power plant is to be installed. The Old Carmi mine, one of the first locations in the valley, has been leased by J. Kerr, T. McArthur, and H. Fritz, of Midway, and has been re-opened after being abandoned for several years.

Barkerville.—It is understood that a 25-ton mill is to be built by Cariboo Gold Quartz Mining Company, Ltd., to treat the gold-quartz ore developed in the veins around Barkerville. Reference has been made

previously to the operations of this company. A considerable amount of underground development has been carried out, but, although there are many promising showings, the tonnage blocked out is negligible.

Portland Canal.—Development work is to be resumed on the Unicorn group, adjoining the Big Missouri on Portland Canal, and J. Howland has returned to the property to supervize operations. The general character of the ore occurrences is similar to that of the Big Missouri, although on a smaller scale.

TORONTO

May 18.

Porcupine.—The annual report of the Hollinger Consolidated for 1931 shows a total income from bullion production of $10,528,865, and an non-operating income of $418,120, bringing the total gross income up to $10,946,985, as compared with $10,902,931 for the previous year. Operating and general expenses were $6,949,860, leaving a net operating profit of $3,997,125. After deduction for taxes, depreciation, etc., there remained a net profit of $3,508,204, as compared with $3,963,728. Dividends and bonuses for the year amounted to $3,440,000, leaving a surplus to be carried forward of $64,204. The total surplus now stands at $11,694,092. During the year there was 1,640,705 tons of ore milled with a daily average of 4·479 tons, the cost per ton being $4·23, as compared with $4·01. The total ore reserves at the end of the year were estimated at $46,241,688, as compared with $48,896,685. The deeper mining programme is being carried out with encouraging results on the 3,350-ft. level and new sections are being opened up with good showings of mineralization and on the 3,900-ft. level, a vein picked up having a width of 15 ft. with signs of free gold. In the Schumacher section the grade is well maintained. Dome Mines is treating about 1,500 tons per day, with millheads slightly over $7·50 per ton. The production for April was valued at $354,254, as compared with $295,680 for April of last year. Underground operations on the 13th level following up a stringer showing gold are reported to have resulted in the discovery of very rich ore but official information is not forthcoming. The Vipond Consolidated during the first quarter of the year produced bullion to the value of $120,017 from the treatment of 25,604 tons of ore, the average recovery being $4·68 per ton. This compares with $5·68 per ton for 1931. Current operations are concentrated chiefly on exploration for new ore-bodies and extension of known veins around a depth of 1,450 ft., but so far the results have been unimportant. At the Ankerite, an old-time producer, operations have been resumed and the mill is treating 150 tons. Development is being actively pushed and ore of medium grade is being opened up with indications of the occurrence of a large tonnage. The Coniaurum is pushing work on the lower horizons where several promising sections have been opened up with assays ranging from $7 to $18 per ton. The mill is maintaining its regular production record with earning running somewhat above development costs.

Kirkland Lake.—The mill of the Wright-Hargreaves is treating an average of 800 tons a day with a recovery of $11·52 per ton. Production during April was valued at $292,000, making a new high record. Good progress is being made with the sinking of its central shaft which has reached a depth of 1,500 ft., its objective being 4,000 ft. New ore sections have been opened up in the lower workings with values stated to have run above the mine average. The Teck-Hughes for the three months ending February 29 produced bullion to the value of $905,960 with a recovery of $12 per ton. The position of the company has been improved by the enlarged capacity of the mill which is now rated at 1,300 tons daily, and the grade of ore now treated shows improvement, with millheads running at a higher average. At the Sylvanite production is now running at about $75,000 per month, with millheads slightly above the former average. The company is expanding its scope of operations, and is opening up several levels down to 3,000 ft. The cross-cut on the 2,500-ft. level is stated to be but a short distance from the point where it is expected to pick up the downward extension of the vein system. The Bidgood Consolidated is putting through a rise from the 500 to the 375-ft. level, which has opened up good ore. Development is also under way at the 125 and 250-ft. levels, where ore shoots have been encountered with an average grade of $15 per ton. Kirkland Lake Gold mine continues to find high-grade values on its lower level. A rise going in from the 4,775-ft. level has cut an ore section showing a width of 9 ft. with values from $40 to $50 in gold per ton.

Arrangements are now being made to sink another 500 ft. to pick up the downward continuation of the high-grade zone. Barry-Hollinger, which for some time past has been treating low-grade ore with a recovery not sufficient to take care of development work, is now opening up high-grade ore. The mill is being supplied from the various levels between the 1,750 and the 2,000 ft. The management proposes to cut operating expenses to a point which will bring it within the earning power of the mine. The mill is handling around 90 tons of ore per day. The Macassa is steadily proceeding with its development programme, the shaft having reached a depth of 2,000 ft., where a station is being cut. The drive from the adjoining property of Kirkland Lake gold is keeping pace with the sinking operations and is in commercial ore for the entire length, the average being estimated at between $12 and $14 in gold.

Sudbury. — International Nickel has nearly completed the work on re-conditioning No. 4 shaft, formerly known as Mond shaft of the Frood mine. Concrete loading stations are now being established and the new Nordberg hoist, a duplicate of the hoist at No. 3 shaft, is on the ground. Workings from No. 4 shaft have been carried as deep as 3,300 ft., whereas No. 3 shaft allows production to be drawn only from above the 2,800-ft. level. Some of the richest ore as yet developed in the Frood mine has been found in the territory between the 2,800 and 3,100-ft. levels. Rises are also being put through to the surface for another ventilation shaft near No. 4 shaft, this being a feature of the elaborate ventilation system recently adopted. The Falconbridge Nickel in its quarterly statement for the three months ending March reports gross operating profits of $113,511. The quantity of ore treated was 31,205 tons, from which was produced 1,480,560 lb. of nickel, and 619,357 lb. of copper in matte. A new 200 h.p. electric motor has been installed for the purpose of increasing the speed of hoisting facilities. This enables more ore to be drawn from the 1,000-ft. level without increasing the shifts. Current operations are chiefly confined to stoping on the 1,000-ft. and 350-ft. levels. On the latter horizon the results have been highly encouraging, the ore-body having shown better than average mine grade across in a stoping width of 40 ft. for a distance of 350 ft. A start has also been made in opening up the 500-ft. level, a cross-cut having been driven across the ore-body and a drive west of the shaft commenced. The mill is treating between 250 and 300 tons of ore daily. The McKellar-Longworth property near Schreiber is being developed and a high-grade vein opened up, from which shipments of ore will be made to the Copper Cliff smelter.

North-Western Quebec.—Noranda Mines has issued an estimated operating statement for the quarter ending March 31 which shows net profits of $1,091,441. Gold is being produced at the rate of about $600,000 per month and, in view of the continued low price of copper, the company proposes to increase its output of precious metals, which will require an enlargement of plant and equipment at a cost of approximately $575,000. The capacity of the concentrator will be doubled providing facilities for handling ore up to 2,000 tons daily. Development work is being steadily conducted and new discoveries are stated to carry high-grade ore. The Noranda is exploring new ground in a group of claims in the Pascalis district where there are good surface showings, the group will be subjected to a thorough test. The Granada is making steady progress with the construction of the cyanide unit which will increase the capacity of its mill to about 150 tons daily. It will probably be in operation before the end of the month. The winze being put down from the 675-ft. level is now close to its objective of 1,075 ft. Ore values opened up below the 625-ft. level are said to be generally higher in gold than those on the upper levels. The mill of the Siscoe Gold Mine during April produced $77,017 from 5,027 tons of ore treated, of an average grade of $15·49 per ton. A new headframe has been ordered which will enable the handling of a larger tonnage. Four new levels are being opened up with satisfactory results. A new vein 18 in. in width carrying good values in gold has been encountered in the shaft at a depth of 805 ft. At the Sullivan, adjoining the Siscoe gold mine, operations have been resumed, a shaft having been put down to a depth of 275 ft. and 1,000 ft. of cross-cutting completed, encountering two veins with indications of a large tonnage of good ore. The Adanac Gold Syndicate is carrying out a programme of exploration on its property adjoining Granada and has encountered veins coming in from that mine. The Beattie Gold Mines, Ltd., is developing a claim in Duparquet

township, where a large tonnage of low-grade gold ore is indicated. Plans are under way for the installation of a large mill. On the Connell claims in the Pascalis district an important discovery has been made on the surface and an enlarged programme of development will be carried on during the summer.

Outlying Ontario Goldfields.—Development work at Ashley Gold Mines in the Matachewan district controlled by Mining Corporation is now directed chiefly towards getting the property ready for production by the end of the summer. Four levels have been opened up, stoping operations are under way on a large scale, and a good tonnage of ore averaging $12 per ton has been opened up. In the Michipicoten area the Minto, since commencing operations, reports a production of over $150,000, The mill is now treating about 60 tons a day, the grade of the ore showing improvement at depth. At the Parkhill in the same area an important new vein has been encountered and the capacity of the mill will be increased. A small mill will be installed on the property of the New Goudreau Gold Mines, Ltd., in the Algoma district. Two shafts 500 ft. apart have been sunk on No. 1 vein, one to 425 ft. and the other to 220 ft. with a connecting cross-cut on the 200-ft. level. In the Patricia district the Howey is maintaining its rate of production and is opening up new ground by putting down a winze from the 1,000-ft. level.

Manitoba.—It is officially announced that the Sherritt-Gordon mine will be closed down in June for at least 90 days. The mine has produced copper to date at a profit, but cannot do so under existing conditions and the directors state rather than jeopardize the company's position they are forced to take this action. As soon as the copper market shows signs of improvement operations will be resumed.

PERSONAL

S. Gordon Cullen is here from Sierra Leone.

J. B. Dennison is home from Spain.

Rowland C. Feilding has left for Germany and Poland.

John J. Freund is home from India.

O. T. Gorton has left for Kenya.

Maurice Gregory is home from Abyssinia.

P. Mercer Hume is leaving for the Gold Coast Colony.

W. McAuliffe has returned to Nigeria.

Malcolm Maclaren is home from South America.

A. J. Marin is returning to France from Colombia.

J. W. Newbery is returning from Queensland.

M. Ponchon is leaving for Canada.

James Roberts is returning from Italy.

H. A. Titcomb has left for the United States.

A. Stanley Williams is returning to Nigeria.

Harley B. Wright is now in Spain.

Percy Bosworth-Smith, who died on May 16, was an Associate of the Royal School of Mines, a Bessemer Medallist, a Life Member of the Institution of Mining and Metallurgy, and a Fellow of the Geological Society in London. After being mineralogist to the Madras Government from 1885 to 1889 he became successively manager and consulting engineer to various companies in the Kolar goldfield and elsewhere in India. He joined the firm of John Taylor and Sons in 1916 to take charge of prospecting and geological work.

Francis Egerton Grosvenor, Baron Ebury, who died in London on May 15 at the age of 48, commenced life as a mining engineer, having been trained at the Camborne School of Mines and later under Benedict Kitto. After being employed as metallurgical chemist by the Canadian Pacific Railway Company, he became chief chemist to the Hall Mines, British Columbia. Later he was associated with the Norton Griffith interests in Western Canada, of which he was managing director from 1912 to 1914.

TRADE PARAGRAPHS

W. H. Dorman and Co., Ltd., of Stafford, have published a folder drawing attention to their Dorman-Ricardo Diesel engines, which are 4-cycle, airless injection, compression ignition, cold starting oil engines, specially adapted for use on road haulage vehicles.

A. L. Curtis, of Chatteris, Cambridge, has published No. 1, Vol. 1, of a new quarterly magazine entitled *Sands, Clays, and Minerals*, which is devoted to interesting those who are concerned with non-metallic minerals, such as sand, slate, Portland cement, clay, and the like.

Mining and Industrial Equipment, Ltd., of 11, Southampton Row, London, W.C. 1, report having received the following new orders:—For England: Two 3 ft. by 5 ft. 2-surface Hum-mer electric screens and two 3 ft. by 5 ft. 1-surface Hum-mer electric screens for coal, one No. 3 hydrator for hydrated lime, one 6 ft. dia. Raymond separating plant for clay, and one 7 ft. by 48 in. Hardinge ball-mill for coal.

Leonard Hill, Ltd., of Thanet House, 231–2, Strand, London, W.C. 2, have published the eighth edition of the Chemical Engineering and Chemical Catalogue. This covers some 370 pages and contains announcements of some of the principal manufacturers of chemical plant and equipment. It also contains indexes, both alphabetical and classified according to products, trade marks, tables and data, and a bibliography.

Demag, A.G., of Duisburg, Germany, in their *Demag News* for May have an article dealing with some recent developments in the design and operation of steam-driven winding engines. Another deals with practical results obtained with one of their cogging scrapers in a Polish Upper-Silesian coal mine. Further articles cover their caterpillar

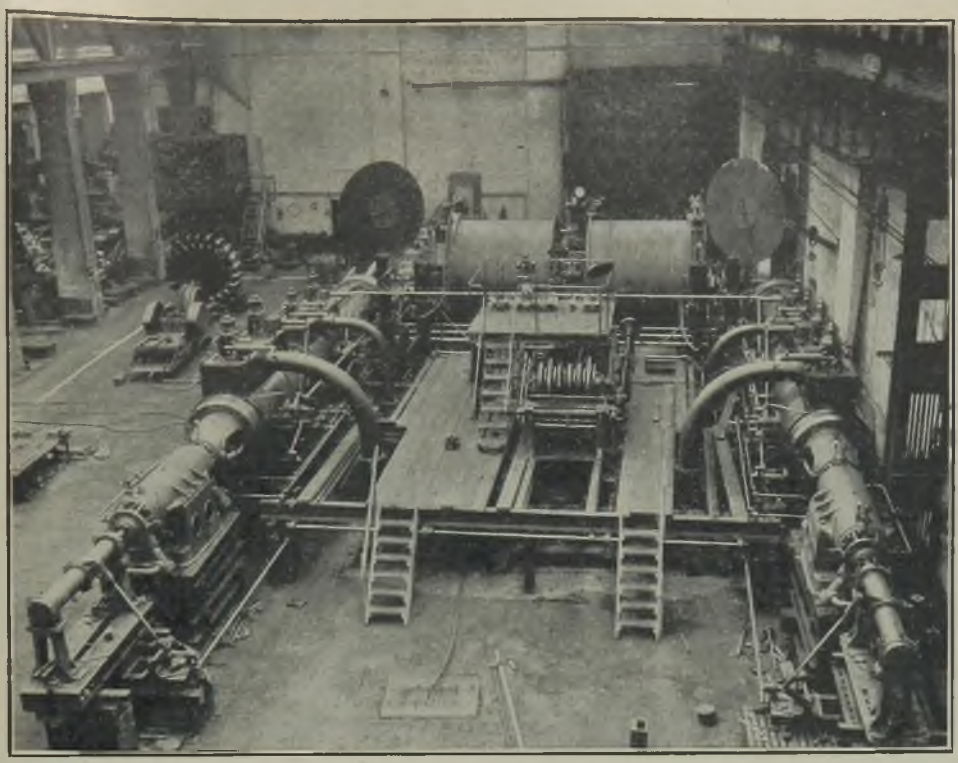


FIG. 1.—MARKHAM STEAM WINDER FOR DAGGAFONTEIN MINES.

conveyor for underground work and rotary air-compressors for mining operations.

Markham and Co., Ltd., of Broad Oaks Works, Chesterfield, have recently completed a steam winding engine for No. 2 shaft of Daggafontein Mines with hydraulic brake gear. The winder is, as can be seen in the illustration, of the compound tandem type. It has two high-pressure cylinders, each of 25 in. diameter by 60 in. stroke, with a working pressure of 140 lb. per sq. in., and two low-pressure cylinders, each of 40 in. diameter by 60 in. stroke, with a working pressure of 40 lb. per square in. It has two cast-steel drums, each 11 ft. in diameter on the tread by 8ft. 3 in. wide, with multiple-tooth clutches and carrying a 1⅛ in. diameter rope. The depth of the shaft is 4,200 ft. and the rock load 10,000 lb., at a rope speed of 3,000 ft. per min., which is later to be increased to 3,500 ft. per min., equal to 109 seconds total winding time. The man load is 9,600 lb. (sixty men), at a rope speed of 2,600 ft. per min., equal to 118 seconds of time of winding when hoisting and 134 seconds when lowering. The hydraulic brake cylinder, which is water cooled and is situated behind each L.P. steam cylinder, is controlled by cam gear, shown in the centre foreground, driven from the righthand drum. Three different shapes of cams control three different types of trips, i.e., "men lowering," "men hoisting," and "rock hoisting," there being one set of each for "forward running" and "backward running." The "rocking tubes" at the extreme back of each engine are turned by only one of the particular cams in gear. The engine piston rods (with circular crossheads on the ends) are extended through the hydraulic cylinders into the rocking tubes and the crosshead sliding-on keys are turned with the rocking tubes. In the hydraulic cylinders are pistons built up of four fixed vanes, A,A,A,A in Fig. 2 (i.e., sliding on keys in the hydraulic cylinders and loose on the piston rod), and four loose vanes, B,B,B,B and C,C,C,C in Fig. 3 (i.e., fixed on keys in the hydraulic piston rods and free to turn with rocking tubes). At the start of a wind the vanes are open (Fig. 2) (i.e., piston only one-third solid, minimum hydraulic braking resistance), at the end of a wind the vanes are closed (Fig. 3) (i.e., piston completely solid, maximum hydraulic braking resistance). The point where and also the speed

START OF WIND.
VANES OPEN.

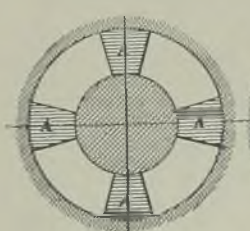


FIG. 2.—A,A,A,A. FIXED VANES. Loose vanes are directly behind fixed vanes.

END OF WIND.
VANES CLOSED.

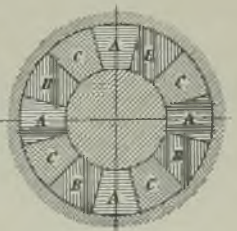


FIG. 3.—A,A,A,A. FIXED VANES. B,B,B,B and C,C,C,C are loose vanes.

at which the vanes begin to close is predetermined and is controlled by the contour of the cams. Also, at a predetermined point in the wind the throttle valves are automatically closed and equalizing valves opened by additional cams. The cam gear is set by the driver on the platform and is so interlocked with the ordinary handling gear that no incorrect setting can be made by the driver.

Scott and Strutt, Ltd., of 25, Victoria Street, London, S.W. 1, have received a report from the Seville Sulphur and Copper Co., Ltd., concerning the successful operation of their model E Morgon hot miller, as described in the MAGAZINE for February, 1931. Seven thousand bits have been dealt with and relatively little wear is shown on the milling wheel. Against this at least 25% increase in the depth drilled per bit employed is said to have been effected. As was pointed out in the original description of this machine, it is important to emphasize that it is not intended to replace the present drill-sharpener equipment but rather to supplement it.

