The Mining Magazine

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CONTENTS

EDITORIAL

THE Royal School of Mines 56th annual dinner will take place at Gatti's Restaurant, Strand, on Wednesday, June 21.

EDINBURGH is this year's venue for the summer meeting of the Institution of Mining Engineers, which is to take place from July 12 to July 14.

A FURTHER course of instruction on the practical control of malaria is to be given at the Ross Institute, Putney Heath, from June 19 to June 23, to which members of the Institution are invited.

THE 1933 issue of the "Oil and Petroleum Year Book," by Walter E. Skinner, which has been published annually for the past 24 years, is now available. A number of additional foreign oil companies has been included, thus making the book still more useful.

THE Birthday Honours List contains the name of Mr. R. Arthur Thomas, who receives the O.B.E. for his work as chairman of the Metalliferous Mining Advisory Committee. Dr. George C. Clayton, a director of Imperial Chemical Industries and president of the Institute of Chemistry, receives a knighthood.

EARLY this month the Anglo-Persian Oil Company was informed by the Persian Ministry of Finance that the new concession agreement between the company and the Persian Government had been signed by the Shah, after ratification last month by the Medjliss. The main features of the new agreement have already been published and it is reassuring to learn that the payment of a dividend to the ordinary stockholders is not expected to be affected by the considerable sums due in the near future to the Persian Government.

AT the eighth annual meeting of the Benevolent Fund of the Institution of Mining and Metallurgy the chairman (Mr. H. K. Picard) drew attention to the substantial increase in income—actually it is more than double that of the previous year—which the committee attribute largely to the publicity given in these columns serving as a reminder to many who might otherwise have lost sight of the fund and its necessities. The need being still unfortunately great, it is hoped that all will continue to give the fund the support it deserves.

THE World Economic Conference, opened by His Majesty the King on June 12, is now in session and great hopes are centred on the results of its deliberations. It seems evident that before international trade can be restored to its former free-flowing channels the principle of national economic self-sufficiency will have to be, in part at least, thrown overboard and tariff walls and exchange restrictions considerably modified. Whatever opinions may be held with regard to the results likely to be achieved by the conference, it is certain that its efforts are of the utmost concern to the whole of the civilized world.

IN the report of the Director for 1932[1] the manifold activities of the Imperial Institute are recorded. Of principal importance is the work of the Mineral Resources Department, which, in addition to a considerable number and variety of routine technical investigations on behalf of private firms and individuals, carried out certain special inquiries. Notable among these were the work of the Legal Committee on points in connexion with the draft of a mining proclamation for Bechuanaland Protectorate and the issue of a questionnaire on the subject of royalties in force on minerals throughout the Empire. The data obtained in reply to the latter is being correlated and will be published later.

The Institution Annual Meeting

According to custom the May meeting of the Institution was reserved for submitting the annual report of the council and for the other business usually dealt with on this occasion, such as the presentation of awards and the induction of the new president. Meetings of the Institution during the past session have all been well attended and that held last month was no exception.

The retiring president (Dr. Sydney W.

[1] Annual Report by the Director of the Imperial Institute to the Board of Governors. Price 2s.

Smith) was able to look back on a most successful term of office. After making brief reference to the main features of the annual report, he turned to the technical sessions that had been held during the year, recalling that discussions had ranged over a wide variety of topics of interest to the mining and metallurgical engineer, starting with the transport of machinery by air and covering many other aspects of professional activity. Coming to the annual awards, he reviewed the career of Sir John Cadman, to whom the gold medal had been awarded. Sir John, who, fortunately, was present, briefly replied and Dr. Smith then presented the Gold Fields medal to Mr. Charles A. Banks. The Gold Fields premium was accepted by Mr. John C. Allan for himself and Mr. John L. Francis, while Mr. Gordon Williams received the William Frecheville Student's prize. In seconding the resolution for the adoption of the report—which was carried without dissent—Mr. E. T. McCarthy briefly reviewed the sound financial position of the Institution. Mr. Robert Annan, in proposing a vote of thanks to the retiring council, referred to the good papers that had been brought forward for discussion, to the work of the Institution in aiding members to find employment, and to the loyal efforts of the permanent staff, concluding by congratulating members on the presence of those who, he felt, might be regarded as the "Elders"—Messrs. McCarthy, McDermott, and Hooper. The vote was seconded by Mr. Llewellyn Parker and briefly acknowledged by Dr. Smith. The vote of thanks to the retiring president was proposed by Professor C. G. Cullis, who congratulated Dr. Smith on a successful year and recalled that he was one of a distinguished group of students who graduated from the Royal School of Mines in 1899, pointing out that his successor, Mr. G. W. Gray, was also in that group. Mr. Humphrey Morgans seconded this vote in a brief but witty manner and Dr. Smith having replied the new president was inducted.

In his inaugural address Mr. Gray briefly referred to the difficulty he had experienced in preparing a thesis on a complex but extremely topical subject. He had set out intending to review the progress that had been made in the improvement of mining technique and the effect of these improvements on working costs. His researches, however, had led him to consider the future. He found that until comparatively recently the great steps forward in the arts and industries had been few and far between, while the knowledge of their application had been the property of individuals. To-day things were very different. The work of the technical institutions and the technical press had resulted in a world-wide dissemination of knowledge, with the result that the elements of the technique of organization and of the efficient planning of industry were known to every student. At the same time the technique of finance was also more widely understood, the result being that the increase in output had been something enormous. As with individuals so with nations and Mr. Gray recalled that nowadays it may be easier to obtain the highest standards of labour efficiency in a country or district where no well-established customs or traditions exist. By the aid of curves he was able to show the trend of events in this direction in the United States, these indicating that, while the population of that country now approached a steady level, the output of commodities continued to rise enormously, although the number of working-days marked a decrease. It will be agreed that the subject chosen by Mr. Gray for his address is of vital interest and his courage in making the choice is worthy of commendation. The remedies for the solution of this situation—which is prevalent throughout the world—are widely sought and that generally recognized as likely to prove most effective is a reduction of working hours. Mr. Gray recalled that it had been difficult to introduce the 48-hour week and it was proving equally difficult to introduce the 40-hour week, but even this limit might have to be still further reduced. As Mr. Gray attributed the rapid growth of efficient industrial technique to the schools, institutions, and technical press, he felt that we must look to them for the required solution, which would necessitate a readjustment of present ideas and a modification of recognized standards. The problem can hardly be left to governments for solution, for, as Mr. Gray pointed out, these are too fully occupied with the difficulties of the day to plan for the future, and he considered that, after all, changes that had taken place as the result of technical progress should be dealt with by those who had really been responsible for bringing them about, a view with which we cannot but agree. The workless man is with us to stay; he must be cared for and the sooner we find out how it can best be done the better.

The New Museum of Practical Geology

The progress of building work at South Kensington, where the new Museum of Practical Geology that will house the headquarters of the Geological Survey of Great Britain has been gradually taking shape, has been watched with close interest by those who know the somewhat restricted conditions under which this branch of the Department of Scientific and Industrial Research has to work in Jermyn Street and the disability under which it is placed in displaying its magnificent collections to the public. In August, 1930, we were able to describe the lines on which future work would be planned,

while in July, 1932, a description of the proposed layout of the new museum was given in these columns. The report of the Geological Survey just issued [1] shows that it had been hoped to occupy the survey offices at South Kensington in March, that the library would be ready in July, and that the museum proper would have been available in October next, but, as was announced in the MAGAZINE last month, the change-over will have to take place at a later date, for the World Economic Conference—to which further reference is made elsewhere—is now holding its meetings in the new building, the façade of which is shown in the accompanying photograph. The edifice, with its front of Portland stone, makes a pleasing addition to the many notable buildings in the neighbourhood and those who are to occupy it, although they may feel impatient at the delay, will probably agree that, in choosing it as an assembly-hall for the delegates to the largest and, it is to be hoped, the most important conference the World has ever seen, our numerous visitors will have received an introduction to one of the most imposing and pleasant parts of London.

Interest in the future home of the Survey and in the use to which it is now being put, however, should not be allowed to disguise the fact that several of the activities of the Survey are worthy of mention. The geophysical work in the field has, temporarily at any rate, been suspended, as was recorded last year, the Survey's instruments having been handed over to the new geophysical department at the Imperial College, but the preparation of reports on surveys already made has been continued, while a special investigation on the magnetic properties of certain igneous rocks as bearing on anomalies observed in the field has been carried out. A joint investigation into the properties of British building stones is being carried out with the officers of the Building Research Station and is at present concerned with the oolitic secondary limestones, especially Portland stone and others of a similar type, and with the magnesian limestones. A new field of interest has, it is stated, been opened up by the discovery that certain slates have properties that may make them useful in directions hitherto unexplored. The work of map revision, collection of data and specimens, and careful surveying of little-known areas goes on and it is a source of satisfaction that the Survey's activities are conducted with every sign of efficient organization.

[1] Summary of Progress of the Geological Survey, 1932, Part 1. Price 2s. London: H.M. Stationery Office.

Metals in the Service of Man

In the preface to his book "Man and Metals" Dr. T. A. Rickard recalls the publication in 1920 of the "Outline of History," by H. G. Wells, expressing the opinion that Mr. Wells had paid too little attention to the effect of metallurgical discoveries on man's progress through the years, and he endeavours in his own work

to show how the advances in civilization have followed on such progress. Something of this history of man in relation to metallurgy is known to mining men—indeed to all men—for the terms "stone age," "bronze age," and "iron age" are familiar as marking epochs in the history of mankind. Last month, in a lecture delivered under the auspices of the British Science Guild, Sir Harold Carpenter traced some of the main trends in this fascinating history, the title of his discourse, "Metals in the Service of Human Life and Industry," being self-explanatory. The subject is so full of interest that it seems well worth while to refer to this lecture at some length.