Head, Wrightson, and Co., of Stockton-on-Tees, call attention to the fact that they have supplied the following plant to the Daggafontein Mines, which information may be regarded as supplementary to the article which appeared in the May issue of the MAGAZINE :—Steel headgear 113 ft. high, five 14 ft. dia. pulleys complete, four 12-ton " Stephen Humble " safety detaching hooks, tube-mill house and bins, seven Pachuca tanks 15 ft. dia. by 45 ft. deep, five tanks 70 ft. dia. by 12 ft. to 17 ft. 6 in. deep, two solution tanks 60 ft. by 10 ft., two clarifying tanks 50 ft. by 8 ft., five tanks 50 ft. by 12 ft. to 15 ft. 9 in., one tube-mill water tank 50 ft. by 13 ft. 6 in., two storage tanks 50 ft. by 12 ft. to 15 ft., nine tube-mills 6 ft. 6 in. dia. by 20 ft. long, crushing and washing plant buildings, conveyor galleries, storage bins, and filter plant building.

Hoffmann Manufacturing Co., Ltd., of Chelmsford, draw attention in a leaflet they have issued to a new development in friction elimination, which refers to an entirely new principle in the application of ball and roller bearings, the use of which has hitherto been confined to minimizing

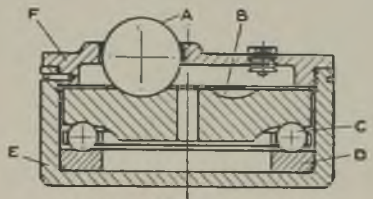


FIG. 1.

friction in journals supporting loads perpendicular to the axis of rotation or thrust bearings carrying axial loads—in other words to rotary motion. The " sun and planet " principle is, however, designed for adaptation to sliding and reciprocating mechanisms, where it has been formerly impossible satisfactorily to employ either ball or roller bearings. The principle of the ball or roller bearings in this instance is illustrated in Figs. 1 and 2. Each is one of a series of complete units capable of carrying loads of from 250 to 6,000 lb. in the first case and 1,500 to 7,500 in the second. In Fig. 1, which shows the ball bearing, (A) is the contact or load ball, (B) the raceway or endless track which

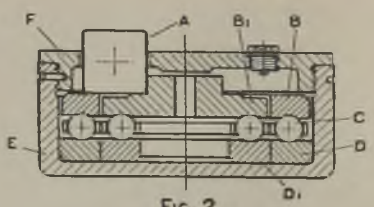


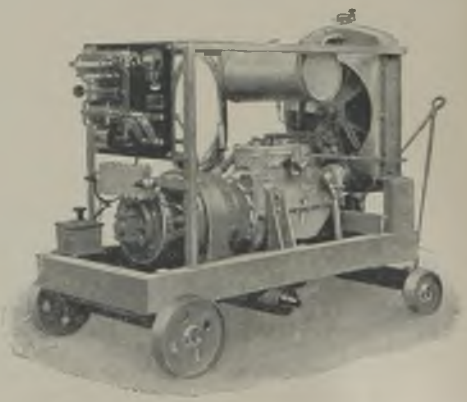
FIG. 2

rotates on the balls (C) running on the fixed raceway (D). The housing (E) has a removable plate (F) having a hole eccentrically disposed to position the contact ball. When a tangentially moving load is applied to the top of this contact ball by either a flat or grooved track it rolls on the endless track without perceptible frictional contact with the plate (F), resulting in a load carrier of an almost frictionless nature. In Fig. 2, which shows the roller bearing, the contact roller (A) is eccentrically mounted above and in contact with two rotating raceways or tracks (B) and (B_1) arranged concentric with one another. These tracks revolve on the balls (C) running on the fixed raceways (D) and (D_1). The housing (E) has a removable plate (F) provided with an eccentrically disposed hole to position the contact roller (A). In this type the roller makes contact with separate races, thus allowing it to revolve in a frictionless manner, while each track revolves at its appropriate speed.

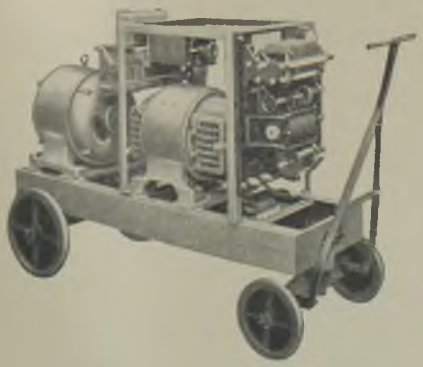
ARC-WELDING IN MINING

In the May, 1931, issue of the MAGAZINE attention was directed to the special features which distinguish Wilson plastic arc welding apropos a visit to the works of **G. D. Peters and Co., Ltd.,** of Slough. This firm have for a considerable time been manufacturing arc-welding plants in portable forms for use by contractors and have of late been turning attention to the production of an outfit suitable for use underground by means of which repairs may be effected on the spot, thus saving a great deal of time. Breakdown, through fracture, of mine cars or damage to track are two notable instances of the use to which such plant might be put.

These portable units are variously mounted on trolley type or railway wheels of different gauge.



G. D. PETERS K TYPE PETROL-DRIVEN SET.



PETERS K TYPE MOTOR GENERATOR SET.

In the former case they can be conveniently trundled on to a mine truck for sending down the shaft. The generator is either petrol engine or electric motor driven, the latter being probably preferred in most cases, since motors suitable for any voltage, phase, or frequency are fitted. No doubt compressed-air motors could be fitted if required.

Apart from the use of arc welding plant for the rapid execution of repairs underground there are many other applications. In addition to repair work of all descriptions at the surface it is probably not generally recognized to what extent arc-welding is replacing rivetting in many forms of constructional work. This means of joining various members of a framework is not only more rapid but is considerably stronger, as has been simply demonstrated. Test pieces made up of welded metals of many shapes which have been subjected to such mechanical stresses as tension, compression, shear, torsion, and bending have shown that in all cases the welded part is the strongest and that fracture of the test piece occurs elsewhere than at the joint.

METAL MARKETS

COPPER.—The trend of the copper market during May was easy, industrial demand remaining quiescent, while the stocks held by producers were not reduced to any extent. At the close of the month Copper Exporters Inc. were nominally quoting 6·25 cents c.i.f. Europe for electrolytic copper, but were offering custom refined metal at down to 5·50 cents, which figure however, was further underquoted by "outsiders" selling at 5·30 cents. It now looks almost certain that a 4 cent import duty will be imposed by the United States; logically, this should tend to depress the world quotation of copper further.

Average price of Cash Standard Copper: May, 1932, £28 11s. 11d.; April, 1932, £29 19s. 10d.; May, 1931, £38 18s. 10d.; April, 1931, £42 14s. 8d.

TIN.—Apart from the fact that producers had already decided to curtail world output to the extent of a further 20,000 tons as from June 1, sentiment was encouraged early in May by fresh and still more drastic proposals aiming at a more rapid improvement in the statistical position. These proposals, called the Byrne scheme, gave the market a distinct fillip, but although they are expected to be adopted they have meanwhile been modified considerably and will therefore lose their immediate effectiveness to some extent. Under the revised scheme it will be left to the discretion of individual producers from a certain date—probably July 1—to close for two months and then operate for 10 months at 40% of the 1929 standard rate or work for twelve months at 33⅓%. Unless consumption shrinks further, the statistical position ought to be improved appreciably by these measures. Prices improved last month although the best figures were not maintained.

Average price of Cash Standard Tin: May, 1932, £122 7s. 6d.; April, 1932, £109 0s. 10d.; May, 1931, £104 8s.; April, 1930, £112 16s. 9d.

LEAD.—This market was easy during May, industrial interest being extremely restricted, while, of course, heavy surplus stocks are held by producing concerns. A fresh attempt, however, is being made to re-establish the International Lead Pool, which used to wield such considerable power as regards prices, and also to secure agreement among producers for a further curtailment in output. It remains to be seen, however, whether these proposals will have any material result, and meanwhile the outlook for the metal, on its own merits, is not particularly encouraging.

Average mean price of soft foreign lead: May, 1932, £10 17s. 1d.; April, 1932, £11 7s. 3d.; May, 1931, £11 12s. 8d.; April, 1931, £12 9s. 9d.

SPELTER.—Although prices have fluctuated, the tendency on balance was easy on the London market during May. The stocks held by the Cartel are shrinking gradually, but some disappointment is felt at the rejection by that organization of the proposal that all members should close for two months. The general situation, in consonance with commodity markets as a whole, is not too reassuring, as demand from consumers remains dull. In the United States, however, mainly as a result of mining curtailment, the price has tended to harden

Average mean price of spelter: May, 1932, £12 11s. 1d.; April, 1932, £11 16s. 3d.; May, 1931, £10 13s. 7d.; April, 1931, £11 11s. 10d.

IRON AND STEEL.—The British pig-iron market was quiet but cheerful during May, as there are expectations that the Government may extend the 33⅓% *ad valorem* duty to imported pig-iron. Cleveland No. 3 foundry remains at 58s. 6d. per ton. Some fresh hematite furnaces are being blown in shortly in anticipation of better demand later on. During the month foreign semis continued to get through the tariff barrier and to compete with home material. Sales of British steel were dull on the whole, but much interest was aroused by a Soviet order for 40,000 tons of steel plates. The Continental steel market is still dull, with prices at extraordinarily low levels.

IRON ORE.—Business continues at a low ebb, as although prices are attractive to many works, their requirements are fully satisfied by deliveries against old contracts, mostly at much higher prices. Best Bilbao rubio is about 15s. per ton c.i.f.

ANTIMONY.—There has been no change in English regulus, which stands at £35 to £42 10s. per ton. Interest in foreign regulus has remained negligible, but prices have recovered a little from the lowest point touched, metal for shipment from China now being quoted at about £18 to £18 5s. c.i.f. Spot is nominally about £24 10s. ex warehouse.

ARSENIC.—Until a decision is made whether arsenic is to be placed on the free list or not demand

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.	Forward.	
	Cash.	3 Months.			Cash.	3 Months.								
May	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	d.	d.	s. d.
11	29 10 0	29 13 1½	34 5 0	—	124 8 9	123 8 9	12 12 6	10 18 9	13 0 0	17 15/16	17 15/16	112 11
12	29 9 4½	29 11 10½	34 5 0	—	121 2 6	123 2 6	12 7 6	10 16 3	12 15 0	17⅛	17½	112 11
13	29 0 7½	29 4 4½	33 15 0	31 5 0	120 17 6	122 12 6	12 7 6	10 15 0	12 15 0	17½	17⅛	113 3
17	28 6 3	28 10 0	33 5 0	31 0 0	119 2 6	121 3 9	12 8 9	10 13 9	12 15 0	17 5/16	17 7/16	113 5
18	28 5 7½	28 9 4½	33 5 0	—	121 10 0	123 13 9	12 10 0	10 16 3	12 15 0	17⅛	17¼	113 2
19	28 9 4½	28 13 1½	32 15 0	—	125 15 0	127 13 9	12 13 9	10 13 9	12 15 0	16 7/8	17	112 11
20	28 1 3	28 3 9	32 15 0	30 10 0	124 16 3	127 1 3	12 15 0	10 10 0	12 10 0	16½	16 13/16	113 3
23	27 11 10½	27 14 4½	32 5 0	—	122 2 6	124 2 6	12 5 0	10 6 3	12 5 0	16⅝	16⅞	112 9
24	27 11 3	27 13 9	32 5 0	30 0 0	123 2 6	125 7 6	12 10 0	10 5 0	12 5 0	16 13/16	16 13/16	112 7
25	27 10 7½	27 11 10½	32 5 0	—	123 8 9	125 13 9	12 2 6	9 18 9	12 0 0	16 15/16	16 15/16	112 8
26	27 9 4½	27 8 1½	32 5 0	—	121 5 0	123 6 3	12 0 0	9 11 3	11 15 0	16⅞	16⅞	112 6
27	27 6 3	27 4 4½	32 0 0	29 15 0	120 17 6	123 3 9	11 18 9	9 15 0	11 15 0	16¾	16¾	112 9
30	26 10 7½	26 9 4½	31 15 0	—	117 7 6	119 12 6	11 16 3	9 15 0	11 15 0	16 13/16	16⅞	112 6
31	25 15 7½	25 15 7½	31 5 0	29 5 0	118 18 9	121 2 6	11 8 9	9 15 0	11 15 0	16 15/16	16 15/16	112 5
June														
1	26 16 3	26 16 3	31 0 0	—	122 3 9	124 8 9	12 1 3	10 5 0	12 5 0	16 15/16	17	112 9
2	26 1 3	26 1 3	30 15 0	—	119 7 6	121 12 6	11 16 3	10 1 3	12 0 0	16 13/16	16 13/16	112 6
3	26 8 9	26 7 6	30 15 0	29 5 0	119 17 6	122 1 3	11 16 3	10 0 0	12 0 0	16 13/16	16⅞	112 6
6	26 17 6	26 17 6	30 15 0	—	—	—	11 17 6	9 15 0	11 15 0	16⅞	16 15/16	112 4
7	26 6 3	26 6 3	31 0 0	29 5 0	115 7 6	117 15 0	11 17 6	9 16 3	11 15 0	16 15/16	17	112 7
8	26 16 10½	26 16 3	31 0 0	—	115 16 3	118 1 3	11 15 0	9 13 9	11 15 0	17	17	113 0
9	26 9 4½	26 5 7½	31 0 0	—	109 7 6	111 17 6	11 7 6	9 8 9	11 10 0	16 15/16	17	112 8

is likely to remain slow. Meanwhile prices are steady at £22 5s. to £22 10s. c.i.f. for high grade Mexican, and £24 10s. f.o.r. mines for 99% Cornish white.

Bismuth.—The official quotation remains at 4s. 6d. per lb., demand being moderate.

Cadmium.—In the absence of any particular inquiry prices have eased to about 2s. per lb.

Cobalt.—Leading interests have further reduced their quotation owing to outside competition, the current figure being 7s. 6d. per lb.

Cobalt Oxides.—About 4s. 3d. per lb. is named for black and 5s. to 5s. 2d. for grey, business being quite moderate.

Chromium.—Current quotations are about 2s. 9d. per lb.

Tantalum.—A quiet business continues at about £25 per lb.

Platinum.—A conference of producers was held recently to determine whether prices should be reduced in an endeavour to stimulate demand, but it was agreed that at the present time sales were not likely to be increased by such a measure. With sterling firmer, however, refined metal has eased somewhat to £9 9s. to £9 15s. per oz.

Palladium.—About £4 to £4 5s. per oz. is quoted, buying interest being very small.

Iridium.—In the absence of any appreciable inquiry sponge and powder have receded to about £12 to £14 per oz.

Osmium.—Dull conditions rule here with prices now about £11 10s. to £13 10s. per oz.

Tellurium.—There is no inquiry and quotations can only be considered nominal.

Selenium.—High grade black powder is in steady request at the unaltered prices of 7s. 8d. to 7s. 9d. per lb. (gold) ex warehouse.

Manganese Ore.—Sales are restricted to small parcels for the Continent, no substantial contracts having been fixed up recently. Prices are not too clearly defined, but best Indian seems to be about 9d. to 9½d. per unit c.i.f., with good 48% Indian and washed Caucasian ore about 8½d. to 9d. c.i.f.

Aluminium.—Demand generally speaking remains light and producers although working at well below full capacity, are still accumulating stocks in certain directions. Prices, however, are without change at £95, less 2% delivered for ingots and bars.

Sulphate of Copper.—There has been quite a good inquiry recently, but with standard copper easier prices have fallen to about £16 15s. to £17 5s. per ton, less 5% for British material.

Nickel.—Business remains slow, but prices are unchanged at £225 to £230 per ton, according to quantity.

Chrome Ore.—Sales are on a much restricted scale, but prices show no change at about 80s. to 85s. per ton c.i.f. for good 48% Rhodesian ore, and 100s. to 110s. c.i.f. for 55 to 57% New Caledonian.

Quicksilver.—Very dull conditions have persisted in this market, accompanied by easier prices. Spot metal is now obtainable at about £14 to £14 15s. per bottle, net.

Tungsten Ore.—The depression in tungsten ore continues unrelieved, forward shipment from China now being obtainable at about 11s. 6d. to 11s. 9d. per unit c.i.f.

Molybdenum Ore.—Although sales are rather few and far between, prices are quotably unchanged at 37s. 6d. to 39s. per unit c.i.f. for 80 to 85% concentrates.

Graphite.—With business still at a low ebb, prices are nominally unaltered at £16 to £18 per ton c.i.f. for 85 to 90% raw Madagascar flake, and £17 to £19 c.i.f. for 90% Ceylon lumps.

Silver.—In the early part of May the market wore a fairly steady appearance, American selling being offset by Continental buying. With the news that President Hoover was considering the question of America receiving payment of War Debts until 1936 in silver, however, sentiment improved, and after standing at 16 1/16d. on May 2, spot bars rose to 17 5/16d. on May 17. Subsequently the Continent turned seller and although India and China were both inclined to buy, the tone on balance was easier, and on May 31 spot bars closed at 16 1/16d.

STATISTICS

PRODUCTION OF GOLD IN THE TRANSVAAL.

	Rand.	Elsewhere.	Total.
	Oz.	Oz.	Oz.
May, 1931	867,949	42,330	910,279
June	855,073	42,677	897,750
July	872,198	44,645	916,843
August	870,822	45,603	916,425
September	872,053	43,971	916,024
October	900,353	44,760	945,113
November	855,102	45,408	900,510
December	877,178	46,175	923,353
January, 1932	890,688	46,096	936,784
February	869,711	44,301	914,012
March	914,017	46,018	960,035
April	901,894	47,902	949,796
May	919,223	46,421	965,644

TRANSVAAL GOLD OUTPUTS.

	April.		May.	
	Treated Tons.	Yield Oz.	Treated Tons.	Yield Oz.
Brakpan	101,000	£154,334	103,000	£155,125
City Deep	83,000	21,282	84,000	21,637
Cons. Main Reef	70,300	23,068	70,300	23,099
Crown Mines	274,000	84,251	280,000	86,522
Daggafontein	38,000	£60,269	41,000	£65,007
D'rb'n Roodepoort Deep	48,500	15,656	50,000	15,613
East Geduld	57,300	17,791	58,700	18,502
East Rand P.M.	157,000	41,786	161,000	42,456
Geduld	84,000	26,895	86,500	27,477
Geldenhuis Deep	64,000	15,076	71,000	16,594
Glynn's Lydenburg	6,500	2,569	5,700	2,540
Government G.M. Areas	207,000	£405,903	208,000	£408,056
Kleinfontein	50,400	9,852	53,300	10,039
Langlaagte Estate	79,000	£110,656	80,000	£112,381
Luipaard's Vlei	34,000	8,504	34,500	8,644
Meyer and Charlton	17,200	£17,482	17,200	£18,166
Modderfontein New	167,000	65,579	171,000	65,651
Modderfontein B	75,000	21,092	77,500	21,853
Modderfontein Deep	44,500	21,574	44,600	21,619
Modderfontein East	73,500	21,580	73,500	21,388
New State Areas	87,000	£179,810	88,000	£181,853
Nourse	70,000	20,774	71,500	21,137
Randfontein	240,000	£283,357	250,000	£291,999
Robinson Deep	93,000	27,106	100,000	28,447
Rose Deep	62,600	12,756	65,000	13,043
Simmer and Jack	78,400	21,528	81,900	21,843
Springs	74,000	£159,696	75,800	£163,191
Sub Nigel	35,800	31,616	37,000	32,426
Transvaal G.M. Estates	18,500	4,963	19,100	5,422
Van Ryn	49,000	£43,473	51,000	£46,029
Van Ryn Deep	69,000	£91,056	69,000	£90,577
West Rand Consolidated	93,000	£104,186	96,500	£106,681
West Springs	74,500	£80,335	75,000	£80,557
Witw'tersr'nd (Knights)	64,000	£53,690	68,000	£55,278
Witwatersrand Deep	43,500	13,368	45,500	14,384

Values in S.A. currency.

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.	£
February, 1931	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	2,698,100	28 0	19 7	8 5	1,140,399
July	2,771,400	27 10	19 6	8 4	1,155,466
August	2,799,800	27 10	19 5	8 5	1,159,382
September	2,765,400	27 10	19 5	8 5	1,162,355
October	2,870,800	27 8	19 3	8 5	1,210,743
November	2,726,720	27 10	19 5	8 5	1,144,208
December	2,793,900	27 10	19 5	8 5	1,173,732
January, 1932	2,880,500	27 5	19 4	8 1	1,163,434
February	2,775,400	27 8	19 6	8 2	1,133,212
March	2,901,300	27 10	19 7	8 3	1,200,278
April	—	—	—	—	1,196,011

NATIVES EMPLOYED IN THE TRANSVAAL MINES.

	Gold Mines.	Coal Mines.	Diamond Mines.	Total.
May 31, 1931	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
August 31	209,409	13,563	1,705	224,677
September 30	209,424	13,276	1,626	224,326
October 31	208,987	13,061	1,517	223,565
November 30	209,270	12,882	1,429	223,581
December 31	211,552	12,260	1,402	225,214
January 31, 1932	215,752	12,394	1,598	229,744
February 29	216,171	12,177	1,363	229,711
March 31	214,024	12,009	—	226,033
April 30	214,334	11,943	—	226,277
May 31	215,926	11,972	—	227,898

PRODUCTION OF GOLD IN RHODESIA.

	1929	1930	1931	1932
	oz.	oz.	oz.	oz.
January	46,231	46,121	45,677	42,706
February	44,551	43,385	42,818	45,032
March	47,388	45,511	42,278	47,239
April	48,210	45,806	43,776	46,487
May	48,189	47,645	43,731	—
June	48,406	45,208	44,118	—
July	46,369	45,810	44,765	—
August	46,473	46,152	43,292	—
September	45,025	46,151	42,846	—
October	46,923	45,006	44,260	—
November	46,219	44,351	44,516	—
December	46,829	46,485	50,034	—

RHODESIAN GOLD OUTPUTS.

	April.		May.	
	Tons.	Oz.	Tons.	Oz.
Cam and Motor	24,800	9,778	24,800	9,783
Globe and Phœnix	6,094	6,343	6,278	6,408
Lonely Reef	8,100	2,488	8,500	2,503
Luiri Gold	1,170	614	—	—
Rezende	6,500	2,590	6,500	2,588
Sherwood Star	4,800	£7,452	4,800	£8,228
Wanderer Consolidated	15,200	3,604	16,700	3,383

WEST AFRICAN GOLD OUTPUTS.

	April.		May.	
	Tons.	Oz.	Tons.	Oz.
Ariston Gold Mines	4,120	£12,441	5,304	£14,676
Ashanti Goldfields	13,590	14,631	13,953	14,611
Taquah and Abosso	9,635	3,644	10,112	3,410

AUSTRALIAN GOLD OUTPUTS BY STATES.

	Western Australia.	Victoria.	Queensland.
	Oz.	Oz.	Oz.
May, 1931	38,255	4,196	784
June	47,507	3,194	893
July	38,785	3,641	1,220
August	52,501	3,020	610
September	38,173	—	638
October	52,741	7,838†	1,031
November	53,869	4,758	1,428
December	49,215	—	1,224
January, 1932	44,037	—	916
February	44,672	—	981
March	47,108	—	—
April	48,936	—	—
May	—	—	—

† Sept. and Oct.

AUSTRALASIAN GOLD OUTPUTS.

	April.		May.	
	Tons.	Value £	Tons.	Value £
Associated G.M. (W.A.)	5,671	5,416	5,432	6,621
Blackwater (N.Z.)	3,442	8,185	—	—
Boulder Persev'ce (W.A.)	7,320	15,646	6,801	14,412
Grt. Boulder Pro. (W.A.)	10,068	23,764	—	—
Lake View & Star (W.A.)	23,555	30,555	—	—
Sons of Gwalia (W.A.)	12,318	15,575	12,138	14,659
South Kalgurli (W.A.)	9,707	16,156	9,183	15,844
Waihi (N.Z.)	18,073	5,287* / 53,547†	18,643	5,251* / 53,664†
Wiluna	27,074	35,210	—	—

* Oz. gold. † Oz. silver.

GOLD OUTPUTS, KOLAR DISTRICT, INDIA.

	April.		May.	
	Tons Ore	Total Oz.	Tons Ore	Total Oz.
Balaghat	3,200	4,245*	1,650	2,225
Champion Reef	8,800	5,161	9,360	5,421
Mysore	16,020	7,523	14,636	7,351
Nundydroog	12,541	7,277	12,583	7,368
Ooregum	11,180	4,356	11,170	4,380

* 2,034 oz. from preliminary clean-up.

MISCELLANEOUS GOLD, SILVER, AND PLATINUM OUTPUTS.

	April.		May.	
	Tons	Value £	Tons	Value £
Bulolo Gold	—	57,000*d*	—	66,000*d*†
Chosen Corp. (Korea)	9,860	17,596	10,640	19,337
Frontino Gold (C'lbia)	3,470	16,777	—	—
Fresnillo	71,596	324*d*	—	—
New Goldfields of Venezuela	7,257	1,997*	6,819	1,638*
Oriental Cons. (Korea)	16,237	91,600*d*	—	—
St. John del Rey (Brazil)	—	37,500	—	41,500
Santa Gertrudis (Mexico)	24,692	40,231*d*	—	—
Viborita	—	—	—	—
West Mexican Mines	1,250	16,500*d*	—	—

d Dollars. * Oz. gold. † To May 22.

PRODUCTION OF TIN IN FEDERATED MALAY STATES.

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

July, 1931	4,757	January, 1932	3,014
August	5,375	February	2,132
September	2,449	March	3,064
October	3,282	April	3,333
November	2,488	May	2,276
December	3,222	June	—

OUTPUTS OF MALAYAN TIN COMPANIES.

In Long Tons of Concentrate.

	March.	April.	May.
Ayer Hitam	119	24	—
Batu Caves	25	16	—
Changkat	47	48	68
Gopeng	60	38	—
Hongkong Tin	78¾	48	—
Idris Hydraulic	29⅜	18½	—
Ipoh	32½	119¾	27
Kampar Malaya	—	—	—
Kampong Lanjut	8	35	30
Kamunting	120½	150	99¼
Kent (F.M.S.)	14⅓	—	—
Killinghall	23	21¼	22½
Kinta	30	11	—
Kinta Kellas	21⅓	23	—
Kramat Tin	105	120	72
Kuala Kampar	32	43	33
Kundang	—	—½	—
Lahat	9½	27½	15½
Lower Perak	—	—	—
Malaya Consolidated	—	—	—
Malayan Tin	107½	95½	54½
Malim Nawar	28	25	25
Pahang	125	125	125
Penawat	—	70	47½
Pengkalen	74⅓	15	—
Petaling	190	169½	—
Rahman	40⅕	40⅕	40⅕
Rambutan	16	—	—
Rantau	48	12½	—
Rawang	40	38	44
Rawang Concessions	40	40	48
Renong	28½	15	19½
Selayang	16⅓	16½	—
Southern Kampar	126	88	—
Southern Malayan	119	107¼	27½
Southern Perak	41⅜	50¼	—
Southern Tronoh	27	42	2⅜
Sungei Besi	33	32½	33
Sungei Kinta	25	34⅜	33⅜
Sungei Way	71½	68⅜	9
Taiping	19	14½	11
Tanjong	45	—	—
Tekka	36	27	—
Tekka-Taiping	45	42½	—
Temoh	—	—	—
Tronoh	43	52	66
Ulu Klang	—	—	—

OUTPUTS OF NIGERIAN TIN MINING COMPANIES.

In Long Tons of Concentrate.

	March.	April.	May.
Anglo-Nigerian	48½	15¼	7½
Associated Tin Mines	235	120	114
Baba River	4½	4½	—
Batura Monguna	3	3	—
Bisichi	38	25	16
Daffo	4	4	—
Ex-Lands	45	41	15
Filani	—	1½	2
Jantar	13	11	13
Jos	13	12⅜	—
Juga Valley	8	8	8
Kaduna Syndicate	16⅜	17	—
Kaduna Prospectors	9	8	—
Kassa	11	5½	4½
London Tin	135	145	48
Lower Bisichi	⅜	⅜	—
Naraguta Extended	—	—	—
Nigerian Consolidated	7	7	7
Offin River	2⅜	5	—
Ribon Valley	17	13	4
Tin Fields	—	—	—
United Tin Areas	24	18	—
Yarde Kerri	—	—	—

OUTPUTS OF OTHER TIN MINING COMPANIES.

In Long Tons of Concentrate.

	March.	April.	May.
Anglo-Burma (Burma)	18⅜	17½	12¾
Aramayo Mines (Bolivia)	141	132	106
Bangrin (Siam)	38½	42	57
Beralt	31*	28½*	29*
Consolidated Tin Mines (Burma)	103	95	82
East Pool (Cornwall)	48	49⅜	—
Fabulosa (Bolivia)	47†	45†	43†
Kagera (Uganda)	24	26	—
Kamra	—	—	—
Malaysiam Tin	8½	8½	8½
Mawchi	225*	236*	—
Patino	813	813	—
Pattani	—	—	—
San Finx (Spain)	—	—	—
Siamese Tin (Siam)	100	147	92½
South Crofty	54	59	50⅜
Tavoy Tin (Burma)	46	50	73¼
Tongkah Harbour (Siam)	54	43	35
Toyo (Japan)	77½	81⅜	80
Zaaiplaats	14½	15½	—

* Tin and Wolfram. † Tons fine tin.

COPPER, LEAD, AND ZINC OUTPUTS.

		April.	May.
Britannia Lead	Tons refined lead	4,230	—
	Oz. refined silver	215,412	—
Broken Hill South	Tons lead conc.	5,114	4,425
	Tons zinc conc.	5,454	4,296
Burma Corporation	Tons refined lead	5,880	5,880
	Oz. refined silver	520,795	520,876
Electrolytic Zinc	Tons zinc	—	—
Indian Copper	Tons copper	370	370
Messina	Tons copper	818	823
Mount Isa	Tons lead bullion	3,358	—
Mount Lyell	Tons concentrates	3,573*	3,639†
North Broken Hill	Tons lead conc.	4,870	—
	Tons zinc conc.	4,480	—
Rhodesia Broken Hill	Tons V_2O_5	30	32
	Tons V_2O_5 conc.	100	100
Roan Antelope	Tons concentrates	—	—
	Tons blister copper	2,113	1,972
San Francisco Mexico	Tons lead conc.	—	—
	Tons zinc conc.	—	—
Trepca	Tons lead conc.	3,391	4,284
	Tons zinc conc.	4,659	6,276
Villemagne	Tons lead conc.	—	—
	Tons zinc conc.	—	—
Zinc Corporation	Tons lead conc.	5,298	5,539
	Tons zinc conc.	3,394	3,637

* To April 20. † To May 18.

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

		March.	April.
Iron Ore	Tons	202,671	137,898
Manganese Ore	Tons	6,382	11,046
Iron and Steel	Tons	130,174	144,535
Copper and Iron Pyrites	Tons	19,068	52,265
Copper Ore, Matte, and Prec.	Tons	2,257	1,576
Copper Metal	Tons	10,401	8,710
Tin Concentrate	Tons	5,688	5,307
Tin Metal	Tons	675	276
Lead Pig and Sheet	Tons	19,987	17,030
Zinc (Spelter)	Tons	13,437	5,880
Zinc Sheets, etc.	Tons	1,375	472
Zinc Oxide	Tons	52	73
Zinc Ore	Tons	7,608	6,742
Aluminium	Tons	531	184
Mercury	Lb.	204,253	57,852
White Lead	Cwt.	5,686	3,714
Barytes, ground	Cwt.	10,228	14,427
Asbestos	Tons	1,067	2,143
Boron Minerals	Tons	751	454
Borax	Cwt.	16,998	24,771
Basic Slag	Tons	1,192	1,930
Superphosphates	Tons	9,274	7,930
Phosphate of Lime	Tons	31,992	24,232
Mica	Tons	217	148
Tungsten Ores	Tons	206	405
Sulphur	Tons	4,433	8,131
Nitrate of Soda	Cwt.	69,300	—
Potash Salts	Cwt.	203,917	124,534
Petroleum : Crude	Gallons	15,456,328	24,626,505
Lamp Oil	Gallons	24,109,167	23,218,161
Motor Spirit	Gallons	63,877,973	78,166,958
Lubricating Oil	Gallons	7,225,260	12,735,463
Gas Oil	Gallons	13,396,134	9,492,979
Fuel Oil	Gallons	33,378,478	44,255,168
Asphalt and Bitumen	Tons	13,373	12,093
Paraffin Wax	Cwt.	135,785	87,946

OUTPUTS REPORTED BY OIL-PRODUCING COMPANIES.

In Tons.

	March.	April.	May.
Anglo-Ecuadorian	16,057	16,766	17,113
Apex Trinidad	43,310	45,170	44,670
Attock	1,493	1,489	2,626
British Burmah	4,169	3,935	3,691
British Controlled	44,231	46,362	44,289
Kern Mex	1,109	1,008	1,091
Kern River (Cal.)	2,529	2,296	2,358
Kern Romana	174	194	178
Kern Trinidad	3,685	2,530	1,845
Lobitos	23,406	24,004	24,809
Phœnix	58,501	68,787	68,380
St. Helen's Petroleum	4,987	4,793	5,208
Steaua Romana	88,677	89,930	91,182
Tampico	2,893	2,738	2,891
Tocuyo	1,270	981	1,283
Trinidad Leaseholds	27,050	25,600	31,050

QUOTATIONS OF OIL COMPANIES' SHARES.

Denomination of Shares £1 unless otherwise noted

	May 10, 1932.			June 9, 1932.		
	£	s.	d.	£	s.	d.
Anglo-Ecuadorian		6	0		5	6
Anglo-Egyptian B.	1	5	0	1	0	0
Anglo-Persian 1st Pref.	1	4	6	1	2	6
,, ,, Ord.	1	13	9	1	4	6
Apex Trinidad (5s.)		11	3		9	9
Attock		9	3		10	0
British Burmah (8s.)		3	9		3	6
British Controlled ($5)		1	3			10
Burmah Oil	2	3	9	1	18	0
Kern River Cal. (10s.)		1	9		1	6
Lobitos, Peru	1	3	0	1	1	3
Mexican Eagle, Ord. (4 pesos)		6	0		5	0
,, ,, 8% Pref. (4 pesos)		6	0		5	0
Phœnix, Roumanian		4	0		3	0
Royal Dutch (100 fl.)	13	10	0	12	12	6
Shell Transport, Ord.	1	14	3	1	10	6
,, ,, 5% Pref. (£10)	10	0	0	10	0	0
Steaua Romana		4	3		4	0
Trinidad Leaseholds	1	7	6	1	8	6
United British of Trinidad (6s. 8d.)		2	3		1	9
V.O.C. Holding	1	1	3		18	0

PRICES OF CHEMICALS. June 9.

These quotations (some of which are affected by the devaluation of the pound sterling) are not absolute; they vary according to quantities required and contracts running.