There can be no question of the truth of Sir Harold Carpenter's assertion that metals have contributed more than any other product of man's effort to the material comfort of the human race, the most striking engineering achievements having followed rapidly on metallurgical discoveries. When reviewing metallurgical research in these columns it has often been observed that the engineer waits on the metallurgist, ever eager for the better materials which will help him in carrying out his more ambitious projects, while the construction of the machinery on which so much of our present-day standards largely depends may with equal truth be called the finished products of combined engineering and metallurgical skill. Sir Harold, pointing out the ingenuity with which the engineer fastens on to each new discovery, quotes the modern motor-car as a good example of the focussing of numerous industries on one product, for it contains nearly every kind of metal in common use, including different varieties of steel and cast iron, brass, bronze, bearing metals, aluminium, nickel, chromium, tungsten, and copper, while the ores from which these metals are prepared are scattered all over the world. It must be realized, however, that metals have contributed as much to man's mental progress as to his material comfort, the applied sciences having their roots in the old-time metallurgy of the alchemists, while engineering has developed with them.

In pursuit of his narrative Sir Harold first dealt with the composition of the earth's crust, pointing out how geological processes have concentrated certain quantities of metals here and there into economically workable deposits, although the metals themselves can only be extracted by the application of elaborate metallurgical processes. The evidence available indicates that man has only known the use of metals for some 5,000 to 6,000 years, so that he spent some 99% of his existence in ignorance of metals, while for 98% of the remaining one per cent he only used them scantily. As Dr. Rickard has pointed out, the outstanding step that has rendered our modern civilization possible was the finding of a process of smelting metal from a stone, an invention which Sir Harold ranks with the discovery of artificial methods of producing fire. From the earliest use of smelting the art of metallurgy progressed but slowly until the nineteenth century, the advance being particularly rapid during the last 70 years. It is hard to realize that more metal has been used during the 30 years just past than in all previous time. Turning to the influence of science on the metallurgical arts, Sir Harold regards the existence of aluminium as an industrial metal as the most conspicuous illustration of this, considering that it is not too much to say that to-day iron and aluminium are the two most valuable metals we know, the one having been in use for 3,000 years, the other for less than 50. It is notable, however, that, although aluminium is so young a metal, our scientific knowledge of it is, in the lecturer's opinion, as complete as that of iron. The mere discovery of a metal and its uses, however, has never contented mankind; his research on alloying has been constant and fruitful and now even more discoveries crowd upon us. New carbide tools, for example, are rapidly coming to the fore to revolutionize machining, while many alloys have solved what seemed once to be insuperable engineering difficulties. Take manganese steel—which afforded Sir Harold an opportunity of paying a tribute to Sir Robert Hadfield—here is a material that will stand up to intense wear, which is an important factor as much in railway and tramway trackwork as in crushing machinery linings, and which saved many lives in the War when it was used for the well-known "tin hat," although the lecturer did not refer to this latter usage. It will be realized that tonnage produced can hardly be reckoned as a satisfactory indication of the usefulness of a metal, for many—such as chromium, tungsten, and cobalt—are now considered indispensable adjuncts to modern civilization. It is, in fact, a story without an ending, for, as Sir Harold has pointed out, no one can imagine what the next twenty years will bring.

REVIEW OF MINING

Introduction.—The chief event to be chronicled is the World Economic Conference, to which reference is made elsewhere. Perhaps next in importance is the all-round recovery shown by the latest employment figures, all industries apart from coal mining participating in the improvement. As to metals, the prices of these also have generally moved in the upward direction.

Transvaal.—The output of gold on the Rand for May was 893,464 oz. and in outside districts 51,140 oz., making a total of 944,604 oz., as compared with 895,097 oz. in April. The number of natives employed in the gold mines at the end of May totalled 227,178, as compared with 225,279 at the end of April.

Rumours as to the likelihood of the Union Government increasing taxation so as to secure a considerable part of the premium now enjoyed by the gold mining industry were confirmed at the end of May, when Mr. Havenga, the Finance Minister, in introducing his budget, stated his intention to take £6,000,000 of the gold premium by special taxation on the actual profits made over a calculated statutary standard. Owing to the ambiguous nature of the budget statement a good deal of uncertainty arose as to the effect of the new taxation proposals, the contention of the Transvaal Chamber of Mines being that the increased amounts to be taken by the Government would be greatly in excess of the figures quoted. A subsequent announcement of the Minister of Mines, however, is to the effect that any excess above £6,000,000 will be refunded. It is still anticipated that as the result of the increased taxation the contemplated treatment of a lower grade of ore and the opening up of new areas will be seriously affected.

Considerable progress has been made in the boring work being carried out by West Witwatersrand Areas and it was stated last month that the Venterspost bore-hole No. 11 had entered the Witwatersrand Series at a depth of 3,098 ft.

Encouraging developments on the Luipaard's Vlei property have, it is stated, resulted in a decision to increase the company's treatment plant.

It was announced last month that the Government had invited tenders for the leasing of areas totalling 2,594 claims on the East Rand, on farms adjoining the properties of the Brakpan, New Kleinfontein, East Rand Proprietary, and Van Dyk companies.

The report of Glynn's Lydenburg for the three months to April 30 last states that the loan from the Central Mining and Investment Corporation has been repaid and the corporation has exercised its option to take up 5,000 reserve shares at par.

The Welgedacht Exploration Company has announced its intention of undertaking an aerial survey of its properties with a view to selecting boring sites.

In order that the money required for the sinking of a new shaft on the southern section of the New Kleinfontein property might be available an issue of £250,000 6% convertible debentures was provisionally underwritten for the operating company last month.

At a meeting of the 6% debenture holders of the Pigg's Peak Development Company held this month the sale of certain assets to South African H.E. Proprietary was approved.

At a meeting of the African Asbestos Trust to be held next month it will be proposed that the company should go into voluntary liquidation.

The accounts of the General Mining and Finance Corporation for 1932 show a profit of £229,378, making, with the balance brought in, an available total of £244,175. Of this amount £126,458 was absorbed in the payment of a dividend, equal to 10%, and, after allowing for taxation, there remained £110,740 to be carried forward.

The report of the African and European Investment for 1932 shows a profit of £10,394, against £2,831 in the previous year, the amount carried forward now amounting to £23,838.

Diamonds.—The report of the Consolidated Diamond Mines of South-West Africa, Ltd., for 1932, shows that mining operations were suspended as from July 1, 1932, and limited prospecting work has since been carried out on the marine deposits directly north of the Orange River mouth, with, it is stated, satisfactory results. The accounts show that the unappropriated balance of £372,196 at the end of 1931 has been decreased to £277,406, after allowing for debenture interest and depreciation.

For the six months ended December 31 last there were no productive operations on the property of the De Beers Consolidated Mines, which has decided to change the end of its financial year from June 30 to December 31. Revenue on diamond account was only £429, as against £307,822 for the preceding twelve months.

A new agreement for the diamond industry has been concluded as the result of the conference between the Union Government and the producers held last month.

Southern Rhodesia.—The output of gold from Southern Rhodesia during April was 53,559 oz., as compared with 49,929 oz. for the previous month and 46,487 oz. in April, 1932. Other outputs for April were : Silver, 8,619 oz. ; coal, 43,594 tons ; chrome ore, 5,377 tons ; asbestos, 3,664 tons ; iron pyrites, 812 tons.

The arrangement for the purchase of the mineral rights of the British South Africa Company in Southern Rhodesia for £2,000,000 was approved by the Assembly of Southern Rhodesia early this month.

In order that the company's liabilities be liquidated and working capital for development provided, it is proposed to increase the capital of the Sherwood Starr Gold Mining Company to £125,000 by the creation of 100,000 new 5s. shares, to be offered to the present shareholders at 10s.

Northern Rhodesia.—It was announced last month that the Roan Antelope Copper Mines is arranging to replace the existing £1,500,000 7% debenture stock by a similar amount of 6% stock. At the same time 431,716 shares are to be offered to existing holders at 21s. The proceeds of the new issue will be available for smelting plant extensions as soon as these are required.

The report of the Rhodesia-Katanga Company for 1932 shows that work at the Kansanshi mine, where there are estimated to be 10,925,000 short tons of ore averaging 4·34% copper and 0·4 dwt. gold, was suspended in November last. The company is at present interested in the development of the Kakamega goldfield, Kenya.

The accounts of Rhodesian Anglo American for the year to March 31 last showed a revenue of £80,643, against £25,733 for the previous year. After adding the sum brought in and making various allowances there was an unappropriated balance of £154,559 to be carried forward.

The report of Mr. Justice Maugham on the re-opened North Charterland inquiry states that charges of bad faith having entirely failed there is no reason to revise the findings of his first report.

Gold Coast.—A new company, known as Gold Coast Banket Areas, having a capital of £500,000 in 2s. shares, has been formed to take over various properties in the Tarkwa district from Fanti Mines, Effuenta Mines, and the Fanti Consolidated Investment Company in return for shares.

An arrangement was concluded last month between the West African Gold Corporation and Gold Coast Selection Trust whereby the assets of the former company were merged with those of the latter. An extensive programme of exploration is in hand.