		£	s.	d.
Acetic Acid, 40%	per cwt.		19	9
,, 80%	,,	1	16	5
,, Glacial	per ton	59	0	0
Alum	,,	8	7	6
Aluminium Sulphate, 17 to 18%	,,	6	15	0
Ammonium, Anhydrous	per lb.		1	0
,, 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.	,,	7	0	0
Antimony, Tartar Emetic, 43/44%	per lb.			10
,, Sulphide, golden	,,			9
Arsenic, White (foreign)	per ton	24	10	0
Barium, Carbonate (native), 94%	,,	4	10	0
,, Chloride	,,	10	10	0
Barytes	,,	8	5	0
Benzol, standard motor	per gal.		1	4
Bleaching Powder, 35% Cl.	per ton	8	15	0
Borax	,,	16	10	0
Boric Acid	,,	26	10	0
Calcium Chloride, solid, 70/75%	,,	5	15	0
Carbolic Acid, crude 60's	per gal.		1	7
,, ,, crystallized, 40°	per lb.			6½
Carbon Disulphide	per ton	30	0	0
Citric Acid	per lb.		1	0½
Copper Sulphate	per ton	16	5	0
Creosote Oil (f.o.b. in Bulk)	per gal.			5
Cresylic Acid, 98-100%	,,		1	4
Hydrofluoric Acid, 59/60%	per lb.			6
Iodine	per lb.	1	0	4
Iron, Nitrate 80° Tw.	per ton	6	0	0
,, Sulphate	,,	2	0	0
Lead, Acetate, white	,,	35	0	0
,, Nitrate (ton lots)	,,	27	10	0
,, Oxide, Litharge	,,	27	10	0
,, White	,,	37	10	0
Lime, Acetate, brown	,,	7	0	0
,, ,, grey, 80%	,,	11	10	0
Magnesite, Calcined	,,	8	5	0
Magnesium Chloride	,,	5	10	0
,, Sulphate, comml.	,,	4	10	0
Methylated Spirit Industrial 61 O.P.	per gal.		2	0
Nitric Acid, 80° Tw.	per ton	23	0	0
Oxalic Acid	per cwt.	2	7	0
Phosphoric Acid. (Conc. 1 750)	per lb.			10
Pine Oil	per cwt.	2	7	6
Potassium Bichromate	per lb.			5
,, Carbonate, 96/98%	per ton	31	0	0
,, Chlorate	per lb.			4
,, Chloride 80%	per ton	12	10	0
,, Ethyl Xanthate	per 100 kilos	7	0	0
,, Hydrate (Caustic) 88/90%	per ton	40	0	0
,, Nitrate	,,	31	0	0
,, Permanganate	per lb.			8½
,, Prussiate, Yellow	,,			8½
,, ,, Red	,,		2	0
,, Sulphate, 90%	per ton	14	10	0
Sodium Acetate	,,	21	0	0
,, Arsenate, 45%	,,	20	10	0
,, Bicarbonate	,,	10	10	0
,, Bichromate	per lb.			4
,, Carbonate (Soda Ash) 58%	per ton	6	0	0
,, ,, (Crystals)	,,	5	5	0
,, Chlorate	,,	28	10	0
,, Cyanide 100% NaCN basis	per lb			8
,, Ethyl Xanthate	per 100 kilos	6	12	6
,, Hydrate, 76%	per ton	14	10	0
,, Hyposulphite, comml.	,,	9	2	6
,, Nitrate (ordinary)	,,	9	0	0
,, Phosphate, comml.	,,	13	10	0
,, Prussiate	per lb.			5
,, Silicate	per ton	9	10	0
,, ,, (liquid, 140° Tw.)	,,	8	10	0
,, Sulphate (Glauber's Salt)	,,	2	15	0
,, ,, (Salt-Cake)	,,	3	1	0
,, Sulphide Conc., 60/65%	,,	10	15	0
,, Sulphite, pure	per cwt.		14	0
Sulphur, Flowers	per ton	10	10	0
,, Roll	,,	10	0	0
Sulphuric Acid, 168° Tw.	,,	4	5	0
,, ,, free from Arsenic, 140° Tw.	,,	3	0	0
Superphosphate of Lime (S.P.A. 16%)	,,	3	5	0
Tartaric Acid	per lb.		1	0½
Turpentine	per ton	60	0	0
Tin Crystals	per lb.		1	0
Titanous Chloride	,,			10½
Zinc Chloride	per ton	9	10	0
Zinc Dust, 90/92%	,,	20	0	0
Zinc Oxide (White Seal)	,,	35	0	0
Zinc Sulphate	,,	8	10	0

SHARE QUOTATIONS

Shares are £1 par value except where otherwise noted.

GOLD AND SILVER:	May 10, 1932. £ s. d.	June 9, 1932. £ s. d.
SOUTH AFRICA:		
Brakpan	3 15 0	3 12 0
City Deep	5 0	4 6
Consolidated Main Reef	1 1 0	1 1 0
Crown Mines (10s.)	5 10 0	5 1 3
Daggafontein	2 8 9	2 7 6
Durban Roodepoort Deep (10s.)	17 9	18 0
East Geduld	2 18 0	2 19 0
East Rand Proprietary (10s.)	12 9	11 3
Geduld	4 3 9	4 3 9
Geldhenbuis Deep	10 0	11 0
Glynn's Lydenburg	6 3	6 3
Government Gold Mining Areas (5s.)	1 15 0	1 13 9
Grootvlei	1 1 3	1 0 0
Langlaagte Estate	1 0 0	17 6
Meyer & Charlton	1 7 6	1 10 0
Modderfontein New (10s.)	2 7 6	2 10 0
Modderfontein B (5s.)	11 3	11 3
Modderfontein Deep (5s.)	16 6	17 6
Modderfontein East	1 15 0	1 16 3
New State Areas	2 10 6	2 11 3
Nourse	15 6	15 0
Randfontein	1 7 3	1 6 9
Robinson Deep A (1s.)	15 0	15 6
" B (7s. 6d.)	9 3	9 9
Rose Deep	5 9	5 3
Simmer & Jack (2s. 6d.)	3 6	3 4
Springs	3 12 0	3 15 0
Sub Nigel (10s.)	4 1 3	4 3 9
Van Ryn	11 0	11 3
Van Ryn Deep	1 0 0	1 0 6
Village Deep (9s. 6d.)	2 6	2 6
West Rand Consolidated (10s.)	11 9	11 9
West Springs	12 3	13 3
Witwatersrand (Knight's)	7 0	7 0
Witwatersrand Deep	6 0	5 6
RHODESIA:		
Cam and Motor	1 11 3	1 16 3
Gaika	3 6	3 6
Globe and Phœnix (5s.)	14 0	15 6
Lonely Reef	15 0	15 0
Mayfair	4 6	4 6
Rezende	1 6 3	1 10 0
Shamva	1 0	1 0
Sherwood Starr (5s.)	14 6	14 6
GOLD COAST:		
Ashanti (4s.)	1 10 6	1 9 0
Taquah and Abosso (5s.)	5 0	5 6
AUSTRALASIA:		
Golden Horseshoe (4s.) W.A.	3 9	4 0
Great Boulder Propriet'y (2s.), W.A.	3 0	6 9
Lake View and Star (4s.), W.A.	10 0	10 6
Sons of Gwalia, W.A.	9 6	8 9
South Kalgurli (10s.), W.A.	17 0	18 0
Waihi (5s.), N.Z.	14 6	13 6
Wiluna Gold, W.A.	19 0	16 6
INDIA:		
Balaghat (10s.)	9 2	8 9
Champion Reef (10s.)	8 9	11 6
Mysore (10s.)	8 6	9 0
Nundydroog (10s.)	18 6	1 0 9
Ooregum (10s.)	3 0	4 6
AMERICA:		
Camp Bird (2s.), Colorado	2	3
Exploration (10s.)	1 0	1 0
Frontino and Bolivia, Colombia	17 0	18 0
Mexican Corporation, Mexico (10s.)	2 6	2 6
Mexico Mines of El Oro, Mexico	2 0	2 0
St. John del Rey, Brazil	18 6	18 0
Santa Gertrudis, Mexico	4 3	5 0
Selukwe (2s. 6d.), British Columbia	1 4	1 3
MISCELLANEOUS:		
Chosen, Korea	3 0	3 0
Lena Goldfields, Russia	3	6

COPPER:		
Bwana M'Kubwa (5s.) Rhodesia	2 3	1 6
Esperanza Copper	13 9	13 9
Indian (2s.)	1 0	0 9
Loangwa (5s.), Rhodesia	1 3	1 3
Luiri (5s.), Rhodesia	2 3	2 0
Messina (5s.), Transvaal	4 0	3 0
Mount Lyell, Tasmania	15 6	13 9
Namaqua (£2), Cape Province	3 0	3 0
Rhodesia-Katanga	10 0	10 0
Rio Tinto (£5), Spain	12 15 0	11 0 0
Roan Antelope (5s.), Rhodesia	5 6	4 6
Tanganyika Con.	15 0	12 6
Tharsis (£2), Spain	2 7 6	2 1 3

LEAD-ZINC:	May 10, 1932. £ s. d.	June 9, 1932. £ s. d.
Amalgamated Zinc (8s.), N.S.W.	5 6	6 3
Broken Hill Proprietary, N.S.W.	11 6	12 9
Broken Hill, North, N.S.W.	2 7 6	2 5 0
Broken Hill South, N.S.W.	1 11 3	1 12 6
Burma Corporation (10 rupees)	7 9	7 0
Electrolytic Zinc Pref., Tasmania	16 3	16 3
Mount Isa, Queensland	7 9	7 6
Rhodesia Broken Hill (5s.)	9	9
San Francisco (10s.), Mexico	5 6	5 0
Sulphide Corporation (15s.), N.S.W.	7 0	6 0
ditto, Pref.	9 0	7 6
Zinc Corporation (10s.), N.S.W.	1 3 0	18 9
ditto, Pref.	2 15 0	2 15 0

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

DIAMONDS:		
Consol. African Selection Trust (5s.)	5 0	5 0
Consolidated of S.W.A. (10s.)	1 3	1 9
De Beers Deferred (£2 10s.)	2 16 3	2 0 0
Jagersfontein	13 9	11 3
Premier Preferred (5s.)	1 0 0	15 0

FINANCE, ETC.:		
Anglo-American Corporation (10s.)	5 0	4 6
Anglo-French Exploration	8 0	7 6
Anglo-Continental (10s.)	2 0	2 0
Anglo-Oriental (Ord., 5s.)	6 9	6 0
ditto, Pref.	7 9	6 0
British South Africa (15s.)	16 9	14 9
Central Mining (£8)	9 5 0	7 15 0
Consolidated Gold Fields	1 0 0	18 9
Consolidated Mines Selection (10s.)	4 0	3 6
Fanti Consols (8s.)	6 6	5 0
General Mining and Finance	15 0	13 9
Gold Fields Rhodesian (10s.)	3 0	2 9
Johannesburg Consolidated	1 0 6	19 0
London Tin Corporation (10s.)	8 6	7 0
Minerals Separation	2 2 6	2 2 6
National Mining (8s.)	3	3
Rand Mines (5s.)	3 7 0	3 3 9
Rand Selection (5s.)	6 3	5 6
Rhodesian Anglo-American (10s.)	5 6	4 0
Rhokana Corp.	2 15 0	2 2 6
Rhodesian Selection Trust (5s.)	4 0	3 0
South Rhodesia Base Metals	2 0	2 0
Tigon (5s.)	2 6	1 6
Union Corporation (12s. 6d.)	2 8 0	2 1 3
Venture Trust (10s.)	4 0	3 6

THE MINING DIGEST

A RECORD OF PROGRESS IN MINING, METALLURGY, AND GEOLOGY

In this section abstracts of important articles and papers appearing in technical journals and proceedings of societies are given, 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.

MILLING OF GOLD ORES

The choice of a mill for the small gold mine is discussed by J. A. Baker in *Mining and Metallurgy* for May and extracts from his article are given here. The author, after examining the preliminary stages in the opening up of a particular property, goes on to show the extreme importance of estimating mill costs and extractions correctly in order to set up a small enterprise on a sound basis. He says that the small operator cannot always achieve immediately the high extractions secured in well established enterprises. The quantity and grade of the ore, its amenability to various recovery methods and the pocketbooks of the owners are all factors that influence the size and design of the mill. Unless these factors are properly correlated, the results may well be unfortunate and involve needless risk of capital. The author then studies several types of gold recovery operations employing different processes in order to get a general picture of operating costs, recoveries, and capital expenditures. Gold is about six times as heavy as quartz and so is easily concentrated at the bottom of traps, sumps, elevator boots, classifiers, or wherever the rate of flow of pulp is retarded and some dead space exists. The rough surfaces of blankets and the depressions in corduroy cloth are particularly efficient retainers of gold, both coarse and fine, when the proper conditions of velocity and dilution of pulp are provided. Almost equally well known is another important physical property of gold, namely its ability to amalgamate with mercury. For this operation, clean surfaces are necessary. The cyanide process, involving the solution of gold and silver in dilute solutions of sodium or potassium cyanide, has come into wide use and has reached a high state of perfection. The recovery of gold by its solution as gold chloride after contact with nascent chlorine may be dismissed briefly. It is feasible technically and commercially, but it is interior to the cyanide process. It is not used today nor do any trends point to its revival.

The application of the flotation process to the recovery of gold and silver is the truly new development in this art. Its technique is not fully developed, but results are favourable enough to show that it has an important place. Enthusiasts claim that it will eventually revolutionize the treatment of all gold ores. This is probably too broad a claim, but on some ores, refractory to previous methods, flotation appears to promise results that change their commercial aspect entirely for the better. This success depends on the fact that modern flotation reagents have a strong selective action on free gold particles as well as on the sulphide, arsenide, or telluride particles with which the gold is commonly associated. It is thus possible to obtain relatively cheaply a froth or concentrate containing in small bulk a large proportion of the gold in the original ore.

Amalgamation Process.—Amalgamation should not be overlooked by the small producer for it affords the simplest and cheapest method of recovering the free gold content of an ore in the form of easily-marketed bullion. The ore must first be crushed finely enough to liberate the gold particle completely from the other ore minerals. A particle of gold attached to a piece of quartz will not amalgamate, but will be carried out with the tailing. The standard machine up to a few years ago for crushing gold ores was the gravity stamp. The crushed ore flows over a broad area of gently sloping copper plates coated with mercury.

No matter how much care and skill is used, all the gold in the ore will not be extracted by amalgamation. The percentage extracted may vary from 90 in clean quartz ores containing coarse gold to 50% or less in ores containing sulphides in appreciable amounts. For the former type, the quick-dropping California type of stamp with outside amalgamation plates was, and still is, good practice. The slow drop, high-lift Gilpin County stamp, relying mainly on inside amalgamation, was developed for sulphide ores more difficult to amalgamate and is practically obsolete. In both types a screen is used in front of the stamps to determine the fineness of crushing. If grinding finer than 20 or 30 mesh is necessary to liberate the gold, the capacity per stamp becomes very low and the screens require frequent cleaning and renewal; also the tendency is to produce a large amount of slime, which is prejudicial to amalgamation as it forms a coating or film around the particle of fine gold.

Experience in crushing large tonnages of copper and similar ores has indicated the advantages of the ball-mill, close-circuited with a classifier, for intermediate grinding. No screens are used. The ball-mill discharges an unfinished product either directly to the classifier or to the plates and then to the classifier. The classifier rake product is returned to the grinding unit and the overflow is considered to be suitably ground. The degree of fineness in the overflow can be regulated by suitable adjustments. A product crushed to 35, 48, 65, or 80 mesh can be readily produced without undue over-grinding or fine screening troubles. The advantages of the ball-mill-classifier grinding system over stamps are even more marked when the direct flotation of gold ores is employed. This grinding practice has been used successfully in the 25-ton amalgamation mill of the Porcupine United Gold Mines. The ore consists of quartz with fine stringers of mineralized schist or of stringers of quartz in schist accompanied by pyrite and often containing visible gold. It averages about $11 per ton in gold. The table concentrate is sold to an affiliated company and treated in its cyanide plant. In this respect the property is

fortunate as a product of this grade will rarely stand shipment to the smelter. Although amalgamation extracts 75% of the gold in the ore, only 40% of this is caught on the plates, with the barrel treatment of blanket concentrates accounting for 35%.

The grinding is to approximately 48 mesh, finer than feasible in a stamp battery. Since the grinding circuit carries a 125 per cent circulating load and the amalgamation surfaces are in series with the circuit, the tonnage passing over the plates and blankets is actually 2¼ times the feed tonnage to the mill or, in effect, every gold-bearing particle has a double chance to be caught by the mercury.

The mill described would cost close to $25,000 to reproduce, and, on this assumption, it will require 2½ years to repay its first cost on the basis of the cost figures assumed. This appears to prove that mining 25 tons daily of $11 ore, even under the favourable conditions of the Porcupine district, is a border-line proposition from a business viewpoint, which any able local operator would admit without proof. The mill recovers $9·20 per ton at a cost of $1·85. On 7,500 tons per year, this amounts to $55,125. Thus the mill has paid for itself in less than a year and has contributed substantially toward reducing development charges on the ore blocked out underground.

The mine is in the development stage so all expenditures can be considered capital charges. If at the end of three years 100,000 tons of ore are developed and conditions warrant building a 150-ton cyanide plant, the total out-of-pocket expenditures will be less by about $140,000 by reason of the operation of the small mill. This illustrates the close relationship between the mill, mine development and the financing of an enterprise in its early stages. Evidently, a distinction must be made between a small commercial mill and a pilot mill at a mine having potentialities for larger scale operation. If the pilot mill is too large, the labour of supplying ore may slow up development and hence defeat the original purpose.

By comparison the results of the operation of a 10-stamp mill in California are interesting. The gold is coarser and contains less pyrite than Porcupine ores. It contains $12 per ton gold and by crushing to pass 20 mesh, 85% is extracted on the plates. Equipment consists of a 10 by 8 jaw crusher, ore bin, two Challenge feeders, ten 1,050-lb. stamps, two amalgamation plates 4 ft. wide by 12 ft. long, amalgam traps, and two Wilfley tables. The tables make a small amount of concentrate assaying about $60 per ton. This is being stacked as there is little profit in shipping it to the smelter. The mill is operated by one man per shift and treats 25 tons per day at a cost of $1·30 per ton for direct charges. The mill, with power plant and water-supply system, cost $20,000 to build. Mining costs are somewhat lower than Ontario and over-all costs work out about as follows: Mining, $4·50 per ton; milling, $1·30; general, $1·00; or a total of $6·80 per ton. Recovery of 85% of $12 is $10·20, so the operating profit is $3·40 per ton, or $25,500 per year on 7,500 tons. This is definitely a good business proposition if the ore reserves are reasonable.

An illustration of a milling operation combining low cost and high extraction is that of the Granada Mines in the Rouyn district in Quebec. The ore is crushed and rolled to minus 1 in. This product is crushed to 35 to 40 mesh in a 6 by 5 ball-mill in closed circuit with a classifier. After passing a coarse-gold trap the pulp passes over two 4 by 14-ft. blanket strakes, from which concentrate is recovered. The sandy portion of the pulp is then removed by a 4-ft. 6-in. classifier and returned to the ball-mill. The classifier overflow (40 mesh) is treated in four more 4 by 14-ft. blanket strakes, the tailing from which goes to waste. The mill has a capacity of 80 tons per 24 hours, the ore carrying about $10 gold per ton. Blankets are cleaned several times per shift. The concentrate, amounting to 800 lb. per day, is ground with lime and mercury in a 3 by 4-ft. amalgamation barrel. The amalgam is retorted in the usual manner and the residues are sold to the Noranda smelter. Tailing from the blankets is reported to run to 10 c. gold per ton, a very remarkable result considering the simple treatment employed. It would appear that the gold particles must be relatively coarse, even though they are associated with the sulphide mineral in a way to interfere with regular plate amalgamation. No official cost figures are available, but first cost might be estimated at between $40,000 and $50,000 and operating cost around $1 per ton. With normal mining costs, this mill probably paid for itself in less than six months' time. Unusual results of this kind show the danger of making any generalizations on the treatment of gold ores.

Cyanide Process. — Although amalgamation works best on coarse gold, cyanide solutions work most effectively, and quickly, on fine gold although in the dilute solutions used hours of contact are required. Since amalgamation recovers coarse gold and cyanidation fine gold, the two processes are supplementary, and amalgamation followed by cyanidation is used in many of the largest gold mines. When amalgamation is used the possibility of the theft of amalgam always exists, which has led some mills to abandon it and to rely entirely on cyaniding. When all-cyaniding is used, the ore is usually crushed in cyanide solution and the use of grinding-mill-classifier combination retains the coarse gold automatically in the grinding circuit until it is ground fine enough to be readily dissolved. It is then possible to separate the sand and slime by classification and leach the former in large vats with porous bottoms, while the latter are treated in agitators followed by a suitable combination of thickeners and filters to recover the dissolved gold.