Nigeria. — The accounts of Kaduna Syndicate for the year to October 31 last showed a profit of £6,992 and including a profit on the realization of investments and the sum brought in from the previous account there was an available total of £13,091, from which various allowances were made, leaving £8,079 to be disposed of. After payment of a dividend equal to 10% there remained £4,079 to be carried forward. During the year 206 tons of tin concentrates was produced, against 256 tons in the previous year.

During the year to October 31 last the Kaduna Prospectors, Ltd., made a profit of £1,188, which, added to the sum brought in and including sundry profits, gave an available total of £4,748. After allowing for depreciation and other items there remained £3,942 to be carried forward. The output of tin concentrates for the year was 93 tons.

The report of Ex-Lands Nigeria for 1932 shows a profit of £1,960, increasing the credit balance brought in to £30,601, which it is proposed to carry forward. The output of tin concentrates totalled 365 tons, against 592 tons in 1931.

The report of Associated Tin Mines of Nigeria for 1932 shows an operating profit of £7,565, increasing the sum brought in to £90,485, of which £41,522 has been appropriated for depreciation and non-recurring expenditure, leaving £48,963 to be carried forward. Under restriction conditions the company's output of tin concentrates was limited to 1,621 tons, a reduction of 1,022 tons on the figure for the previous year, operating costs increasing, in consequence, to £68 17s. per ton f.o.r. Bukeru.

The profit of the Nigerian Electricity Supply Corporation for the year to

February 28 last was £19,521. It is proposed that certain assets of the corporation should be written down by £171,002 and to effect this meetings are to be held later this month at which it will be proposed that the ordinary share capital should be reduced from £200,000 to £50,000.

Australia.—A circular to shareholders of the Lake View and Star, issued last month, stated that the ore-treatment plant was now complete, over 40,000 tons being treated in March and April. The new power plant is estimated to have resulted in a saving of £5,000 per month.

At the annual general meeting of Great Boulder Proprietary Gold Mines, to be held this month, it will be proposed that the capital of the company be increased to £250,000 by the creation of 750,000 new 2s. shares, 583,333 of which are to be offered to existing shareholders at 5s. per share. The erection of a new treatment plant is under way and recent developments at the mine are stated to be favourable.

It was announced early this month that in order to provide a reserve which will enable the company to participate in any promising ventures that might be offered Gold Mines of Australia, Ltd., propose to make an issue of shares at par to existing holders, three shares to be offered for every two held.

The profits of the Kalgoorlie Electric Power and Lighting Corporation for last year were slightly higher at £22,500, the dividend being maintained at 6%. The company continues to improve its plant, additions to properties and plant last year being estimated at £19,500.

Burma.—During 1932 Tavoy Prospectors, Ltd., suffered a loss of £472, increasing the debit balance brought in to £1,811.

Malaya.—The profit of Sungei Besi Mines for 1932 amounted to £83, increasing the balance brought in to £22,108. Under restriction conditions the year's output of tin concentrates totalled 314 tons.

Arrangements have been made to re-start the Temoh company's dredge on July 1.

China.—The report of the Pekin Syndicate for the year to June 30 last states that the Wang Feng Colliery is now producing and that an administrative agreement has been reached with the Chung Yuan Mining Company.

Mexico.—The report of the Mazapil Copper Company for 1932 shows a loss of £69,353, increasing the debit balance to £162,026. The directors have granted an option to purchase the property, excluding the interest in the New Sabinas Company for a lump sum payment of £150,000.

United States.—It was announced last month that the trustees of the Mountain Copper Company are to redeem by drawing at par £40,000 of the outstanding £77,675 of debenture stock.

Yugoslavia.—The directors of Trepca Mines have declared an interim dividend equal to 6%, as compared with an interim payment equal to 3% a year ago.

Holland.—The operations of the Billiton Tin Company for 1932 resulted in a small loss—£270—against a loss of £130,000 in the previous year.

Portugal.—Shareholders of Beralt Tin and Wolfram, Ltd., have been informed that a contract has now been arranged for the sale of ferro-tungsten and other alloys.

Chemical and Metallurgical Corporation.—A circular to shareholders of the Chemical and Metallurgical Corporation stated last month that negotiations were in hand for the sale of the whole of the issued share capital.

British-Borneo Petroleum.—The report of the British-Borneo Petroleum Syndicate for the year to March 31 last shows a profit of £26,991. After payment of a dividend equal to 7½% there remained £20,738 to be carried forward.

Tin.—The price of tin during the past month has steadily increased and it is now well over £200 per ton. Demand from the United States has been particularly good, a remarkable upswing in tinplate demand in that country having brought the output up to 90% of capacity. The report of the Tin Producers' Association for 1932 states that the International Tin Research and Development Council is busily engaged in exploring such improvements as will lead to an increased demand for the metal.

Copper.—The Copper Development Association, formed last month, has, under the chairmanship of Mr. A. Chester Beatty, speedily got down to work and is inviting applications for the post of general manager. In America there has been much talk of a copper agreement and it is expected that through the Administration's Industrial Control Bill a plan will be evolved by which some mines will be closed down completely and others limited to an output equal to 10% of capacity.

RUBY MINING IN UPPER BURMA

By J. COGGIN BROWN, D.Sc., M.Inst.M.M.

The author deals with the history of the industry and describes the geology of the deposits, the mineralogy of the gemstones, and both native and European mining methods, concluding with a discussion as to prospects.

INTRODUCTION.—Gem mining in Burma, in areas which have been notified as "stone tracts," is not governed by the rules applicable to ordinary minerals, but by the provisions of the Upper Burma Ruby Regulation of 1887. There are four of these stone tracts in Burma proper and three in the Federated Shan States. The former include the Mogok Tract and areas within the Thabeitkyin township of Katha district (22° 53′ : 96° 1′); around Naniazeik in Myitkyina (25° 37′ : 96° 37′), and near Sagyin (22° 17′ : 96° 7′), 16 miles north of Mandalay (Fig. 1). Besides the ruby, sapphire, and spinel, for which the country is renowned, Burma produces many other precious and semi-precious stones, including the gem varieties of the following minerals :—Quartz (amethyst, etc.), apatite, beryl (aquamarine), chrysoberyl, epidote, garnet, iolite (water sapphire), jadeite, lapis lazuli, felspar (moonstone), olivine (peridot), phenacite, tourmaline (rubellite), topaz, and zircon (jacinth).

THE MOGOK STONE TRACT.—The observations which follow refer entirely to conditions in the Mogok Stone Tract, for no mining has been attempted in any of the others for many years and their exploration has not been particularly encouraged.

The Mogok Tract occupies an area of over 600 square miles of mountainous, deeply-dissected, and for the most part forest-clad country in the Mogok Township of Katha District, on the east of the Irrawaddy. Geographically it forms part of the Shan Highlands. Geologically it is made up of gneisses and associated rocks of Archæan age, amongst which are the bands and masses of crystalline limestone from which some of the gems have been shed into the detrital and valley deposits whence they are now won. These Archæan rocks probably extend through the Mongmit State on the north and join with similar strata known to occur in the hills which form the Burma - China frontier region between Bhamo and Têng-yüeh.

Mogok (22° 55′ : 96° 33′), a town of about 10,000 inhabitants, all of whom are dependent on the gem industry, is connected by a motor road, 60 miles long, with Thabeitkyin, a river port, 70 miles north of Mandalay. From Thabeitkyin, at 200 ft., the road gradually rises in an easterly direction, attaining an elevation of over 5,000 ft. above sea-level before descending to the Mogok valley at approximately 4,000 ft. This is a picturesque locality, surrounded by lofty mountain ranges, culminating in Taung Me, 7,544 ft., to the north. The climate is good, malaria and the tropical epidemic diseases are rare, and the rainfall averages about 100 in. per annum. The local labour forces are augmented by abundant transfrontier Maingthas and Yunnanese Chinese during the open season. Mining in recent years has been restricted to an area in the east of the tract, approximately 20 miles across from east to west and 10 miles from north to south. Important

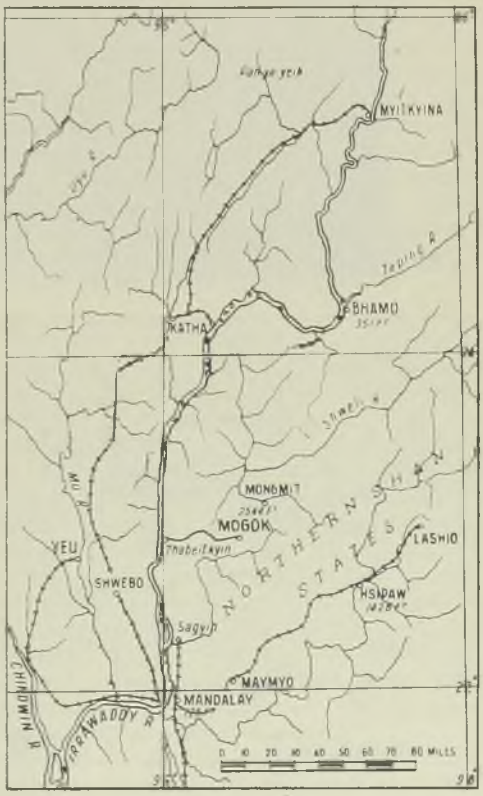


FIG. 1.—SKETCH MAP OF UPPER BURMA TO SHOW RUBY LOCALITIES.

subsidiary centres in this are Kathe, 8 miles, and Kyatpyin, 10 miles west of Mogok on the main road (Fig. 2).