More often, however, the "all-sliming" method is used in which all the ore is crushed to a mesh where it can be handled in agitators. An excellent example of a small mill using this process is that at the Elko Prince mine in Nevada. The ore is a hard, brittle quartz, containing less than 2% sulphides. It contained $12 to $20 in gold and 10 oz. silver per ton. The mill had a capacity of 40 tons per day. It employed "all-sliming" using a ball-mill and a tube-mill in closed circuit with a classifier to produce a pulp of 5% plus 150 mesh and 82% minus 200 mesh. After agitation the pulp was washed by decantation in thickeners followed by a filter. An extraction of 97% of the gold and 87% of the silver was obtained.

The mill and refinery cost $70,000. The thorough treatment given makes both mill construction and operating costs look high in comparison with amalgamation mills. These costs were warranted by the complete extraction obtained on a rich ore. The mine was fully developed and the ore thoroughly tested before the mill was built so that

the element of risk, as far as concerned the investment of capital in mill construction, was small. The average value of gold and silver recovered per ton treated was $20·74. Costs (this was fifteen years ago), were $3·12 per ton for mining; $3·02 for milling; $1 estimated for development; and the same for general expenses; or a total of $8·14 per ton. The profit per ton was $12·60 which, on the basis of 1,000 per tons per month, returned the first cost of the mill in less than six months. The small all-sliming cyanide plant was a sound a profitable investment. In a location favoured with cheaper power and better transport, these costs would have been reduced about 20%. However, it is quite clear that this type of treatment is not adapted to a low-grade ore.

It is not always necessary to resort to fine grinding with its attendant higher operating cost per ton. The results at the Howey Gold Mines in the Patricia district, western Ontario, show a successful operation with 40 mesh grinding which also avoids separate treatment of sand and slime and the consequent complications attendant upon the operation of leaching vats in a cold climate. This plant treats 500 to 600 tons of $5 ore per day at a cost of $0·81 per ton. It embodies skilful adaptation of well-known methods in a simple flowsheet.

Given an ore that responds well to cyanidation at a coarse mesh and carries $8 to $9 in gold per ton, the economies of a 100-ton pilot mill appear attractive both from a first cost and operating standpoint since the same principles can be employed with either a smaller or larger tonnage. Operating costs of less than $1·50 per ton may be expected and first cost should not exceed $1,000 per ton of daily capacity.

The cyanide process can be effectively employed on very low-grade surface ores mined by open-cut or glory-hole methods. Oxidized gossans are porous by nature and often permit leaching at a relatively coarse mesh. Sometimes crushing to 10 mesh, followed by removal of a low-grade slime by classification, and leaching of the sand, comprising about 80% of the original ore, has yielded good results. An excellent example is the gossan deposit of the Mountain Copper Co. in Shasta County, California. This gossan is the leached outcrop of a large sulphide ore-body. It contains about $2 in gold per ton, 0·4% copper, a little arsenic and mercury, 50 to 55% iron, and 10% silica. It is porous and friable, so can be bulk-leached after cruching to ⅜ in. The present plant treats 540 tons per day and cost $75,000 to build. Quarry equipment cost about $25,000.

A 500-ton-per-day operation is not a small gold mill and the ore could not be handled profitably on a scale of 50 to 100 tons per day. This is true, but from the business man's viewpoint the capital expenditure is a better measure of the size of operation than the number of tons treated. Here the sum involved for equipment was not far different from that required for the mine and mill equipment on a 50 or 75-ton daily basis for many underground mines.

Flotation Process.—In view of the excellent results obtainable by cyanidation, it is not surprising that the application of flotation to gold ores has made relatively slow progress compared with its advance in the field of base metals. Early experiments with the flotation of precious metal ores, using coal tar, creosotes and similar reagents, gave viscous froths and poor recoveries. The advent of chemical promoters of definite chemical composition, such as the xanthates and the dithio-phosphates, has changed this situation and flotation is now being widely used with highly successful results. With modern reagents, it is possible to get high ratios of concentration and high recoveries as well. In general, floating auriferous sulphides is not different from floating the same sulphides without the gold. Metallic gold, if not too coarse, is easy to float with the reagents mentioned. Arsenopyrite is often a carrier of gold and yet it is seldom associated with base-metal ores. This mineral is more difficult to float than pyrite. The latter can, if desirable, be removed first. A little copper sulphate or sodium sulphide is often helpful in bringing up the arsenopyrite.

Intense agitation, a high water level, and the rapid removal of a thin froth are typical of most gold flotation operations. A marked feature is the very small amount of reagent required. Where the floatable minerals are only a small fraction of the feed and the ratio of concentration is high, a counter-current operation, permitting a recleaning of the froth, is desirable. Evidence indicates that lime has a depressing effect on the free gold, so soda ash is commonly used to neutralize acid constituents in the ore. By both amalgamation and cyanidation the gold will ultimately be produced as doré bullion. Flotation produces a relatively high-grade concentrate, the gold content of which will depend on the nature of the ore. This concentrate will require further treatment, usually by cyanidation, so flotation is an auxiliary rather than a complete process.

Where the mine is not far from a smelter, flotation may be an auxiliary to smelting. From the mine operators' viewpoint, only one hydro-metallurgical process is involved and flotation is a complete treatment. An example of this is the Spring Hill mine of the Montana Mines Corp. near Helena, Mont. The gold is very fine and is intimately associated with sulphides in the presence of arsenic and antimony minerals. Cyaniding proved unprofitable. The ore is ground in ball-mills, close-circuited with classifiers, to 83% minus 200 mesh. The classifier overflow goes direct to M. S. flotation cells and the froth is settled, filtered and shipped by truck to the East Helena smelter. Where the flotation concentrate is rich, as it is sometimes, it will stand shipment for considerable distances.

Some of the more common combinations of flotation and other methods of treatment are given below:—

(1) Flotation followed by cyaniding the concentrate, with or without roasting.—Where the gold exists as a telluride and therefore requires roasting, flotation followed by roasting of the small tonnage of concentrate and cyanidation of the calcine is a happy solution of a difficult problem. This practice is used at the Wiluna mine in Australia, where the high cost of fuel makes unattractive the roasting of raw ore of medium grade. Here flotation has proved a definite stimulus to gold production.

At the McIntyre Mine in the Porcupine district of Ontario, practice at the raw mill consists of closed-circuit grinding in ball-mills and Dorr classifiers followed by flotation in Fahrenwald machines. The concentrate is reground and cyanided. An operating saving is made by discarding a large tonnage of tailing at a coarse mesh, and thus subjecting only a small portion of the original ore to the more expensive final treatment.

A small mine in California treats 100 tons per day of quartz gold ore in which 10% of the gold is free and the remainder associated with the pyrite. The ore is ground to all minus 60 mesh in a ball-mill close-circuited with a classifier and is then floated at 36% solids in an 8-cell Kraut machine. Average results are: Feed, $12·50 gold per ton; concentrate, $58·00; tailings, $0·36; with a recovery of 97%. The only reagents used are: Aerofloat No. 301, 0·001 lb. per ton; and steam-distilled pine oil, 0·120 lb. per ton. Reagent cost in gold flotation here usually runs from $0·04 to $0·08 per ton of ore treated. The concentrate, amounting to about 20 tons, is reground and cyanided.

(2) Flotation followed by cyaniding both the flotation tailing and concentrate.—This flowsheet is to be used at the Lake Shore Mines, Kirkland Lake, Ont., for the removal of sulpho-telluride gold minerals which are resistant to cyaniding. The tailing will require less thorough cyanide treatment. The small bulk of flotation concentrate will be cyanided with intensive agitation, very strong cyanide solution and heavy liming. The net results will be increased extraction of about $1 per ton.

A similar practice is used at the Portland Gold Mining Co., Victor, Colo., except that flotation is here carried out in cyanide solution—an unusual practice—whereas Lake Shore will grind and float in water. Flotation ahead of cyaniding is also of value in removing cyanicides such as stibnite and sulph-antimonates.

(3) Amalgamation followed by flotation of the tailings.—This flowsheet is coming into quite general use on the Mother Lode in California. One property is treating pyritic quartz ore in which approximately 65% of the total gold is free. After stamping to 20 mesh and amalgamating, the tailing is reground, thickened, and floated, using the following reagents: Copper sulphate, 0·01 lb. per ton; American Cyanamid reagent No. 208, 0·002; amylxanthate, 0·002; and cresylic acid, 0·15 lb. per ton. Concentrate is shipped to the smelter. The average assays are as follows: Flotation feed, $1·90 per ton; concentrate, $120 per ton; tailing, $0·30. Somewhat similar is the practice at the experimental unit of the Alaska Juneau Gold Mining Co. treating gravity mill slime. From a feed containing about $1·50 gold per ton and 2% lead, a concentrate assaying $75 gold per ton and 14% lead is produced. The ratio of concentration is about 80 to 1, with potassium amylxanthate and cresylic acid the reagents used.

Enough has been said to show the value of flotation in gold recovery and no gift of prophecy is necessary to predict that it will play an increasing part with the passage of time. Nothing of comparable importance has occurred since the introduction of the cyanide process almost half a century ago. With flotation as a sister process of amalgamation and cyaniding, the importance of careful ore testing before building any mill is greater than ever. The examples given in the article are selected ones. Flotation does not always apply and proper grinding, classification, and skill in selecting reagents are essential to success. The character of the water supply is an important point frequently overlooked.

The small operator would do well to employ amalgamation where 60% of his gold can be won by this method and try flotation on the tailing. Where direct flotation is indicated, the handling of the concentrate requires careful study. In some circumstances, even with $100 concentrate, the job is less than half done. Direct flotation, however, where operators are adjacent to smelters or custom cyanide plants, gives the small operator his chance to treat a variety of ores with a smaller plant investment than heretofore possible. The ball-mill-classifier combination for grinding permits the proper control of flotation feed and a simple flowsheet. A 50-ton plant can usually be built for from $30,000 to $40,000 and operating costs should be less than $1·50 per ton.

COPPER SULPHATE PRODUCTION

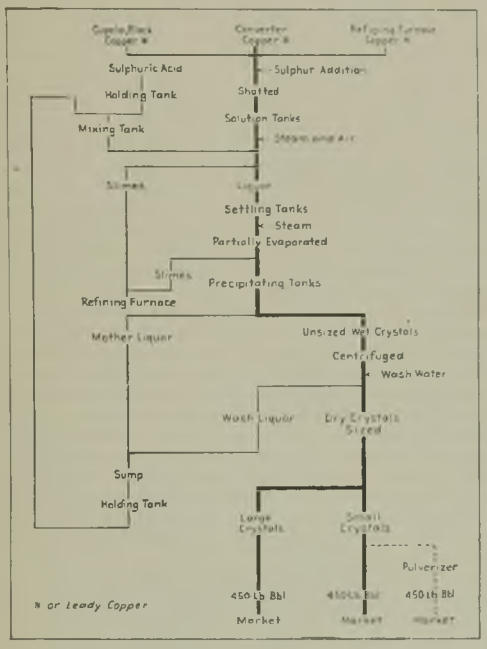
The production of copper sulphate by the leaching of shot is described by P. Barker in *Chemical and Metallurgical Engineering* for May. The author says that most copper sulphate is produced in the United States as a byproduct of electrolytic copper refining. It is, however, also manufactured by chemical companies and occurs as a byproduct in parting gold and silver in smelting operations concerned with the refining of other metals. A small quantity results from lead smelting where copper-bearing lead matte is produced. No attempt should be made to manufacture copper sulphate alone, as it is not economical. Its advantage lies in being a byproduct where overhead and manufacturing costs are absorbed by the other products of the plant and its operation results in freeing from the copper shot valuable metals in the slime.

The trade demands a firm, solid crystal which must be free from any porous spots containing dilute acid of the mother liquor. Crystals must be pure—99·0% or better—and possess a good colour; greenish tints are not permitted, as they indicate high iron. The larger crystals usually command a slightly higher price than the smaller, or fines. In order to obtain pure crystals, the solution of copper sulphate must be not only clean and free from slimes and other foreign substances, but also of high enough concentration to insure deposits upon cooling. The manufacturer generally has demands for large (plus ½ in. mesh), and small (minus ⅛ in. mesh), and sometimes for pulverized crystals. Where faulty crystals are made they may be pulverized if a demand for such a product exists.

The production of copper sulphate by the method described in the article involves oxidizing the metal as rapidly as possible and putting the oxide in solution in the least quantity of sulphuric acid while providing opportunities for any impurities to settle out before the precipitation portion of the cycle is reached. It may be considered that the production takes place in a cycle of eight major periods: (1) Oxidation of the copper, (2) solution of the oxide in dilute sulphuric acid, (3) settling out of impurities, (4) concentration of the clear solution, (5) precipitation of the copper sulphate by crystallization, (6) washing and drying of the crystals, (7) sizing, and (8) packaging.

Copper must be in the form of shot to provide

the maximum surface for oxidation and solution. The shot is porous with a surface made up of irregular kidney shapes and cracks which are obtained by using copper with a sulphur content of about 4%. Cracks aid the penetration and oxidation of the shot in the dissolving tank. Where the copper shot is derived from the converter, it is purposely not blown to a complete sulphur elimination previous to shotting. Where it is derived from a copper-refining furnace, sulphur may be introduced by melting in either copper sulphide or copper matte, and also by using petroleum coke for a cover when refining. Petroleum coke alone will not introduce sufficient sulphur for shotting, but it assists the effect desired. Black copper from a



FLOW SHEET OF COPPER SULPHATE PLANT.

cupola may also be used, but it must be remelted, usually with scrap copper and sulphur introduced as above. Scrap copper, too, is sometimes utilized as a source of bluestone.

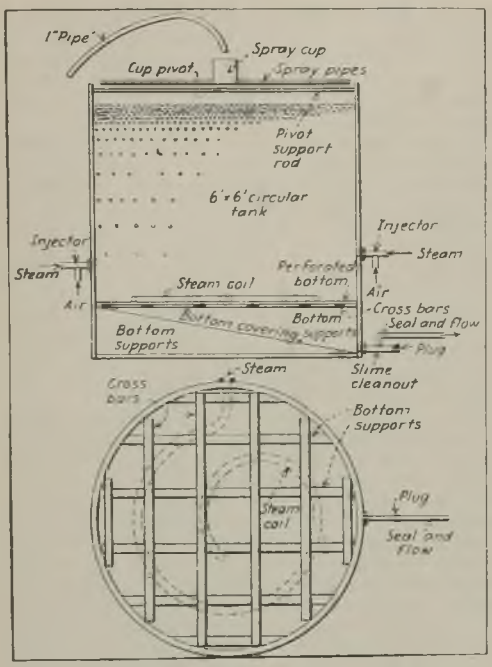
Shots are formed by pouring the copper in a controlled stream either against a rotating cone or cylinder, or from a board rolled back and forth on a pipe. The copper spatters into a metal basket placed in a pit of water at 180° F. The basket is perforated on the sides, but not on the dished bottom.

Oxidation of copper and solution of the oxide take place in a lead-lined circular dissolving tank. Fifteen tons of shot is placed in the tank, filling it to within a few inches of the top, and the sulphuric acid mixture is sprayed over the shot through a rotary spray. The mixture is led to the centre cup through the lead feed pipe and escapes through two radial perforated pipes, which causes them to rotate and sprinkle the acid. Meanwhile live steam is forced into the mass through two injectors. Using injectors with the steam allows air to assist the oxidation of the metal. The necessary heat is supplied by a steam coil placed over the perforated false bottoms and the shot is heated to 180–200° F., which has a drying action on the sulphuric acid mixture sprayed at the top of the tank. The air taken in by the injectors is wet with steam, which tends to dilute the acid spray, but this is more than offset by its action as an oxidizing agent, which increases the yield of copper oxide, which in turn is soluble in the dilute sulphuric acid. Reasonably dry steam should be used in the process and if possible it should be generated in furnace flue boilers as a byproduct, if economical manufacturing costs are to result. The oxidation is further increased by allowing the steam in the coil and injectors to operate continuously. The spray is stopped at the end of the day's operation, and the mother-liquor sulphuric acid mixture is dried on the shot by the heat and air from the coil and the two injectors, forming a coating of copper oxide and some sulphate. The greatest quantity of oxide is formed during this oxidation period at the time of drying of the salts on the shot, which lasts 15 hours or more.

In mixing the 60° Bé. sulphuric acid with the mother liquor from the precipitating tanks and washings from the centrifugal machine in the mixing tank preparatory to spraying it over the copper shot, it is essential that the acid be controlled and an excessive quantity not be used. The gravity of the mixture should be about 28° Be. at 52° F. A greater gravity may be obtained by the use of more acid, but an excessive quantity will not increase the rate of solution of the copper and will produce porous crystals filled with dilute acid as the final product. The process of oxidation and solution in the dissolving tank will not take place with sufficient rapidity until the sprayed solution of sulphuric acid is built up in copper sulphate to the quantity of at least 20 grams per litre of copper and 250 grams of sulphuric acid.

After the drying of the salts on the shot, previously referred to, has progressed sufficiently—usually 15–18 hours—the mother-liquor sulphuric acid mixture is again sprayed on the shot and the cycle repeated. This is continued as long as the copper sulphate liquor leaving the tank is of the right gravity. The first liquor coming from the solution tanks is heavy in copper sulphate; this diminishes as the oxide and sulphate salts are gradually consumed from the surface of the shot. After the solution has flowed 3 or 4 hours over the shot, it is so weak in copper sulphate that it is no longer economical or practical to continue it over the tank, and another solution tank must be started and the former one put on the oxide period of the cycle. The formation of the copper oxide from the action of the air and steam is so slow that it does not keep up with the rate of solution flow over the shot; hence the liquor leaving the tank becomes too lean in copper sulphate for precipitation. The tank is then said to be "dead."

A dissolving tank will last about four weeks of continuous operation alternately on the oxidation and solution portions of the cycle, after which time it becomes so loaded with slime that the rate of percolation and solution is too slow and it should be cleaned. Also the shot becomes coated with lead sulphate, resulting in too slow a rate of oxidation. A man flushes the shot with a fire hose having good water pressure, to free it from slimes, which are mostly lead sulphate with lead and any previous metals which were originally



Design of Oxidation and Solution Tank.

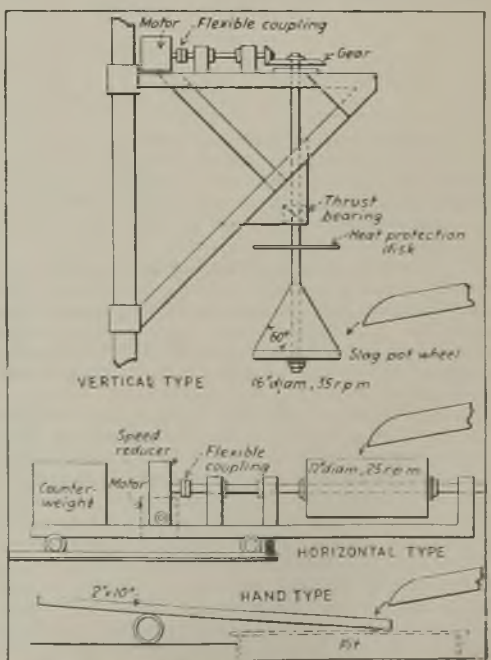
in the copper. He then shovels it out on to a platform. The flushed slimes are caught in settling tanks and the water overflows to the mother-liquor sump. The slimes are allowed to dry partially after settling, and the mud is either treated in a cupel furnace if it contains precious metals, or if it contains mainly lead, it must be returned to a lead blast-furnace charge.