Early History.—The earliest reliable Burmese reference to the mines is in a royal edict of the contemporary monarch dated A.D. 1597, which proclaims that Mogok and Kyatpyin, until that time part of the territories of the Shan State of Mongmit, should thereafter be included in the Burmese realm, the Shan State being granted the town of Tagaung in exchange. The document naively adds—"The officials concerned must take over the rubies, with a list of all descriptions, big and small, and pay into the Treasury."

It is evident from this edict that at the time ruby mining was an established industry and the date of its foundation is likely to remain unknown. Many of the early European adventurers in the East knew of Burmese rubies and interesting historical details occur in the writings of Santo Stefano (15th century); Ludovic di Varthema, who visited Pegu in 1496; Duarte Barbarosa (1501–16); Cæsar Fredericke (1569), and the London merchant Ralph Fitch (1586). Fredericke, who resided in the Burmese capital for some time, states that one of many titles of the king was "Lord of the Mines of Rubyes, Safyrs and Spineles," while his account of the methods of the ruby brokers might have been written of the native gem bazaar in Mogok to-day. According to Fitch, rubies were so abundant in Pegu "that they know not what to do with them, but sell them at most vile and base prices."

Fig. 2.—Sketch Showing the Eastern End of the Mogok Stone Tract.

The kings for obvious reasons shrouded the mines with the greatest secrecy possible and it was not until 1833 that Père Guiseppe d'Amato was the first European to visit them. At Kyatpyin he found square shafts, 20 or 30 ft. deep, sunk to the gem-bearing gravel below the valley floor, lateral galleries being sometimes made from them, but the influx of water soon caused their abandonment and the sinking of new ones. Besides rubies and sapphires, topaz and oriental emeralds were then being found and spinels were abundant.

A proclamation by a later king, dated 1783, exists. It extended the boundaries of the tract and they continued to be enlarged until at the time of the British Annexation in 1886 they enclosed their present area.

The best stones were always regarded as the perquisite of the kings. Thus Father Sangermano, an Italian priest who lived in Ava between 1783 and 1806, wrote as follows:—"It is the rubies of the Burmese Empire which are its greatest boast, as both in brilliance and clearness they are the best in the world. The Emperor employs inspectors and guards to watch the mines and appropriates to himself all the stones above a certain weight and size; the penalty of death is denounced against anyone who conceals, or sells, or buys any of these reserved jewels."

During the reign of King Mindon Min (1855–1898) the governorship of the Stone Tract was auctioned to the highest bidder and the latter's payment in silver to the royal treasury gave him the sole right to purchase gems. A race of hereditary miners had in the meantime evolved, partly from prisoners of war banished to the mines by various kings. Their descendants, carefully enumerated and registered, are the only natives permitted to mine in the tract at the present time.

It is necessary to describe very briefly the conditions ruling at the time of the annexation, not entirely as a matter of history, for, modified in accordance with British ideas of equity, they formed the foundation on which the Upper Burma Ruby Regulation of 1887, the existing law, was laid down. The Stone Tract then formed part of the private estates of the Burmese kings, managed directly on their behalf at first and at a later date farmed out for what it would fetch. King Mindon is

believed to have received about one lakh of rupees per annum from this source of revenue. King Thebaw, the last of the Burmese monarchs, undoubtedly obtained a larger sum, but his attempt to raise it to two and a half lakhs of rupees nearly ruined the industry.

The local officers, or " so-thugyis," as they were called, were given a free hand both as to the total revenue raised and the methods employed in its collection, so long as the lessee's demands were met. The latter possessed an option to buy all gems found by the miners, except those reserved under the royal prerogative. In cases of disagreement regarding valuation the stones were sent to the ruby mart at Mandalay to be sold for the owner. He in the meantime had to pay the " Seal Tax," buy an export permit, deposit 25% of the estimated value of the parcel—which, needless to remark, was pocketed by the lessee—and run the risk of the gems being stolen on their way to the capital. The lessee also collected a house tax from the miners and levied an irregular cess at times suitable to himself. In addition to all this he augmented his income by monopolistic money lending, by imposing rates on the local produce markets, and by auctioning out the gambling saloons at the mines. Exorbitant taxation of every conceivable form and perpetual harassments of the kinds described could have but one end, expressed in a few words many years ago by a British officer who was well acquainted with the situation in the following sentence :— " Had it not been for the annexation taking place about that time the Stone Tract would have been almost deserted."

Fig. 3.—View Looking South-West down the Mogok Valley.

European Developments.—Mogok was occupied in December, 1886. In October, 1887, the Ruby Regulation came into force. It empowers the Government to notify the boundaries of the stone tracts and to make rules regarding the mining, cutting, possession, buying, selling, and carrying of precious stones. Under one clause, 5 (2), a licensed miner is compelled either to (*a*) sell at his own valuation to the lessee all the gems he may find or (*b*) pay on that valuation to the lessee such duty as the Government may direct. Here we find embodied the chief privilege of the lessee under the Burmese regime.

From the commencement of the British era registration of the mines was adopted to prevent illicit working and annual fees of Rs. 50, 25, and 12 were levied according to the character of the operations. In 1889 Messrs. Streeter and Co. were recognized as the lessees, but before the lease was granted to them Mr. Barrington Brown reported on the industry for the Secretary of State. His specimens were examined by Professor Judd and formed the basis of his classical petrological studies of the area.

The first lease embodied Clause 5 (2) of the Regulation mentioned above, the amount to be received under the second option being placed at 30% of the valuation which

the miner placed on the stone. It was also provided, however, that the Government, in concurrence with the lessee, could issue licences to the miners at fixed fees and that the lessee could take these as royalties in lieu of the other privilege. In practice, except for a very short time, this latter alternative has functioned, for without the arbitrary compulsion of the Burmese officialdom it proved impossible to force the miners to adopt the other course. The lessees then collected the rents brought in by the miners and organized their own staff to supervise them. The lessees were also granted an exclusive right to mine for gems by any method they liked to adopt in unoccupied lands not reserved by the Government for the native miners. Their hereditary rights, then as now, have always been rigorously safeguarded. For these and other privileges the lessees agreed to pay a rent of Rs. 4 lakhs per annum and a further sum of one-sixth part of their net annual profits to the Secretary of State for India.

The Burma Ruby Mines, Ltd., was floated on February 27, 1889, with a capital of £300,000, amidst scenes of extraordinary enthusiasm in St. Swithin's Lane, but the usual crop of unforeseen difficulties, inherent in the introduction of Western methods into Eastern jungles, was encountered and it was not until 1895 that profits were made and 1898 that the first dividend of 5% was paid. Meanwhile, in 1890, important changes affecting the native miners were introduced. Instead of the royalty charge levied on the mines a monthly fee of Rs. 20 per workman employed was now adopted, payable, of course, to the company. Restrictions on sales were also removed and an open gem market was instituted. Both these arrangements persist to the present time.

A second lease was granted in 1897 for a period of 14 years at an annual rent of Rs. 3,15,000 *plus* 20% of the net profits, but this was again modified in 1899, when the rent was reduced to Rs. 2 lakhs, the share of the profits payable to the Government raised to 30%, and certain outstandings remitted. A new clause in this lease granted an absolute right to a mining licence to any member of a family resident in the tract before the advent of the company. In 1897 the capital of the company had been reduced to £180,000.

Ruby mining by European methods now entered a profitable phase. For the six years 1898 to 1903 inclusive the average annual value of the stones obtained was £89,345 and the average annual dividend just over 11%. Royalty receipts from the native miners, the value of whose output is not included above, varied between £12,765 and £23,460 per annum in the same period.

A third lease was granted for 28 years from April, 1904, on much the same terms as the 1899 arrangement. Prosperity continued until the autumn of 1907, when the demand for rubies temporarily ceased following a severe financial crisis in America. During these times the company found employment for over 2,000 workers. Royalties fell from £19,340 in 1907 to £8,050 in 1908, a striking testimony to the effect of the depression on the native industry. This slump was long continued and its effects were probably accentuated by the competition of synthetic stones in the jewel markets of the world. It has been stated that the combination of these two circumstances caused the price of fine two-carat rubies to fall from Rs. 200 to Rs. 60 per carat, while the lower grades showed a greater fall. Slightly better trading conditions resulted in small dividends to the shareholders in 1911, 1912, and 1913 and had not the Great War then intervened the industry would probably have flourished again. The value of the company's finds, which averaged over £84,000 per annum during the period 1904–1908, fell to £63,272 between 1909 and 1913 and then to £41,817, the average amount for the years 1914 to 1918.

The accumulated rent arrears due to the Government totalled nearly £24,000 in 1909 and in that year the Secretary of State sanctioned the postponement of their payment and agreed that the company should henceforth make over the royalties collected from the native miners instead of the fixed annual rent, less 10% commission. In 1913, on the understanding that £20,000 should be expended on the development of new areas, the Government agreed to remit the debts, with the stipulation that if and when profits exceeded 10% on the paid-up capital half the excess should go towards their liquidation.

At the commencement of the War the European and American gem markets closed down and the Eastern demand slowly fell away. The officers of the company took up military duties and in 1914 the Government made further remissions. The years 1915, 1916, and 1917 all registered losses and the state of the Burmese industry is seen from

the royalty returns, which dropped from £23,000 in 1914 to £4,000 in 1916, rising again to £8,000 in 1917. In 1918 the company paid its then outstandings and in 1919 a profit of over £30,000 enabled a small dividend to be paid. The situation, however, never recovered and nothing is to be gained by enumerating the various steps taken in the attempt to retrieve it. In 1925 the company went into voluntary liquidation, unsuccessfully offering the mines for sale in 1926. A skeleton organization continued to work, however, until the lease terminated. Operations finally ceased at the end of June, 1931.

The end of the Burma Ruby Mines, Ltd., if no steps had been taken to meet the position, would have left the large native industry uncontrolled, for the company had managed it on behalf of the Government from the early days. The author was deputed to investigate the industry in 1927–28 and formulated plans for its control and future development. At his suggestion a new large-scale topographical survey of the eastern part of the Tract was undertaken, to form the basis of a modern geological survey, which the writer commenced on the existing maps and handed over to others in 1930. This survey is still in progress. Its objects are twofold. First, to subdivide the crystalline complex into its various sub-groups, to map them separately, to unravel their exceedingly complicated structure, and to come to some conclusion about their origin. The general relationship between the Burmese Archæan rocks and those of Peninsular India will be revealed in the process. Secondly, to map the true distribution of those members of the complex which are gem-bearing. Once this is accurately known, it will be a comparatively simple matter to delineate those portions of the Stone Tract that are favourable for the accumulation of secondary gem-bearing deposits of detrital and alluvial origin. This information is needed for the future guidance of the industry as well as for its administration. Sufficient is already known to warrant the assertion that, important though the ruby and spinel-bearing crystalline limestones are as sources of these stones, the whole story does not end there. The ruby is not entirely confined to the limestones and it is doubtful if the sapphires, of increasing importance in recent years, are derived from them at all. Many of the other valuable stones that the area produces also come from different rock groups and not from the limestones.

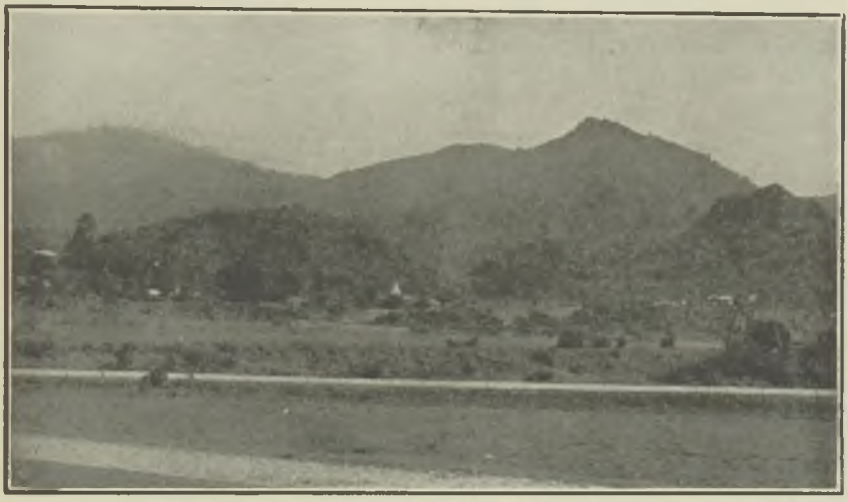


Fig. 4.—View Looking North across the Valley, Mogok.

Geology.—The rocks around the Mogok valley are typical members of the Archæan complex, which occupies the whole of the Stone Tract. Looking downstream towards the south-west from the high ground at its head (Fig. 3), both the Kyini Taung-Myo Taung ridge on the left and the two outer ranges on the right, are built up of members of the Mogok Series, a highly metamorphosed, strongly-folded group of sedimentary origin in part. Its commonest representatives are garnet-biotite gneisses, with or without sillimanite, and garnetiferous granulites. The latter are widely spread about Mogok

town and yield the local building stone. Excellent sections are exposed in the gorge of the Yeni Chaung, which leaves the valley below the lakes (flooded workings) in the photograph, between Mogok and the power house. Here they are permeated with veins, sheets, and films of aplite and pegmatite, forming typical *lit par lit* injections. Other rocks of this series are augite and calc-gneisses, calciphyres, and crystalline limestones. The calc-gneisses usually contain diopside and sometimes graphite and the common silicates in the calciphyres are diopside, phlogopite, and forsterite, but chondrodite, scapolite, and zircon also occur. The jagged crests in the middle distance on the right of the valley in Fig. 3 are outcrops of calciphyre.

Of more importance from an economic point of view are the crystalline limestones, of which there are at least five large independent masses on the north-eastern side of the valley. They are sometimes pure white and very coarse-grained, oftener medium-grained, carrying flakes of graphite and phlogopite. Rarer varieties are pale blue, pink, and yellow. They contain pseudomorphs of forsterite, colourless diopside, tremolite, chondrodite, pyrite, apatite, spinels of many colours, and rubies and they are always slightly dolomitic. Veins of felspar rock and granite pegmatite are frequent in these limestone masses and show the development of interesting minerals at the contacts. Mr. A. K. Banerji, to whom the writer handed over the geological survey, has described the case of a felspar rock intruded into coarse-grained limestone on Sontabe Taung, north-east of Mogok. The vein is from 6 to 8 ft. thick and is composed of coarsely crystalline felspar, mostly albite. The only other non-felspathic mineral present is apatite. At the contact is developed a coarse rock made up of nepheline, diopside, calcite, felspar, and apatite. In another case on Myo Taung, four miles east-north-east of Mogok, the contact rock between a thick granite-pegmatite vein and a white saccharoid marble is composed of scapolite, diopside, felspar, calcite, and flakes of graphite.

An acid gneiss, tentatively regarded as intrusive into the Mogok Series, occurs at Kyauknaga (22° 57′ : 96° 30′ 30″). It is a medium-grained rock, light in colour, with abundant quartz and microperthite, a little oligoclase, and brown biotite.

Great intrusions of augite syenite occur in the amphitheatre between Kyaukthinbaw Taung and Lennu Taung, the rounded and sharp peaks, respectively visible on the sky line of Fig. 4. A large laccolitic intrusion near the village of Oongain in this amphitheatre has caught up bands of limestone within its own substance, with remarkably little alteration to either parent or host. Most of the felspar in the syenite is microperthite, but a little orthoclase and albite are always present too. The pyroxene is either augite or ægirine-augite. The accessories are sphene, apatite, and zircon. In a rare type of the rock the felspars exhibit a remarkable schiller and this material has been worked for moonstones.

Nepheline rocks, very rich in dark minerals and of various unusual types, occur north-west of Chaunggyi (22° 58′ : 96° 32′).

Apart from the special contact effects mentioned above, the interaction, mingling, and subsequent metamorphism of such a large variety of types in so small an area has resulted in many curious hybrid rocks and minerals of great petrological interest.

The strike of the strata at the top of the Mogok valley is north-north-east. Near Mogok itself the pitch of the prevailing folds is east-north-east, while the major feature of the structure hereabouts may prove to be the great syenite laccolith.

To Professor Adams the whole rock suite between Thabeitkyin and Mogok presented a most remarkable and striking resemblance to a section through the Grenville Series in Canada.[1] According to Dr. Fermor, Director of the Geological Survey of India, it exhibits a grade of metamorphism characteristic of the hypomorphic zone and its only close parallel in the Indian Empire is to be found in the Eastern Ghats Province (Vizagapatam, etc.) and in Ceylon and Tinnevelly.[2]

Matrix of the Ruby and Sapphire.—Most of the rubies are derived from the crystalline limestone and specimens surrounded by calcspar are not uncommon. The ruby, however, also occurs under other conditions, for the author has seen it crystallized with tourmaline and with other minerals. The sapphire, though of the same chemical composition (Al_2O_3), is not associated with the limestones. Mr. A. H. Morgan, for many years agent of the company in Mogok,

[1] F. D. Adams. *Trans.* Can. Inst. Min. Met., Vol. XXIX, p. 18, 1926.

[2] L. L. Fermor. *Rec.* Geol. Surv. India, Vol. LXV, p. 85, 1931.

gives its matrix as a pegmatite gneiss. Adams describes it as a granular white acid plagioclase intergrown with orthoclase and constituting a micro-perthite.[1] The writer has examined many specimens occurring in felspar of this type. The thick veins of felspar in the sapphire mine at Kyaungdwin, near Kathe, may be recalled in this connexion, though the gems won there actually came from the detrital deposit. Banerji found a nepheline-corundum syenite in which the latter mineral was of a blue gem variety.[2] Such rocks resemble the corundum syenites of Coimbatore (South India),

Fig. 5.—Washing Floor for Ruby-Bearing Gravel, Enjouk, near Mogok.

described by Sir Thomas Holland.[3] It is evident that in Mogok, as elsewhere, there are several modes of origin of corundum.

Characters of Burmese Rubies and Sapphires.—The rubies when they exhibit their crystal forms are practically always combinations of hexagonal prisms and basal planes, sometimes with subsidiary rhombohedral faces and generally of a tabular habit. Sapphire crystals on the other hand always show steep pyramidal planes, whereas rubies showing them are exceedingly rare. Star sapphires which exhibit a six-rayed opalescent star when viewed nearly in the direction of the principal axis and particularly well when the stone is suitably cut with the curved surface known as *en cabochon*, are common. Star rubies are rare. Rubies tend to be small and it is not generally realized what an unusual stone a large and perfect ruby is. Stones about 5 carats or more are considered important sizes in the trade.[4] A ruby weighing 10 carats is a most exceptional gem and it is for this reason, coupled with their splendour and referring to specimens as flawless as possible, that the ruby begins to rival the diamond in value when it is about 2 carats in weight, while above that the ruby greatly exceeds the diamond in price. Large rubies of superb quality are perhaps the most valuable minerals known to mankind. Two stones brought to Europe from Burma in 1875 weighed 37 and 47 carats each, when re-cut the stones weighed 32·3 and 38·6 carats respectively. It is recorded that the smaller stone brought £10,000 and the larger one £20,000.[5] A stone weighing 77 carats in the rough, found by the company in 1899, was valued at Rs. 4 lakhs (£26,666). A ruby found by A. H. Morgan weighing 9 carats sold uncut for Rs. 27,000 and when cut to 6 carats brought £2,000; one of 21 carats, cut to 13 carats, brought £7,500. Another weighing 36 carats was sold by King Mindon Min for £30,000. The great "Peace Ruby" of 1919, a superfine stone of magnificent colour, weighed 42 carats.