The dissolving vessel consists of a circular tank. Six triangular shaped pieces of wood are placed upon the bottom, and a false bottom is nailed on. The whole tank is then lined with sheet lead. Six triangular pieces of wood are placed on the false bottom, so that the channels between lead to the overflow; seven lead-covered strips are placed upon these to support the perforated bottom, which is made of lead with holes drilled every inch. Upon the perforated bottom, a lead pipe for steam is laid, which is allowed to exhaust inside the tank. Six inches above the perforated bottom is an injector made of lead and operated by 75 lb. steam pressure, which introduces air into the tank for oxidizing purposes. Injectors are placed, one front and one back, 180° apart, one slightly higher than the other. The overflow has an offset pipe which acts as a seal. A wooden plug causes the overflow to pass through the offset pipe, sealing the steam in the tank by maintaining a level of solution above the slime clean-out.

Settling and Crystallizing.—Settling and precipitating tanks are made from boards lined on the sides and bottom with lead. This type of tank is the most economical; in the case of puncture from digging crystals it may readily be repaired. If the wooden tanks are painted inside and out previous to lining with three coats of acid-proof paint, they will last for about ten years.

The liquor leaving the oxidation and solution tanks passes through a launder to the top of the settling tanks. And in order for the solution to leave the tank it must pass under the baffle located at the overflow and carry the heavier liquor, thus preventing segregation of the heavy liquor at the bottom with the slimes settled out. The rate of flow is not sufficient to stir up the settled sediment, and in passing upward it mixes with and also displaces the heavy liquor already in the tank. The first tank will have the heaviest sediment of impurities, while those after the third will have hardly any. All slime, insoluble sulphates or metallics, and dirt which have been carried from the dissolving tank will settle in these tanks; hence the liquor leaving them is freed of impurities which would otherwise be entrained in the copper sulphate crystals, if they reached the precipitation tanks.

It is essential to provide sufficient settling-tank volume to allow a large evaporation ratio. This is the reason for providing at least 6, and preferably 18, settling tanks where large production is desired. These are provided with coils, and during the oxidation period in the solution tanks there should be no liquid flow through the settling tanks (the manufacture of copper sulphate is distinctly a cycle of intermittent periods; where continuous operation is required, duplicate sets of solution and settling tanks must be provided). Steam is kept on continuously in these tanks, and during the oxidation in the solution tanks a simultaneous period of evaporation takes place in the settling tanks. During the solution period, the liquor heavy in copper sulphate flows to the settling tanks and gradually displaces the liquor in them. At the end of the filling period for the precipitating tanks, the settling tanks contain liquor of almost the same gravity as that which left the solution tanks. During the evaporation period this liquor is concentrated, but as long as the steam is kept on and the temperature maintained, crystals do not form. To insure continuous operation, the same number



Three Types of Equipment for Shot Production.

of crystallizing tanks must be filled as are pulled for crystal production. Hence a greater evaporation capacity permits a greater number of tanks to be pulled for crystal production.

It is advisable to have 8 crystallizing tanks to every one solution tank. The shallow precipitation tanks are arranged in rows, resting on acid-proofed timbers or concrete acid-proofed supports. The precipitating strips are either lead or copper. The strips are hung on planks laid across the 5 ft. width of the tanks. The lead or copper strips are equally spaced on the planks. There are 9 rows of strips, 15 strips per row, making 135 strips per tank. The strips reach to within 1 ft. of the bottom of the tank. They should not touch the bottom; otherwise they will become imbedded in the bottom crystals and will be impossible to remove without extra labour of releasing the strip and bottom crystals, in which the strips become firmly held. The maximum number of strips are placed in the tanks in order to get the greatest precipitating areas.

Upon removing the crystals from the tank, which provide four to five barrels of 450 lb. per pull, they are immediately hoisted to the centrifuge floor, for washing. The crystals are washed with a water spray for 15 to 20 seconds; a minimum quantity of water is used to give an acid-free dry crystal product. They are whirled dry for a period of 3 to 3½ minutes. A centrifuge with the motor mounted on top, which may be swung back on a hinge when changing the basket, is convenient. This type is mounted on a three-rod suspension which is really a ball and socket tripod. The motor is connected to the basket through a combined clutch and brake. In loading the centrifuge basket, the crystals must be evenly distributed; otherwise, bumping results.

The wash water, which contains a small percentage of copper sulphate, is collected in the sump tank and helps increase the mother liquor, which later, with added sulphuric acid, is used for solution of the copper oxide.

Plenty of ventilation for the cooling of the crystallizing tanks is required, so that the solution may cool at a uniform rate. It takes five days for a tank to cool and precipitate completely. In the summer months, unless good ventilation is provided, it will take six or seven days for complete precipitation. In any event, it is best to allow six or seven days for complete precipitation by providing sufficient precipitating capacity so that the cycle may be maintained on this basis; it is uneconomical to circulate any more copper in solution than is necessary.

TABLE I. TYPICAL FIGURES FOR SOLUTION CONTROL

Solution to	*Copper Grams per Litre.*	*Iron Grams per Litre.*	*H_2SO_4 Grams per Litre.*
Dissolving Tank—			
27° Bé. at 52·5° F.	23	1·5	269
Settling Tank—			
34° Bé. at 72° F.	80	2·0	100
Precipitating Tank—			
39° Bé. at 80° F.	113	3·0	198
Sump—			
21° Bé. at 33° F.	27	2·2	118

The crystals are delivered from the centrifuge to a trommel where sizing is effected. All crystals which are oversize for a ½ in. screen are designated as coarse crystals, while those below this size are fine crystals. For insecticide work, dry pulverized crystals may be required, in which case the minus ½ in. mesh crystals may be pulverized direct; or if there is a demand for small crystals elsewhere, these will be sized at the washer and a minus ½ in. mesh crystal produced for pulverizing. The Ross type pulverizer is excellent for this purpose.

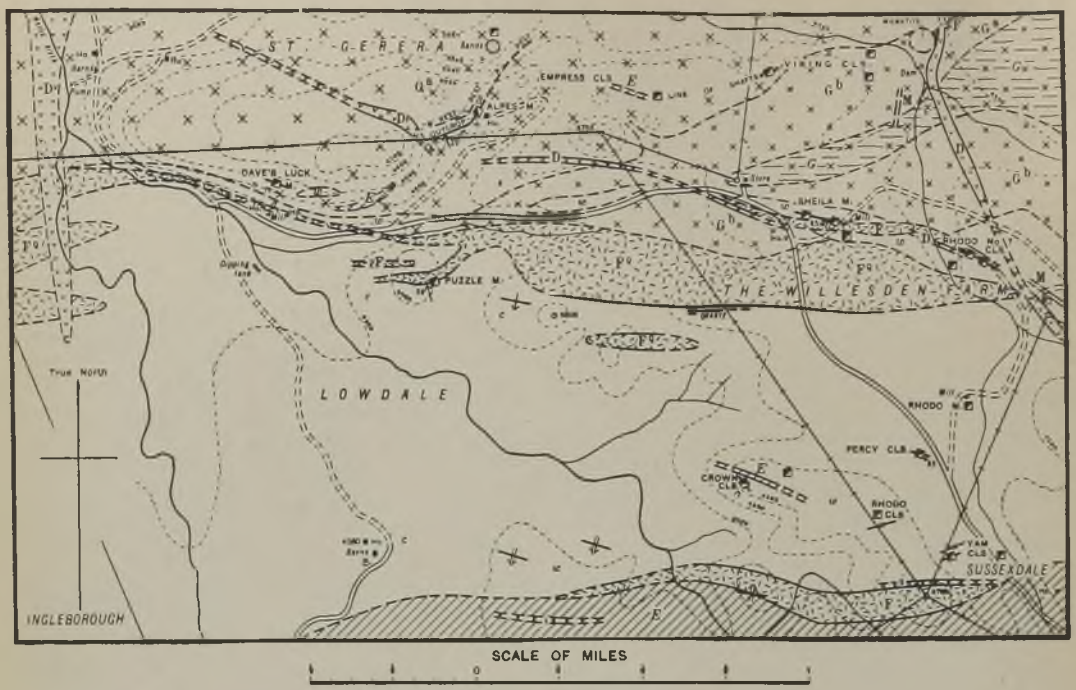
Copper sulphate should be barrelled immediately after washing and sizing, as it is efflorescent, losing its five molecules of water of crystallization, and turning white upon exposure to the air. The barrels usually are clean sugar barrels holding 450 lb. of large sulphate crystals. Sometimes where trade demands exist, no sizing is done; the whole is barrelled as small crystals, particularly where no price difference is allowed.

The steam required will be a 50-h.p. boiler for three 6 by 6 ft. dissolving tanks and 40 precipitating tanks. In other words, a horsepower per precipitating tank plus ten for line and other losses for 200–300 ft. of steam travel. It is well to allow 20 h.p. per dissolving tank and twelve precipitating tanks per dissolving tank. Steam pressure is 50 lb. minimum at the tanks. The labour required for a 300-bbl. a week plant will be seven men.

THE SALISBURY GOLD BELT, SOUTHERN RHODESIA

An interim report on the geology of part of the Salisbury gold belt, by R. Tyndale-Biscoe, has been published as Bulletin No. 19 of the Geological Survey of Southern Rhodesia. The author says that the provisional geological map of Southern Rhodesia shows a continuous belt of Basement Schists extending westwards from a point about 28 miles east by north of Salisbury, through the Enterprise district to the neighbourhood of Mount Hampden; thence northward and north-eastward to the Concession district and the Mazoe valley. The area described in Bulletin No. 19 cannot be regarded as belonging to either the Enterprise or to the Mazoe valley gold belt, but it is included in what was formerly called the Salisbury gold belt, which term is necessarily vague, implying undefined north-western and eastern boundary lines. The area is about 60 sq. miles, and its centre lies about 14 miles north by east of Salisbury. It is one of considerable interest from a geological point of view, and there is a definite revival in mining activity taking place at present in the district. It lies astride the boundary between the Mazoe and Salisbury native districts, but wholly within the Salisbury mining district with the exception of St. Gerera farm, which is in the Mazoe mining district.

PREVIOUS GEOLOGICAL WORK.—The district was visited in 1893 by Mr. A. R. Sawyer in the course of an examination, under extremely trying conditions, of some of the gold belts of Southern Rhodesia. The Matabele rebellion was going on, and he had to carry out his work "with a rifle in one hand and his hammer in the other." The



Sketch Geological Map of Part of the Salisbury Gold Belt.

Salisbury goldfield (as he termed it) he described as "a well-favoured one." Further references are made to this work in the section on the individual mines and claims. Many of these have also been examined and reported on by mining engineers and members of the staff of the Geological Survey from time to time.

Physical Features.—The area forms a tract of country with a general slope northwards from the high plateau. Most of the streams converge towards the gap in the granite range near the north-west corner of Lowdale farm, the largest of these being the Mazoe River, which enters the mapped area at the southern end of Calgary farm and leaves it in the western part of St. Gerera farm, flowing northwards to the Mazoe dam, which is about four miles farther on. The other streams to the east flow in a similar direction to join the Mazoe River beyond (north of) the area of the map.

The topography is controlled to a large extent by the geological formations, the granite and greenstones being more resistant to weathering than the intervening sedimentary, or partly sedimentary, group of rocks. These last give rise to a broad vale trending east and west from the east end of the Willesden farm, through Sussexdale and Lowdale farms, to the northern part of Ingleborough farm. This vale is bounded on the north by a broken hilly tract of granite country, and on the south by rolling tree-clad greenstone hills rising gradually southwards and merging into the high plateau. The edge of this plateau curves round from a general east and west direction in the south to a north and south direction in the east. Its course runs from just outside the southern boundary of Calgary farm, through Hatcliffe, Glenforest, Georgic, and Thelksinoi farms, with a north-westward spur from Glenforest into Oaklands farm. Many of the hills in the broken granite country of St. Gerera and Balkiza farms rise to the height of the plateau and indicate that this area once formed part of the plateau (peneplain), but is now dissected. The present edge of the plateau is very slowly receding as the headwaters of the streams cut back into it.

Table of Rock Formations.

			Symbol on map.
Intrusive Igneous Rocks	Dolerite		D
	Minor acid intrusions	Felsite	F
		Quartz-porphyry	F^Q
		Quartz, epidosite	Q, Q^E
		Pegmatite	M
	Granite	Hatcliffe granite-porphyry	G^c
		Medium-grained massive	G^b
		Coarse-grained, massive and gneissic	G^a, G^a
		Gneissic hornblendic	*G*
Basement Schists	Greywacke group	Greywacke	w
		Conglomerate	c
	Banded ironstone		i
	Crystalline limestone		
	Greenstone series	Epidiorite, pillow lavas	*E*
		Chloritic and epidotic greenstones	*B*

Outline of the Geology.—The greater part of the mapped area is shared about equally by the granite and the greenstone series. The latter is a very monotonous group of rocks, mainly

fine-grained massive epidiorite, very rarely showing any indication of strike or dip. In places pillow structure is visible, indicating the probable origin of the rocks as basic lavas, but no other typical lava structures are preserved. Narrow belts of banded ironstone are fairly abundant, running through the northern part of the greenstone area in a general east and west direction, and crystalline limestone is associated with one of these belts at one locality as a small lenticle.

The vale lying between the greenstone and the granite areas, mentioned in the last section, is underlain by a group of rocks which, to judge from the abundant conglomerate it contains, is probably largely, if not wholly, of sedimentary origin and to which the name Greywacke group has been applied. Exposures showing dip and strike are commoner in these rocks than in the greenstones, and they appear to underlie the greenstones. The evidence is not conclusive, however, for there may be overfolding. The rocks mentioned so far, with the exception of the granite, are regarded as belonging to the Basement Schists.

The granite displays abundant evidence of its intrusive nature and the map shows how it cuts across the strike of the Basement Schists. There seem to be at least two ages of granite intrusion represented, probably more, and the contact zone contains many pegmatite dykes, frequently greisenized and carrying lepidolite, and large "blows" and thick reefs of quartz and epidosite. Close to the contact also and instrusive into the Greywacke group are dykes and irregular bodies of felsite and quartz-porphyry, with which some of the gold deposits seem to be closely associated. These rocks also cut the granite to the north as thick branching dykes, and show much variation in texture. In places the rock looks like quartzite. A few dykes of dolerite intrude all the main rock groups mentioned, and a big sill outcrops in the northern and western parts of the area. This is the youngest rock seen, with the exception of the recent deposits, alluvium and soils.

Gold is at present the only economic mineral being worked in the area. Two properties are crushing at the time of writing, and two more will shortly be doing so. Others are undergoing development. The reefs occur in all the principal formations represented in the area, and are essentially quartz reefs occupying fissures, although the wall rocks are in many cases mineralized and may constitute ore.

Lepidolite is of common occurrence, but under present economic conditions the deposits are not of commercial value. Alluvial tin has been worked in the past, and efforts have been made to find its source. The results of both ventures have been disappointing.

CYANIDE EQUATIONS

In the *Chemical Engineering and Mining Review* of Melbourne for April 5, G. O. Ramsay discusses the action of cyanide on gold. He says that the present intensive search for gold is somewhat reflected in the increasing space allotted to the element in the current literature and perhaps, therefore, the time is quite opportune to reopen for discussion the question of what is the particular action of cyanide on gold.

On account of the preponderance of assertion in the immediate past given to the Elsner equation, it may come as a surprise to many cyanide operators and others not so intimately connected with the industry that this equation was ever called in question. Possibly Julian and Smart is the only text-book that has taken exception to the equation. The history of our knowledge of the process can be seen in Mellor's "Dictionary of Chemistry," wherein it is stated that, in 1846, Elsner showed the presence of oxygen to be necessary, thereupon postulating the equation

$$4Au + 8KCN + O_2 + 2H_2O = 4KAu(CN)_2 + 4KOH.$$

Bodlander has suggested that this is really a two-stage process, and introduces a hypothetical molecule of hydrogen peroxide, and R. M. Caven takes it one step further. He says: "The equation for the cyanide process of gold extraction may be built up as follows:—

$$2Au + O_2 + H_2O = Au_2O + H_2O_2$$
$$2Au + H_2O_2 = Au_2O + H_2O$$
$$2Au_2O + 8KCN + 2H_2O = 4KAu(CN)_2 + 4KOH$$

The parts of this reaction are remarkable, for, whilst the first two equations represent what cannot possibly take place alone, since gold is not susceptible to atmospheric oxidation, they likewise show the fact of the intermediate formation of H_2O_2 through the partition of the oxygen molecule between gold and water which is not shown in the final equation."

There is, however, another possibility as was suggested by Janin, following the research of McArthur and Forrest. Janin suggested

$$2Au + 4KCN + 2H_2O = 2KAu(CN)_2 + 2KOH + H_2.$$

In remarking on the equations of Elsner and Janin, Mellor says that of Janin is doubtful since no hydrogen has been detected. But it would seem that, if Janin's equation is questionable, those of Bodlander and Caven are likewise subject to discount. However, support for Janin is not wanting, as may be seen in the following excerpt from Evans: "The most stable aurous salts are the complex cyanides. Gold, silver, and copper are not like noble metals to KCN, and the reason is that the gold passes into the anionic condition in presence of CN ions. Dissolution proceeds only when oxygen is present to remove hydrogen as formed so at the anodic areas of gold surface.

$$Au + 2(CN)' = [Au(CN)_2]' + e$$

and at the cathodic

$$H + e = H$$

followed by either

$$2H + O_2 = H_2O_2$$
$$\text{or } 2H + O = H_2O$$

on which assumption

$$2Au + 4KCN + 2H_2O + O_2 = 2K[Au(CN)_2] + 2KOH + H_2O_2.$$

And this is to all intents and purposes the Janin equation.

It occurred to the writer that it may be possible to detect the formation of hydrogen, if any is evolved in the process, by following the change of potential of a gold electrode in a solution of KCN. As a Leeds and Northrup Type K potentiometer was available it was necessary to provide only a calomel cell and a gold electrode to complete the outfit. In making the cell, the calomel used was that of Merck, and the KCl solution was saturated with calomel. The cyanide solution was

made from freshly boiled distilled water and of molar concentration, that is, about 6·5 per cent KCN. The gold electrode was annealed at a red heat, then dipped in HNO_3, and finally rinsed in water. Time was not available to complete the experiment, but one interesting set of readings is given in Table 1.