[1] F. D. Adams. *Loc. cit.*, p. 26.
[2] *Rec.* Geol. Surv. India, Vol. LXVI, p. 95, 1932.
[3] Sir T. H. Holland. *Mem.* Geol. Surv. India, Vol. XXX, p. 169, 1901.
[4] C. Mathews, "Notes on the Ruby," *Gemmologist*, Vol. I, No. 4, p. 121, 1931.
[5] Sir T. H. Holland, "Indian Corundum," p. 60, 1898.

Except for a fracture estimated to take away a slice of about 8 carats, it was perfect and sold in the rough, on the spot, at Mogok for Rs. 3 lakhs (£22,500). In October, 1932, the discovery of a fine stone weighing about 30 carats and valued at £7,000, was announced from a native mine in Mogok, while on February 3, 1933, the *Times* stated that a rough ruby, weighing nearly 20 carats, recently found in Burma, had been cut in Hatton Garden to a weight of 7½ carats and was valued at nearly £10,000.

Sapphires attain much larger sizes than rubies. For example, stones of 630 and 293 carats were found at Kathe in 1930, while a specimen weighing 514 carats came to light in a native working at Mogok in December, 1932, but probably the record stone was one found at Gwebin on August 12 of the same year which weighed nearly 1,000 carats. Sapphires are very much cheaper than rubies and medium-sized, first quality stones may be taken to be worth approximately one-tenth of the value of similar rubies.

Burmese Mining.—There are three types of native mines. "Loodwins," in which fissures, caves, and hollows in the limestone, filled with detritus from its disintegration, are followed and their contents, often cemented or buried under recent travertine, extracted and washed (Fig. 5). "Hmyawdwins," or excavations driven into hillside detrital deposits which are broken down by water often brought long distances in ditches, the gem-bearing gravel, or "byon," being washed in lengthy ground sluices (Figs. 6 and 7). "Twinlons," unlined pits, or narrow, timbered shafts, sunk in the alluvium of the valleys to reach the "byon" which lies below, the spoil being removed in small baskets by means of balanced bamboo levers (Fig. 8). Major J. F. Halford-Watkins, late Deputy Agent of the Company, has recently described the native methods of mining, washing, and grading the stones in greater detail than can be attempted here.[1]

European Mining Methods.—The first operations of the company consisted in the removal of "byon" from Pingutaung, a hill near Kathe, and from Kyaukpyin and Tagaungnandine, near Kyatpyin, and its treatment in machines similar to those used at the South African diamond mines. Work was also started on Kyauktaung, a limestone hill which rises steeply from the edge of the Mogok valley. Attempts to mine for rubies in the limestone of Pingutaung were made between 1890 and 1895, two long adits being driven into the hill. The Panma deposit on the eastern slopes of Pingutaung was also tackled with but indifferent success between 1891 and 1895. Indeed, the early operations of the company in the valleys, like those of the native miner, were greatly handicapped by their waterlogged condition and it was not until A. H. Morgan solved this problem that success was achieved. By sinking a drainage shaft, equipped with pumps, in the Tagaungnandine valley in 1893 it proved possible to strip the 10–12 feet of barren overburden and remove the "byon" to the washing plant on a large scale. Morgan's methods were then extended to the Luda valley and later to Mogok itself, where by 1895 the Shwebontha mine was yielding satisfactory results.

Operations in the Mogok Valley.—The Mogok valley is an old lake basin and there are two stages of alluvium in it, one an ancient terrace deposit with its base about the level of the recent alluvium, and in the former many of the native "hmyawdwins" are located. The richest layer of "byon" usually laid between 15 to 25 ft. below the surface in the more recent deposit, though sufficient gems occurred in the lower horizons, generally down to the valley floor, to make its removal profitable, provided it could be excavated in large quantities. It is a true rock basin, formerly occupied by a lake, like most of the similar physiographical features in the Shan States and in Yunnan. It is thoroughly waterlogged. Some 10 miles long and 2 miles wide at a maximum, its drainage presented a bigger problem than the earlier smaller valleys. Steam pumps were used at first, replaced by a hydro-electric installation in 1898, the first of its kind in this part of Asia. By 1901 there were two washing pans working at Shwebontha, three at the Redhill mine close to it, and one at Kyauklongyi, erected in 1898, further north. Another plant with a double pan was situated at Padansho, near Kyauklongyi, and preparations were in progress to start at Chaungzon, at the southern end of the valley.

In 1902 and again in 1908 and 1909 parts of the town were purchased and the people settled elsewhere. Profits were made continuously from 1899 to 1908, except in 1903 when floods damaged the pipe-line and filled the workings with debris. Drainage, however, still continued to be the main

[1] J. F. Halford-Watkins: "Methods of Ruby Mining in Burma," *Gemmologist*, Vol. I, No. 11, pp. 335–342. No. 12, pp. 367–373, 1932.

trouble and in 1904 Morgan's bold scheme for a drainage tunnel through the rock, 100 ft. below the surface and more than a mile in length was brought forward. Finished in 1908, it was a success from the first, leading the water quickly away, preventing flooding, opening up lower levels of alluvium for exploitation, and freeing power for use elsewhere. Unfortunately its completion coincided with a depressed gem market, a period of restricted output and of rigid economy. (The tunnel was blocked by a fall in 1925 and the valley has now reverted to its prehistoric condition, a series of large lakes filling the old workings.)

After draining an area the ground was removed by open-cast mining. The alluvium, varying from 20 to 70 ft. in thickness and generally lying on a limestone floor, irregular beyond description, was worked in conical bays. The ground was broken down by hand and at a later date by monitors, the high pressure water supply being led from mountain streams often many miles away by elaborate systems of flumes and ditches. Although some layers of " byon " are richer than others, gemstones as a rule occur throughout its thickness and the definite pay streaks of some alluvial metallic minerals of higher specific gravity are unknown. Profits, therefore, depend largely on a big throughput and at each of the mines in the prosperous days over 1,000 tons of material was moved daily. Loaded into trucks, the broken ground was hauled to the washing plants by endless ropeways, though in later years it was entirely treated by monitors and raised to sluice-boxes by means of hydraulic elevators and gravel pumps. According to R. R. Simpson, late Chief Inspector of Mines in India, the average mining cost in 1919 was about 8 annas and the value 12 annas per ton, while A. H. Morgan has stated that an average daily turnover of 7,000 tons of earth would yield good dividends when an average value of 8 annas per ton was recovered.

Treatment of the Gravels.—The object of the sluicing and pan treatment was to produce a clean gravel concentrate from the clayey earth, or " byon," from which the rough gems could be picked out by hand. From the gravel pumps and elevators the material went through screens, the clean oversize after breaking and casual inspection going to the dumps; the smaller stuff (2 in. cubes maximum) passed into a long sluice-box fitted with riffles at proper intervals. The concentrates from this went to the sorting houses.

Fig. 6.—Burmese Ruby Working, " Hmyawdwin " Type, Yegyi, near Mogok.

The hand-dug material, after passing through screens and trommels, was fed into circular pans with revolving arms, the overflow carrying away the lighter sand and mud and a concentrate remaining behind. This was sized through appropriate trommels in the sorting houses and sizes over $\frac{5}{8}$ in. went direct to the picking tables. The fines were passed on to pulsators to obtain as close a concentration as possible, but the large quantities of ilmenite, garnet, and valueless corundum prevented a very select separation.

The first sorting was done by Europeans and the later ones by trained natives under strict supervision and fitted with headgear designed effectively to stop the easy road from hand to mouth.

A curious local custom, known as "kanase," permits women to work without licences in stream beds, tail races, and dumps from mines and washeries and to keep any gems they may discover as their own property. The writer has seen upwards of 50 women and girls sorting rejected gravel on the dumps of the old Red Hill washer near Mogok, but it is doubtful if they earn more than a few annas per day.

Hydraulic Developments. — About the beginning of the War period it was becoming clear that the portions of the Mogok valley hitherto worked by the company were approaching exhaustion; working costs were also increasing as the distances between the faces and the mills lengthened; the market, too, was falling. New ground was opened up at Kathe in 1914, where large-scale drainage and stripping operations had commenced two years earlier. A mine was started at Saza-in in 1916. The Kyaungdwin valley, near Kathe, was also tapped about this time and was one of the last areas working in 1928. It lies on a contact of limestone with biotite schist, intruded by felspathic veins of pegmatitic origin, and contained rich but deep-lying "byon," remarkable for the size and beauty of its sapphires. Other areas worked during this period, mainly by hydraulic sluicing arrangements, were Datangataung and Panma, near Kathe, Enjouk, near Mogok, and Bernardmyo, 11 miles north of Mogok, long known as a region yielding sapphires and peridots.