TABLE 1.

Time of immersion, minutes	*Potential difference, volts*	*Time of immersion, minutes*	*Potential difference, volts*
1	·750	27	·926
5	·800	30	·928
9	·913	35	·929
14	·922	42	·931
22	·925		

From these figures it can be seen there is a distinct rise in potential difference. This rise is not so marked in the first four minutes as in the second four and thereafter it rapidly tails off.

The action of hydrogen was tried in a fresh system, whereupon the voltage rose immediately to ·925, increasing to ·945 at the end of five minutes. No attempt was made to reach a final end point, which would probably be about ·950. With the solution of gold at a standstill, the element would stimulate a hydrogen electrode.

During one of the experiments the opportunity was taken to pass oxygen over the gold electrode, which at the time had been subject to 36 minutes' immersion. The potential immediately dropped from ·892 volt to ·630 volt. If the measure of solubility of gold may be determined by the difference between its present p.d. and some definite figure such as is with this cell ·950 volt, then it can be seen that any depressant such as oxygen would not be without virtue to the cyanide process.

It is not claimed that these experiments are anything but tentative, but it is believed that thereby colour is lent to the theory that hydrogen is evolved when gold is dissolved in cyanide, thereby vindicating the equation of Janin.

DURALUMIN SKIPS

It has been known for some time that the use of duralumin for the construction of mine skips and cages has been extending and several mines on the Rand have now made successful tests with skips of this nature. In the *Mining and Industrial Magazine of South Africa* for April 27 a few more details of Rand experience are given. With regard to the installation of duralumin skips on the Randfontein Estates, the first four started work in January, 1931, on the North Vertical shaft. They have, therefore, been in commission for over 12 months. Such was the success attending their adoption that the first order was rapidly followed by another comprising four skips for the South Vertical, four skips and three cages for the No. 2 North shaft, and three skips for the South Sub-Incline at the Estates. About the same time, four skips were supplied to Brakpan and two to the Witwatersrand Deep. Duralumin skips have also been supplied to the Witwatersrand mine, but are not yet functioning.

In the development of this new type of haulage equipment, consideration has also been given to the question of lightening man cages. These offer abundant scope for the introduction of duralumin, with the result that the saving of weight in man cages is very marked. In the 2-decker man cage, for example, which is designed to carry 40 natives, this saving amounts to 2,400 lb., and has enabled a lighter winding rope to be used. The reduction in the weight of this equipment allows, if necessary, increased capacity for man-carrying, or, alternatively, the saving secures a longer life for the haulage rope, owing to the increase in the factor of safety employed.

Experience of duralumin skips on the Witwatersrand Deep mine is of a very satisfying nature. Maintenance costs so far have been practically negligible. Whereas, formerly, the mine employed a whole-time underground mechanic to effect repairs to the steel skips at the South Incline shaft, since the new type of skip was introduced, the services of this employee have been almost dispensed with. In place of four tons of ore being hoisted per trip, as with the steel skip, five tons of ore are being raised with the duralumin skip. The gain in tonnage hoisted and power saved is considerable. It will either make a larger tonnage of ore per month available or, alternatively, will do away with the Sunday hoisting shift, which has long been unpopular. A lighter skip will also make possible the adoption of a longer stage for the same diameter of rope.

The duralumin skips supplied to Randfontein Estates have a capacity of seven tons against the 6-ton steel skips previously used, with the added advantage that the total gross load on the rope is reduced by 445 lb. Though the "out of balance" load is increased, under operating conditions, no appreciable increase in power required at the moment of starting can be observed on the ammeter. The total current consumption by the hoist has been considerably reduced, the average annual saving at one shaft being in the neighbourhood of £1,000 per annum (current consumed at 0·25d. per unit), the units per 1,000 foot-tons hoisted falling from 1·75 to 1·57. The average haul with one engine from one shaft is 100,000 short tons per month from a depth of about 4,500 ft. and the record haul for one day is over 5,000 tons; this has only been made possible by the use of duralumin skips.

The construction of all the skips has been on the same general lines, modified, of course, to suit local conditions. The skip pans, trunnions, bearings, etc., are made of duralumin which has a tensile strength of 25–27 tons against 28–30 for mild steel. The interior of the skip pans is lined with special manganese plate, $\frac{1}{8}$ in. thick. The bottoms of most of the vertical skips are lined with Linatex rubber, about four inches thick, with the object of throwing out any deposit which tends to adhere to the bottom of the pan. The Linatex also reduces the shock on the skip during loading. Judging by results to date, the lives of both the manganese and rubber linings will be considerable. Costs of repairs and maintenance, so far, have not been excessive.

Duralumin is not particularly easy to manipulate, as the maximum temperature that the material will withstand is 480° C. Riveting with duralumin rivets has, however, been successfully carried out on the mines. The method employed is as follows:

The rivets are heated in an electric furnace to 480° C. and are then quenched in cold water. They are then comparatively soft and must be used within a limit of from three-quarters to one hour. A peculiar property of duralumin is that it "age hardens." After quenching it is quite soft. It gradually hardens for about four days, after the expiry of which it has developed its maximum strength. Duralumin appears to resist the corrosive action of acid mine water exceedingly well.

Economies on winding ropes consequent on the employment of the lighter skip are naturally effected, since, on a fixed tonnage, a reduction of 16–20 per cent in hoisting time occurs with duralumin equipment, thus materially adding to the useful life of the rope.

ELECTRIC POWER AT KIRKLAND LAKE

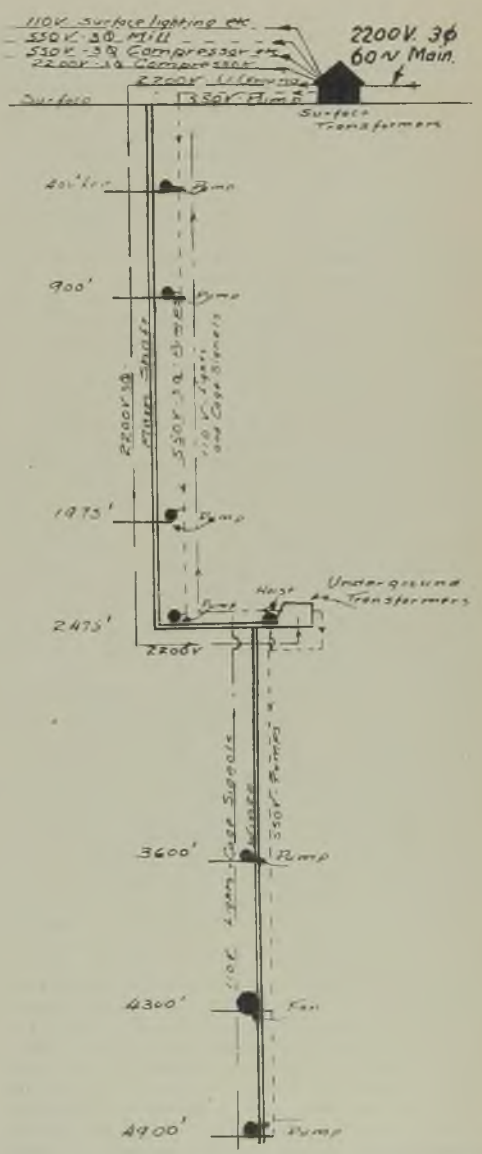
The use of electricity in the Kirkland Lake mine is described in *Electrical News and Engineering* of Toronto for April 15, as part of the report of an interview with Dr. J. B. Tyrrell. Dr. Tyrrell says that how deep a mine can be economically worked, providing the rock formation is suitable, depends primarily upon the hardness of the rock, for depth presents no unsurmountable mechanical difficulty in Canada owing to the fact that comparatively cheap power is always available. In fact, electricity has made deep mining possible in Canada, as it has in other countries where difficulties such as high temperature and flooding are met. In Peru, for instance, electric refrigeration and ventilating plants are used to cool the air for the lower workings owing to the fact that the temperature rises as the shaft goes down. In the Kirkland Lake area the temperature rise is one degree Fahrenheit for every 150 ft. the shaft is taken down, but owing to the fact that the rock temperature just below the earth's surface is low, around 36 degrees, the temperature at the 5,000 ft. level of the Kirkland Lake Gold Mining Company is about 70 deg. F., although there is a fairly high degree of humidity.

Kirkland Lake mine claims to be the deepest mine on the North American continent, with a depth of almost 5,000 ft. Other gold mines in northern Ontario that may lay claim to great depth are: Teck-Hughes, 4,100 ft.; Hollinger, 4,000 ft.; and Lake Shore and Wright-Hargreaves, which are both around 3,000 ft. As an illustration of the importance of electric power in deep mining the equipment used in Kirkland Lake Gold Mining Company, where all power used, except for heating at the surface, is electrical is briefly described:

The total power used is around 1,300 h.p. and is distributed for different uses as follows: Mill, 350 h.p.; compressors and surface hoisting, 700 h.p.; underground, 250 h.p. Power supply is from Northern Ontario Light & Power Company, at 2,200 volt, 3-phase, 60 cycles.

In the mill power is used at 550 volts, 3-phase, for various induction motors, including power for machine shop and electric welding. Other heavy surface equipment includes a 100 h.p., 550 volt, induction motor with full magnetic control and grid resistors for the surface hoist; two compressors—belt driven by 200 h.p., 550 volt, induction motors; and one compressor direct-connected to a 200 h.p., 2,200 volt, synchronous motor with 80% leading power-factor. Surface lighting is 110 volt.

Pumping is taken care of at the 400, 900, 1,975, and 2,475 ft. levels by 550 volt power from surface, the underground power being taken down at 2,200 volts to the 2,475 ft. level and used at 550 volts and 110 volts. The underground 550 volt power is also used for the winze hoist, the lower level pumping



SKETCH SHOWING LAY-OUT OF THE ELECTRIC MAINS IN THE KIRKLAND LAKE SHAFT.

and ventilating fans. All lighting and cage signal circuits throughout the mine are on the underground 110 volt line. The winze hoist motor is a 150 h.p. induction motor with full magnetic control and grid resistors. Fan and pump motors are all small induction motors. The 2,200 volt underground is 3-conductor, cambric insulated, lead covered, galvanized wire armoured, tested for 3,300 volts at constant full load, and the 550 volt underground cable is 3-conductor, rubber insulated, lead covered, galvanized wire armoured. Great precaution must be taken in all underground electrical connexions to exclude water and all equipment must be installed with this fact in view. For instance, the underground transformers at the 2,475 ft. level are housed in a specially-cut rock chamber, walled off by a tile and concrete bulkhead with an air-tight steel door. This chamber is fan ventilated from without and would be automatically sealed if the temperature of the transformers should reach an abnormal height. These transformers are three 75 kv.a., 2,200/500 volt single phase, o.i.s.c., and one 5 kv.a., 2,200/110 volt lighting transformer.

All electrical equipment is supervised and maintained by a master electrician and one helper.

THE PRELIMINARY WASHING OF FLOTATION FEED

The advantages of washing flotation feed are discussed by A. L. Engel in *Mining and Metallurgy* for May. He says that in the treatment of complex ores by flotation, one of the most important steps is conditioning the feed. Conditioning primarily consists of the addition, in the grinding circuit, of an alkaline reagent, for example sodium carbonate which neutralizes any acidity of ore and mill water, counteracts the effect of harmful soluble salts, disperses colloids, and provides the necessary alkalinity for the best metallurgical results. The several minerals of the ore should be put in such condition that they may be floated or rejected as desired, through the action of further reagents thereafter used. Many ores contain harmful soluble salts and colloids in amounts that vary from time to time, so that it is seldom possible to maintain a constant quality of flotation feed. But unless constant quality of flotation feed is possible, difficulty follows in the control of conditioning reagents and other reagents as well, and hence in control of the treatment in general. Results suffer accordingly.

The proposal has been made, and perhaps in some instances put into practice, that such ores be thoroughly washed before flotation, whereby soluble salts and colloids would be completely removed and flotation results considerably bettered. Some laboratory tests have indicated successful application of this idea. In one instance, after washing a lead-zinc sulphide ore, lead flotation concentrate grade improved 6% with 3% better lead recovery; zinc concentrate grade improved 3%, with 4% better zinc recovery. The ore had been crushed to ½ in., well washed to separate all minus-10-mesh material, and this latter again washed to separate all minus-200-mesh material. These last fines were carefully de-slimed, to prevent loss of valuable mineral as far as possible while getting rid of undesirable colloids and excess water. Much of this procedure could no doubt be carried out on a practical scale with current types of classifiers. The washed residues were combined, ground to flotation feed size and treated as usual.

In another instance, a copper sulphide ore showed that after slow elutriation of ore ground to flotation feed size, recovery was increased from 65 to 90%. In elutriation, only 1½ grams of material was removed from a 1,000 gram sample. The removed material consisted almost entirely of colloidal silica, which had prevented flotation of fine particles of bornite.

In a third case, lead carbonate ore was ground to minus 10 mesh, hydraulically classified to coarse sand, fine sand, and slime, and these products tabled. Slime table tailing was thickened to provide flotation feed. It was found that when thickener overflow was slightly dirty rather than clear, no noticeable loss of valuable mineral occurred, and flotation gave improved results. Concentrates were 3% higher grade and recovery was slightly better.

Crushed ore can be washed before grinding to flotation feed size, but this requires considerable auxiliary equipment and it is not certain that such partial washing would always be sufficiently effective. Grinding circuit discharge (flotation feed) can be washed by dilution followed by thickening to the water-solid ratio required for flotation. This seems to offer greater possibilities, as it holds the advantage of combining benefits of washing with those of thorough mixing which the ore receives while being washed. An economically feasible scheme which would embody washing flotation feed could be applied in the design of plants with the following distinctive features:

1. Small fine-ore bin, of only sufficient capacity to carry over intervals between regular crushing periods. If plant capacity is 300 tons daily and crusher operates eight hours, bin capacity should be 200 tons.

2. Large grinding unit with high classifier capacity. If plant capacity is 300 tons daily, grinding unit should be one 300-ton mill, rather than two 150-ton mills.

3. Large capacity washing equipment: Thickening tank with peripheral drive mechanism; and possibly, peripheral discharge with outlets at several levels to allow greater flexibility in controlling density of pulp for flotation feed. Thickened pulp could be circulated for repeated washing if necessary. The storage capacity of the tank should be sufficient to cover maximum grinding circuit maintenance during shutdown periods; for relining mill, for example.

In this design of plant there is saving in construction on the fine-ore bin, which can be one-third the size usually built. A minimum of feeder and conveying equipment is needed to remove material from bin to grinding circuit. This saving would offset in part the cost of washing equipment. A small fine-ore bin also prevents accumulation and oxidation of ore in dead spaces such as commonly are found in large bins. As it is seldom practical thoroughly to mix varying qualities of ore in fine-ore bins, whether of large or small capacity, such mixing becomes a prime function of the washing tank, as mentioned previously. Large grinding units are preferred in this proposed design rather than several small units. Higher

efficiency is possible when large units are utilized. No standby grinding units are needed, as grinding section repairs and shutdowns will not affect flotation operation. More water may be used in the classifier than is consistent with maintaining high-density classifier overflow for direct flotation feed, since the classifier overflow here goes to the washing tank and is thickened. The large washing tank provides storage, allowing for shutdowns in the grinding circuit without reduction of tonnage to flotation, which is a great advantage. Flotation feed may be regulated closely at the tank discharge for both density and quantity. Partial or temporary shutdowns in the flotation section would cause little interruption of usual operation, as flotation feed could be regulated in exact proportion to the capacity of flotation machines remaining in operation, while the grinding operation need not be reduced, the temporary excess amount ground finding storage in the washing tank. The storage capacity of the tank thus takes the place of equivalent storage capacity in a large fine-ore bin, while affording much greater plant flexibility.

Although an excess of "hydraulic" water is needed for dilution in the washing tank, under most conditions water needed for washing would add but little to the total mill-water requirements of current practice. Overflow from the washing tank could be settled and sediment removed; cleared water could again be used in the grinding circuit and washing tank; fouled water could periodically be discarded if necessary.

Washing ore would often eliminate harmful material sufficiently from the flotation feed so that addition, for this purpose, of a conditioning reagent to the grinding circuit or washing tank would be unnecessary, which would be an economy. Thickened washing-tank discharge would go to a small conditioning and agitating-tank ahead of flotation, where required reagents would be added. Use of such conditioning tanks is current practice in many mills, anyway. However, if desirable, the conditioning reagent still could be added to either grinding circuit or washing tank. If the conditioning reagent is present in the washing tank, a long time of contact with the ore is provided. There would possibly be some economy in the amount of conditioning reagent used through this feature, and also through use of return wash water containing such reagent.

In conclusion, the adoption of a plant design, including means for washing flotation feed, should be given consideration where the nature of the ore makes ordinary treatment difficult. Not only would there be better results from using the conditioning reagent but removal of harmful material by washing would enable much more efficient use of other reagents. There would be no useless consumption of reagents by colloids. Minerals would present clean surfaces for action by all the reagents. Flotation control would be simplified, since the ore would be extremely well mixed. In many respects, therefore, the washing tank will be found justified.

New Plant at North Broken Hill.—New installations at the North Broken Hill mine are described in the *Chemical Engineering and Mining Review* of Melbourne for January 5. It is there stated that the new concentrating mill being erected will occupy a space of 130 ft. by 137 ft. The ore will first be crushed in a 36 in. by 24 in. jaw breaker, and the secondary breakers will be 5½-ft. Symons cone crushers. The ore will be conveyed from the breaker station nearly 1,000 ft. to the mill bins by two 24-in. conveyor belts and will pass over a magnetic separator for arresting tramp steel, etc. From the mill bins the ore will pass through four sets of 36 in. by 18 in. Cornish rolls, each set belonging to one of the four sections of the mill, and the product from the rolls will pass over Weir-Meredith screens with ⅜-in. holes. The screen product will be fed by gravity to four 48 in. by 8 ft. conical mills. The first, or pilot conical mill, is installed and running well. Its product is about 4% plus 40-mesh and 96% minus 40-mesh. Three other mills have yet to be erected. The conical mills will be run in open circuit and subsequent classification will be effected by Dorr classifiers, a granular and a slime product being delivered. The granular product will go direct to the primary lead flotation boxes and the slime product to Dorr thickeners, from which the thickened slime will be fed to the flotation boxes.

The flotation plant will consist of nine sets of boxes containing, in all, 84 cells. There will be four boxes consisting of 12 cells each, four of eight cells each, and one four-cell box. In their circuits all the products will be handled from box to box by Wilfley pumps. The type of box, scraping gear, and impeller have all been developed at the mine, and each impeller is belt-driven from a line shaft equipped with heavy-type roller bearings. All pumps and line shaft motors are in a basement, leaving the working floors clean, and all basement and foundation floors are well graded for ease in washing down and cleanliness. The final lead and zinc concentrates will be handled by Dorr vacuum filters. It is expected that the plant will be finished at the end of June next.