Future Prospects.—It is in the more extended application of intensive hydraulic methods that most hopes of success are centred, if ruby mining is ever attempted again on a large scale by capitalistic enterprise in this Stone Tract. Many adverse causes have contributed to the existing depressed condition of Burmese ruby mining and most of them will suggest themselves to the reader. Exhaustion of the gem-bearing deposits of the tract as a whole is not, in the author's opinion, to be numbered amongst them.

Fig. 7.—Washing Channel from a Burmese Working of the "Hmyawdwin" Type, Yegyi, near Mogok.

The operations of the Burma Ruby Mines, Ltd., apart from early abortive attempts to mine gems in the parent rock and a few experiments on certain hill slopes, were in the main confined to removing and washing gravels from valleys in the neighbourhood of Mogok, Kyatpyin, and Kathe. There are, however, other valleys in the Stone Tract (an expanse of over 600 square miles, with bands and masses of crystalline limestone throughout its extent), and in particular those of the Kin and Khabine streams, in which gems occur and which merit further exploration, with the object of proving their potentialities as hydraulicking propositions rather than as territory to be exploited by slow and costly methods of hand removal. The greatest possibilities for the future, however, lie, the writer thinks, in the mass treatment on such

lines of the hill-side deposits and a stretch of country known as the "Western Slopes" seems to be worthy of more than passing attention. This lies on the western side of the ranges between Bernardmyo and Kathe and if the remains of small, scattered native workings are any criterion it is a gem-bearing region of great extent. Moreover, it has been stated that water can be brought to it by the cutting of a ditch from Bernardmyo, a long channel surveyed under Mr. Morgan's direction in 1924, the construction of which was not undertaken before the company went into liquidation.

they satisfied the home demand and were sent to various Continental and American centres. Representatives of the great jewel establishments of Paris and New York were permanent residents in Mogok until a very short time ago.

The trade, of course, is peculiarly sensitive to economic conditions. "The production of precious stones has always been a good business barometer."[1] The existing depression in the industry will not lift until the general purchasing power of the world begins to function normally again. If it be true that history repeats itself, there will then arise a renewed demand

FIG. 8.—RUBY MINING BY THE PIT OR "TWIN-LON" METHOD, MOGOK.

The market for rubies is a world-wide one and, although the company put vast quantities of stones on the market, in times of prosperity no difficulty was apparently experienced in selling them, though fine stones of great price naturally took longer to find a purchaser. The small stones which form the bulk of the output were sold in Calcutta, Madras, or Bombay or auctioned at the mines in parcels to brokers and dealers from various parts of the East. These in their turn passed the stones on to others or to the local cutters and middlemen, whence they reached the jewellers of the bazaars or the travelling pedlars, who distributed them in all directions. The better stones were sold in London, whence

for luxuries such as the ruby, for it is a characteristic of the human race from prehistoric times onwards that increasing possessions and more lavish feminine adornment proceed together.

It is a fact that the market has suffered from the competition of synthetic stones, but these are distinguished easily enough by the initiated and the discriminating buyer may be relied upon to prefer the natural article.

To-day the native miner works alone again as he did before the advent of the company. The revenue received by the Government of Burma hereafter in licence

[1] S. H. Ball. "Historical Notes on Gem Mining," *Econ. Geol.*, Vol. XXVI, p. 699, 1931.

fees will be a sure indication of the fluctuations of the industry in response to the vagaries of the market, provided a strict check is kept on illicit operations, but the figures will furnish no idea whatever of the actual value of the gems recovered.

The writer wishes to thank Dr. L. L. Fermor, Director, Geological Survey of India, for permission to publish this article and its accompanying photographs, which were kindly supplied by his colleague, Mr. A. K. Banerji.

THE ELECTRICAL STUDY OF DAM FOUNDATIONS

By M. LUGEON and C. SCHLUMBERGER

The authors describe the application of electrical prospecting methods to the study of dam foundations and associated structures.

INTRODUCTION.—During the past 10 years electrical methods of subsoil exploration have found numerous practical applications in the field of tectonic studies and ore exploration. It has appeared interesting to the authors to apply these methods to the study of the weathering of rocks and their permeability to water. These two factors play a very important rôle in the construction of dams and penstock tunnels. For a first investigation along these lines the dam site at Sarrans (France) was chosen. This dam

FIG. 1.—LEFT BANK OF THE TRUYÈRE: ROCHE PERDRIÈRE.

is now being built on a tributary of the River Lot, La Truyère, in the department of Aveyron.

The Sarrans Dam Site.—After a long course through crystalline schists, through which it has hewn a relatively large valley, the River La Truyère cuts near Sarrans a narrow gorge through a granitic mass. It is this narrow gorge which led the authors of the water-power project to decide on a dam site about 150 metres downstream from the contact between the granite and the crystalline schists. The position of the structure was also largely determined by the topography, since further downstream the valley broadens again and the neighbouring hills are of lesser altitude. The left side of the gorge forms an inaccessible wall, about 150 metres high, known as La Roche Perdrière. The right side, although steep, is more accessible (Figs. 1 and 2).

The dam being built is of the gravity type, about 105 metres high. The volume of the wall is to be about 450,000 cubic metres, the angle with the vertical being 0·03 for the upstream face and 0·7 for the downstream face. For an average density of the beton of 2·325 an effective bottom pressure of 75% has been adopted. The axis of the dam is slightly curved, with a radius of 475 metres. The whole structure will be laid on granite, with black mica and large felspar crystals, a type of rock which is very common in the Massif Central.

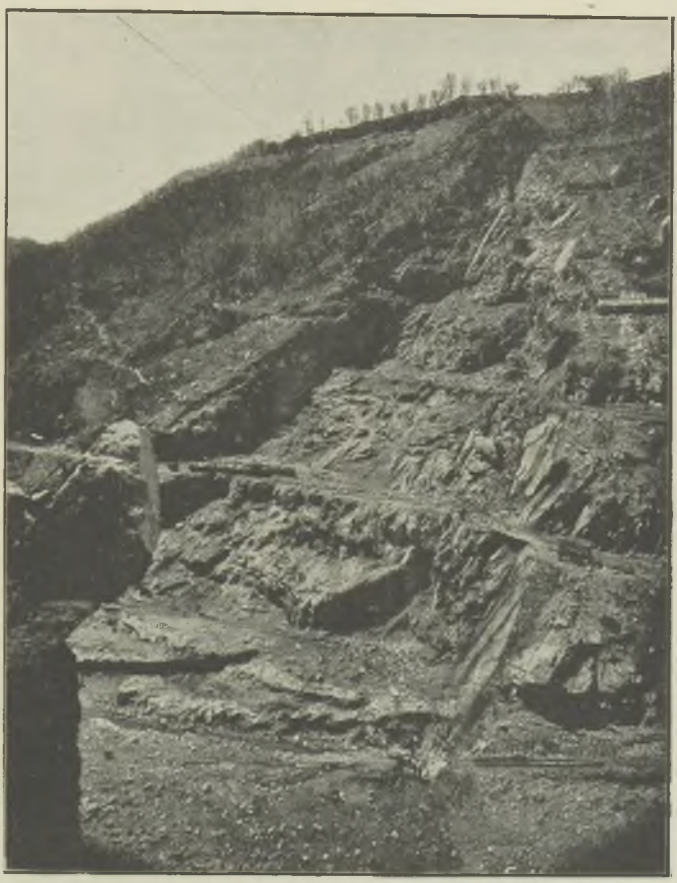


Fig. 2.—Right Bank of the Truyère.

The foundation of the dam was studied with great care over a period of several months by means of rotary drills, which discovered several local weathered zones. Several tunnels, also, have been driven on the right bank, in order to determine the average thickness of the material to be excavated. Before excavation work com-

menced, therefore, it was known that in several places the ground would have to be excavated particularly deeply. It was also known that this would apply more to the right bank than to the left bank, for, as geologists know, with any massive rock the smaller the slope the greater the weathering.

This preliminary exploration, as previously stated, lasted several months. The excavation work brought into evidence a series of oriented fractures, visible on the wall of the Roche Perdrière ; this double fracture system divides the whole mass into large, oblique parallelepipeds. It was also discovered that the zones of soft rocks located by drilling in the river were situated in shattered granite, the importance and direction of which could not be determined.

of the dam filled the bottom of the gorge up to a height of several metres and modified the natural conditions of the rocks at the site. Furthermore, the building equipment, metallic masses, and numerous cables and electric lines did not facilitate the task of the geophysicists. In spite of these difficulties the results obtained were very encouraging and it seemed worth while to make them known.

Measurements of Resistivity. — It is possible to measure the electrical resistivity of the subsoil from the surface by the following procedure. A difference of potential is applied between two given points A and B of the surface. A flow of current takes place between these two points and creates differences of potential in the ground and at the surface. Such variations of potential

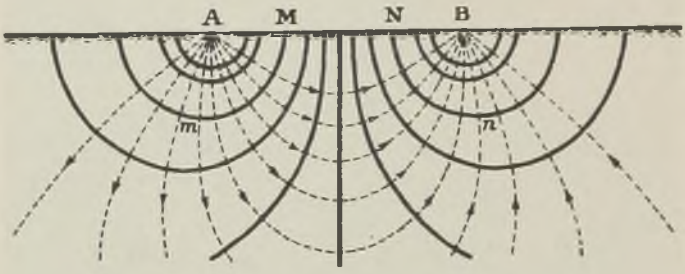


Fig. 3.—Arrangement for Measuring Underground Electrical Resistivities.