It is expected that by July the two electric winding engines will be installed at the new shaft. The winders have been made by Metropolitan-Vickers, Ltd., England; one is for skip haulage and the other for cage hauling, both operating on a common headgear. The electric equipment is the latest developed by Metropolitan-Vickers, and the winders are driven by direct-coupled d.c. motors. The primary energy will be supplied by the central power station at 6,600 volts, a.c.; this will drive the motor-generator sets. Each set is of the Ward-Leonard type, consisting of an a.c. motor, flywheel, hydraulic slip regulator and d.c. generator. The d.c. motors of the winders are each rated at 1,085 h.p. at 55·7 r.p.m., and both winders have 10-ft. drums and are equipped with the Lilly controller and automatic brake mechanism. The skip winder will handle a load of six tons per skip and is rated for an output of 198 tons of ore per hour. The cage winder, which will be mainly for hauling men and material, will, nevertheless, be fully equipped for truck haulage and will be capable of hauling two trucks of ore per trip and has an output of 100 tons per hour. A building to house the winders has already been erected, and the winders are at present in process of erection.

The company is also erecting a new steel headframe at the shaft. Its fabrication consists of 500 tons of steel and from ground level to centre of wheels it will be 120 ft. high. The type is the full square frame of six main legs and three back legs, and 67 ft. above the ground level there will be a brace equipped for automatic truck hauling, if cage hauling is desired. When the cage comes to rest

the trucks are mechanically tipped out of the cage and propel themselves by the grading arrangements to the weighbridge, thence on a creeper and to an automatic mechanical tippler, where, after tipping, they again propel themselves around to the cage in readiness to return underground.

Carried in the framework, just above the brace, are the automatic tipping devices for the skips. These consist of guides and horns through which the skip passes and automatically upends itself. Snugged into the frame is a 100-ton bin, into which both skips and cages tip, and at an angle beneath it is the breaker station. The flow of ore from the bin to the primary and secondary breakers is by gravity over fixed grizzlies. The ore will leave the breaker station $\frac{5}{8}$ in. in size. Both cages and skips will be equipped with safety gear, and the headframe has the usual equipment for overwinding. The cage ropes are $1\frac{1}{2}$ in. diameter, Lang's lay, and the skip ropes are $1\frac{5}{8}$ in. locked coil.

SHORT NOTICES

Top-Slicing.—M. J. Elsing discusses the costs of top-slice stoping in *Engineering and Mining Journal* for May.

Mine Skips.—An article on mine skips by Lucien Eaton appears in the *Engineering and Mining Journal* for May.

Gold Dredging.—Bulletin 352 of the United States Bureau of Mines, by S. H. Ash deals with safety practices in Californian gold dredging.

Liquid Oxygen Explosives.—G. St. J. Perrott and N. A. Tolch give the results of an investigation into liquid oxygen explosives in Bulletin 349 of the United States Bureau of Mines.

Mine Ventilation.—In *Mining and Metallurgy* for April O. A. Glaeser describes a method of intermittent mine ventilation.

Cyanide in Flotation.—In *Engineering and Mining Journal* for May, T. B. Brighton, G. Burgener, and J. Gross discuss depression by cyanide in flotation circuits.

Classifier Overflows.—Devices for the spreading of pulp and for equalizing Dorr classifier overflows are described by E. T. Dunstan in the *Journal* of the Chemical, Metallurgical, and Mining Society of South Africa for March.

Ore Reduction.—The first part of an article by G. B. Livingwood on the science of ore reduction is given in the *Canadian Mining Journal* for May.

Flotation of Gold Ore.—M. Kraut describes the floating of gold on the Mother Lode in *Mining and Metallurgy* for April.

Water Problems on the Rand.—In a paper, presented before the Third (Triennial) Empire Mining and Metallurgical Congress held in South Africa in 1930, L. Bok described the water problem of the East Rand Proprietary Mines, Ltd. Further notes on this same question by the same author appear in the *Journal* of the Chemical, Metallurgical and Mining Society of South Africa for March.

Geophysics.—J. B. Eby discusses the economic relation of geophysics to geology on the Gulf Coast of America in *Economic Geology* for May.

Structural Welding.—A paper on structural welding by S. Couzin appears in the *Journal* of the South African Institution of Engineers for April.

N'Changa Ore Deposits.—The ores of the N'Changa mine and extensions, Northern Rhodesia are described by G. C. A. Jackson in *Economic Geology* for May.

Copper in Alaska.—A. M. Bateman describes a Kennecott type of copper deposit at Glacier Creek, Alaska, in *Economic Geology* for May.

Placer Gold.—An article on placer gold by V. Dolmage appears in the British Columbian *Miner* for May.

Ronnskar Copper Works.—In *Metall und Erz* for April 1, Dr. A. Lindblad gives a short description of the plant at Ronnskar, Sweden, where ore from the Boliden mine is treated.

Mercury Recovery.—A Californian quicksilver plant is described by G. J. Young in the *Engineering and Mining Journal* for May.

Gold Mining in Roumania.—The treatment of gold ores in Roumania is described by Dr. G. Quittkat in *Metall und Erz* for May 1.

Gold in Canada.—W. M. Goodwin discusses the trend of Canadian gold developments in the *Canadian Mining Journal* for May.

Japan.—The mineral resources of Japan are discussed by M. Kuklops in *Mines, Carrières, Grandes Entreprises* for May.

Phosphate in North Africa.—E. S. Greigor describes the occurrences of phosphate in North Africa in *Mines Carrières, Grandes Entreprises* for May.

Copper Industry.—The outlook for copper is dealt with by Arthur Notman in *Economic Geology* for May.

RECENT PATENTS PUBLISHED

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

28,691 of 1930 (369,913). United Verde Copper Co., Arizona. Sulphide minerals are smelted with an excess of air to produce SO_2 and matte, the latter being then treated to produce H_2S. The two gases are then allowed to interact in the presence of a zeolite catalyst to produce elemental sulphur.

28,693 of 1930 (369,958). United Verde Copper Co., Arizona. The reactions set out in patent No. 369,913 above are found to be appreciably accelerated if carried out in the presence of a mixture of absorbent materials.

30,150 of 1930 (370,962). I. G. Farbenindustrie A.-G., Frankfort-on-Main, Germany. Improvements in the manufacture and production of metal carbonyls.

32,390 of 1930 (369,981). Vereinigte Stahlwerke A.-G., Düsseldorf, Germany. Pulverized ores and other metallurgical products are roasted in a blast furnace wherein the column of ore has at intervals layers of fuel or coarse grained material connected by passages formed through the layers of material to be roasted.

32,765 of 1930 (370,026). American Smelting and Refining Co., New York. Silver is removed from molten lead in the dross formed by the addition of zinc, bismuth being afterwards recovered from the cooling lead in a dross formed on the addition of a lead-calcium alloy.

33,709 of 1930 (370,965). Nichols Copper Co., New York. Chlorine is eliminated from solutions containing zinc chloride by the addition of copper

sulphate to form cupric chloride and zinc sulphate. Copper powder is then added, whereby the cupric chloride is converted to insoluble cuprous chloride.

37,554 of 1930 (369,593). Electric Smelting and Aluminium Co., Cleveland, Ohio. Alumina is recovered from aluminous silicious material, which is roasted with alkali and alkaline earth carbonates to form an alkali metal aluminate.

871 of 1931 (370,494). R. D. Tullis, Bearsden, and P. Oakley, Liverpool. Borax trichloride is introduced into molten copper either alone or along with a volatile metallic chloride, such as vanadium tetrachloride, in order to remove occluded gases and other impurities and to improve the grain of the copper.

1,542 of 1931 (370,516). W. C. Menzies, Scranton, Pennsylvania. Apparatus for the separation of the heavy constituents of minerals such as coal.

13,413 of 1931 (371,174). L. Hoyois, Belgium. Apparatus for the grading of granular material such as coal or ores.

13,878 of 1931 (370,694). National Smelting Co., Cleveland, Ohio. A process for the recovery of metallic aluminium from finely-divided material such as borings, skimmings, dross, etc., involving treatment in a reaction chamber with chlorine gas.

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.

The Scientific Principles of Petroleum Technology. By Dr. Leo Gurwitsch and Harold Moore. 2nd edition. Cloth, octavo, 572 pages, illustrated. Price 30s. London: Chapman and Hall.

Markscheidekunde. By G. Schulte and W. Lohr. Cloth, octavo, 242 pages, illustrated. Price RM. 13. Berlin: Julius Springer.

Safety in Mines: Report of International Conference at Buxton, 1931. Safety in Mines Research Board Paper No. 74. Paper covers, 67 pages, illustrated. Price 1s. 6d. London: H.M. Stationery Office.

Coal Mines Act, 1911: Regulations and Orders relating to Safety and Health (1932 edition). Paper covers, 184 pages, Price 1s. 6d. London: H.M. Stationery Office.

Canada: Report of the Department of Mines to March 31, 1931. Paper covers, 61 pages. Price 25 cents. Ottawa: Department of Mines.

South-Eastern Manitoba: Geology and Mineral Deposits. By J. F. Wright. Canadian Geological Survey Memoir 169. Paper covers, 150 pages. illustrated, with map. Price 25 cents. Ottawa: Department of Mines.

Canadian Department of Mines: Investigations in Ore Dressing and Metallurgy, 1930. Paper covers, 215 pages, illustrated. Ottawa: Department of Mines.

Canadian Geological Survey: Summary Reports, 1930, Part D and 1931, Part B. Paper covers. Ottawa: Department of Mines.

Quebec: Annual Report of Bureau of Mines, 1930, Part C. Gold and Copper Deposits of Dubuisson and Bourlamaque Townships, Abitibi County, and Molybdenite Deposits of La Corne Township, by J. E. Hawley. Paper covers, 125 pages, illustrated, with map. Quebec: Bureau of Mines.

Nyasaland Protectorate: Water Supply Investigation, Progress Report No. 1, 1931. Paper covers, 27 pages, illustrated, with sketch maps. London: Crown Agents for the Colonies.

Bonanza Mining District, Colorado: Geology and Ore Deposits. By W. S. Burbank and C. W. Henderson. United States Geological Survey Professional Paper 169. Paper covers, quarto, 166 pages, illustrated, with map. Price $2. Washington: Superintendent of Documents.

Copper Deposits near Keating, Oregon. By James Gilluly. United States Geological Survey Bulletin 830-A. Paper covers, 32 pages, illustrated with maps. Price 15 cents. Washington: Superintendent of Documents.

Alaska: A geological reconnaissance of the Dennison Fork District. By J. B. Mertie, Jr. United States Geological Survey Bulletin 827. Paper covers, 44 pages, illustrated, with map. Price 45 cents. Washington: Superintendent of Documents.

New Jersey: The Crystal Cavities of the Zeolite Region. By W. T. Schaller. United States Geological Survey Bulletin 832. Paper covers, 90 pages, illustrated. Price 45 cents. Washington: Superintendent of Documents.

Mineral Resources of the United States, 1930. Part II, pp. 303–313, Talc and Soapstone, by O. Bowles and B. H. Stoddard; pp. 375–386, Sand and Gravel, by E. R. Phillips; pp. 397–432, Cement, by B. W. Bagley; pp. 457–481, Natural Gas, by G. R. Hopkins and H. Backus. Washington: Superintendent of Documents.

Pacific North-West: Ochres and Mineral Pigments. By H. Wilson. United States Bureau of Mines Bulletin 304. Paper covers, 74 pages, illustrated. Price 15 cents. Washington: Superintendent of Documents.

Paraffin and Congealing-Oil Problems. By C. E. Reistle, Jr. and O. C. Blade. United States Bureau of Mines Bulletin 348. Paper covers, 171 pages, illustrated. Price 55 cents. Washington: Superintendent of Documents.

COMPANY REPORTS

Taquah and Abosso. This company was formed in 1927 and works a gold mining property in the Wassau district of the Gold Coast Colony. The report for the year to March 31 last shows that 120,272 tons of ore was treated, the 41,398 oz. of gold recovered being worth £175,653, or, with gold premium realized, £211,821. Working costs amounted to 19s. 5·52d. per ton, or, including development redemption, to 23s. 10·54d. per ton. After providing for depreciation, etc. and placing £4,500 to contingencies, there was a credit balance of £50,060, which, with the sum of £10,465 brought in, gave an available total of £60,525. Of this amount, £27,141 was distributed as dividends, equal to 18¾%, and £20,000 was placed to reserve, leaving a balance of £13,384 to be carried forward. The ore reserves at the end of the year were estimated to be 355,965 tons, averaging 31s. 2d. per ton. The work of opening up the Cinnamon Bippo property is in progress and the plant necessary to unwater and equip the mine is in course of shipment and erection.

Kaduna Prospectors. — This company was formed in 1913 and works alluvial tin property

at the Bauchi plateau, Northern Nigeria. The report for the year 1931 shows the output of tin concentrates to have been 139 tons, which realized £73 17s. 4d. per ton, as compared with 240·5 tons, realizing £85 14s. 5d. per ton, in the previous year. Output was, of course, restricted in accordance with general policy. The operating profit for the year was £1,277, which, added to the sum of £3,908, brought in, gave an available total of £5,185. The sum of £2,000 was transferred from reserve to cover a part of the depreciation in investments and, after making other allowances, there remained a balance of £3,289, which was carried forward.

Kaduna Syndicate.—Formed in 1910, this company is working alluvial tin property in Northern Nigeria. The report for 1931 shows that 256 tons of concentrates was recovered, which realized £69 12s. 8d. per ton, as compared with 386 tons, realizing £82 15s. 5d. per ton, recovered in the previous year. The operating profit for the year was £3,787, which, added to the balance of £3,674 brought in, gave an available total of £7,461. After making various allowances and transferring £3,000 from reserves, to meet depreciation in investments, there remained a sum at credit of £6,141. Of this amount £2,000 was distributed as a dividend, equal to 5%, leaving a balance of £4,141 to be carried forward.

Great Boulder Proprietary.—This company, formed in 1894, works a gold mine in the East Coolgardie district of Western Australia. The report for 1931 shows that 97,789 tons of ore was treated, yielding 79,547 oz. of gold worth, after deducting the cost of realization, £249,992. The net profit for the year was £35,971, against £4,847 in the previous year, and £21,875 was distributed as dividends, equal to 12½%. The ore reserves at the end of the year were estimated to be 132,139 tons, averaging 8·127 dwt. per ton, as compared with 87,064 tons, averaging 8·997 dwt. per ton, at the end of the previous year. Exploration by diamond drilling on the X lode was carried out during the year, joint bore No. 382 at 95 ft. south of the northern boundary on the 1,750 ft. level being extended 793 ft. At 120 ft. west of the boundary this bore penetrated lode material continuing to 123 ft., the ore averaging 10 dwt. per ton. At 301 ft. west of the boundary a 12 in. vein was struck, averaging 6 dwt. in value per ton. The balance of the core was in quartz-dolerite greenstone country. Recent favourable developments at the property are referred to elsewhere in this issue.

Pengkalen.—Formed in 1907, this company works alluvial tin property in the Kinta district, F.M.S. The report for the year to September 30 last shows that the two dredges treated, under restriction allowance, 2,424,660 cu. yd. of ground (against 2,643,170 cu. yd.), recovering 727·77 tons of tin concentrates, worth £51,917. The profit for the year, after making allowances for depreciation etc., was £9,219, making, with the balance of £27,178 brought in, an available total of £36,397. Of this amount £7,000 was distributed as dividends, equal to 10%, and, after making other allowances, the balance of £21,913 was carried forward.

Sungei Kinta.—This company was formed in 1925 and works alluvial tin property in the F.M.S. The report for 1931 shows that 1,212,000 cu. yd. was treated by one dredge, 315¾ tons of concentrates being recovered, worth £23,465, the working profit being £5,337. The area worked out during the year amounted to 22·47 acres, the average depth being 33·43 ft. The net profit for the year was £654 and, after making various allowances and adding the sum brought in, there was a balance in credit of £2,055, which was carried forward.

Tekka-Taiping.—This company was formed in 1919 and works alluvial tin property in the district of Larat, Perak, F.M.S. The report for the year to October 31, 1931, shows that Nos. 2 and 3 dredges treated 2,269,000 cu. yd. of ground during the year, as compared with 2,412,000 cu. yd. treated by the three dredges in the previous year, the tin concentrates recovered amounting to 590·4 tons, worth £41,074. The profit for the year was £1,198, after writing off £9,350 for depreciation on machinery and plant. With the balance of £19,175 brought in, together with £10 recovered on an investment, there was an available total of £20,383, which was carried forward.

DIVIDENDS DECLARED

Ashanti Goldfields.—1s., less tax, payable May 31.

Frontino.—Pref. 1s., Ord. 9d., less tax, payable July 1.

Great Boulder Proprietary.—3d., less tax, payable June 28.

Lonely Reef.—2s., less tax, payable July 29.

Malayan Tin Dredging.—1½d., less tax, payable June 17.

North Broken Hill. — 1s. 6d. (Australian currency), less tax, payable June 30.

Sons of Gwalia.—6d., less tax, payable July 27.

Taquah and Abosso. — 6d., less tax, payable June 10.

Tekka.—3d., less tax, payable May 31.

Transvaal and Delagoa Bay.—1s. 6d., less tax.

Trepca Mines.—3%, less tax, payable June 16.

Waihi Grand Junction.—4d., free of tax.

Zinc Corporation.—Pref. 2s. 6d., Ord. 6d., less tax, payable July 1.

NEW COMPANIES REGISTERED

Fricker's Metal and Chemical.—Registered as a public company. Capital: £300,000 in 50,000 8% cumulative preference and 250,000 ordinary shares of £1 each. Objects: To acquire the whole or any part of the undertaking of Fricker's Metal Co., Ltd. (now in liquidation). The purchase consideration for the above business is £117,250 in shares, credited as fully-paid up. The company are to allot to the Imperial Smelting Corporation, Ltd., 20,000 ordinary shares, credited as fully-paid up, and shall grant to them an option to take up at par 20,500 preference and 87,250 ordinary shares. Directors: Lindsay Scott, W. S. Robinson, L. B. Robinson. Office: Norfolk House, Laurence Pountney-hill, E.C.

West African Mines and Estates.—Registered as a public company. Capital: £35,000 in 2s. 6d. shares (120,000 7% non-cumulative preference and 160,000 ordinary). Objects: To aquire the business carried on by West African Mines and Estates, Ltd. (in liquidation). Directors: G. Parkins, S. S. Briggs, S. Bratchell. Office: Broad Street House, Old Broad Street, E.C. 3.