The broken zones are local and rectilinear, the granite being transformed locally, although only over short distances, into a granular mush, resulting from the alteration of the felspars and mica. It is well known that this kind of weathering may be a great inconvenience if it extends to great depths or spreads laterally on the slope of the valleys. It may render the building of a gravity dam almost impossible, as has been the case in Calabria, so great may be the amount of material which has to be dug out. It interested the authors, therefore, to ascertain whether it would have been possible to obtain beforehand, by electrical prospecting, the information which was brought to light by the long excavating and drilling campaign. To this end the relations which must necessarily exist between the degree of weathering of the granite (and in particular its permeability to water) and its electrical resistance were studied. It is unfortunate that these electrical investigations, which were proposed by one of the authors, were undertaken rather late. Already the concrete

can be represented by equipotential surfaces and, in the case of a homogeneous terrain, these surfaces have the form shown in heavy lines on Fig. 3. On the same figure the lines of current, which are perpendicular to the equipotential surfaces, have been represented in broken lines.

Let us now measure the difference of potential occurring between two points M and N at the surface, as well as the intensity of the current which passes through the earth grounds A and B. The application of Ohm's law to a three-dimensional infinite conductor makes it possible to compute the average resistivity of the ground between the two equipotential surfaces, passing respectively through M and N, by means of the following formula :

$$\rho = K \frac{\Delta V}{i}$$

where K is a geometrical coefficient depending upon the dimensions of the measuring arrangement $AMNB$.

The current flowing from A to B penetrates

quite deeply into the ground and the resistivity figure obtained corresponds to a layer of ground of thickness about equal to $\frac{AB}{4}$. Therefore, if the length of the line AB is progressively increased, it is possible to obtain the average resistivity of a volume of terrain which becomes progressively greater and which takes into consideration a continually greater depth of the ground. In other words, it is possible to choose an appropriate depth of investigation by adopting an adequate dimension for the measuring arrangement.

Results Obtained by the Resistivity Map.—A series of resistivity measurements were carried out in the region of the Sarrans dam site, with the following measuring arrangement: $AB = 30$ m., $MN = 10$ m. Each of the resistivity figures obtained must be considered as representing the average resistivity of a cube of ground 7·5 metres on an edge, located immediately under the station where the measurement is being made. The figures are expressed in ohms-m²/m. The repetition of the experiment at a number of stations made it possible to prepare a map with equi-resistivity curves. This map is more or less comparable to a geological map, but the different rocks, instead of being indicated by their specific mineralogical names (and in this particular case by their degree of soundness), are simply characterized by their electrical parameters.

In the building of dam sites the consulting engineer determines the degree of soundness of a homogeneous, non-stratified rock, which may undergo weathering or may be broken by fissures permitting the passage of water, by measuring the amount of water absorbed by the rock in question under a given pressure. One of the authors, as a result of experience acquired in the building of dams of various heights on different types of bedrock, was able to establish a scale showing the amount of water absorbed by the rocks, which must not be exceeded in order to be certain of the impermeability of the foundations. We call "permeability coefficient" the quantity of water absorbed by a rock in a drill-hole per minute and per unit of length under a pressure of 10 kgs./cm². At La Truyère it was considered that the rock was practically impervious if it would not absorb, in a drill-hole of small diameter, more than 1 litre per minute and per metre under a pressure of 10 kgs. The tests lasted from 5 to 10 minutes.

It is very interesting to note that there is a definite relation between the resistivity obtained by geophysical measurements and the degree of soundness of the granite. This relationship may be discussed more fully.

The Roche Perdrière is characterized by high resistivity figures exceeding 5,000 ohms and reaching as high as 20,000 ohms per metre. These resistivities are typical of a compact granite and this point can easily be verified in a general way by the mere inspection of the ground. On the slope of the Roche Perdrière a satisfactory impermeability of the rock generally exists, at depths varying from 5 to 25 metres. (This is the depth to the bottom of the cut-off wall, which is 3 to 4 metres below the average level of the excavation to the sound rock.) Since it is very difficult to gain access to the steep wall of the Roche Perdrière it was not possible to carry out a close network of electrical measurements. Had this operation been possible (as would have been the case if electrical exploration had been applied in the early stage of the building of the dam) very interesting observations would have resulted.

For instance, it is worth noting that the resistivity contour of 3,000 ohms on the left

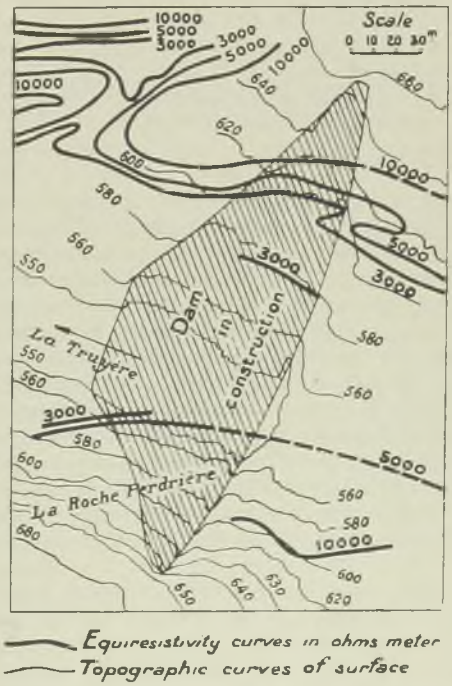


Fig. 4.—Equiresistivity Map at the Sarrans Dam Site.

bank of the Truyère shows an inflection in the direction of the slope, from upstream to downstream, instead of being parallel to the river. In this region the by-pass tunnels driven on the left bank in the Roche Perdrière encountered a narrow zone of crushed moist granite, which diverges gradually from the axis of the valley in the downstream direction and penetrates the mountain. This departure from homogeneity in the granite at depth possesses the same direction as the 3,000 ohm curve. The parallelism of the two phenomena is so striking that it can be said that the resistivities studied from the surface actually bring into evidence the direction of geological features which otherwise could be discovered only by drilling exploration or excavation work.

On the right bank the resistivity map shows quite abnormal disturbances downstream from the dam position. These disturbances indicate the existence of sound granite masses surrounded by weathered zones, a fact which has been verified with the hammer in the course of a surface reconnaissance.

At the dam position itself the map shows a decreasing resistivity in the lower part of the slope and in a general way a much smaller resistivity than on the Roche Perdrière. As a matter of fact this right bank has been found much less satisfactory than the left bank, as far as the permeability of the rocks is concerned. It was sometimes necessary to drive the drill-holes to over 50 metres from the level of the bottom of the cut-off wall in order to reach sound rock. Consequently, on the whole, by comparing the two banks of the river, the resistivity figures vary proportionally to the average impermeability of the rocks. It might have been desirable to study in greater detail the right bank, but, due to the fact that the continuation of the dam was already commenced, it was impossible to carry out more detailed measurements.

The holes for the injection of cement for grouting under the dam foundation are driven from the bottom of the cut-off wall. Therefore, no other information is available, except a transverse cross section of the porosity of the slope, since in the building of a dam no special attention is paid, at least in this particular case, to the porosity of the rocks at great depth under the whole structure. The absorption of water observed was considerable in the high parts of the cut-off wall, becoming smaller in the neighbourhood of the 600-metre level, but increasing again at a lower level in the region of the river. The resistivity map shows this variation of porosity on the right bank in the neighbourhood of the 600-metre level, such a variation being indicated by an inflection of the 5,000-ohm curve. The coincidence is really striking.

On the whole the resistivity measurements show that the permeability is greater on the right bank. This is in agreement with the information furnished by the drill-holes. It also agrees with the geological rule which states that the weathering of a rock is

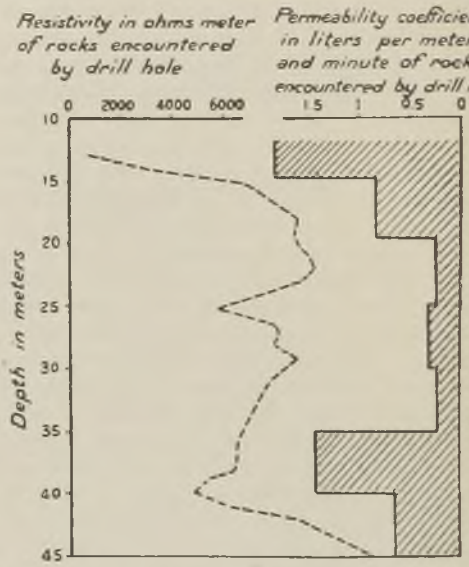


Fig. 5.—Bore-Hole 20 B at the Sarrans Dam.

inversely proportional, as a rule, to the steepness of the slope.

Resistivity Measurements in the Drill-holes.—The measuring arrangement $AMNB$, which was utilized by the authors to obtain resistivity figures at the surface, can be lowered into a drill-hole. With a distance between the grounds $AM=MN=1$ metre every measurement takes in only a few cubic metres of the ground. By moving the measuring arrangement all the way along the drill-hole it is possible to study the electrical characteristics of the different rocks traversed by the hole. This is the technique called "electrical coring."

Figs. 5 and 6 show the resistivity diagrams and the permeability coefficients of the two holes 20 B and 19 bis of the Sarrans dam. The resistivities were measured every metre,

while the permeability was studied on sections of 5 metres in length. It is easy to see that in drill-hole 20 B (Fig. 5) the resistivity increases rapidly, while at the same time the permeability decreases. The three minima shown by the resistivity curve at depths of 13, 25, and 40 metres correspond probably to small fissures in the rock. The minimum at the depth of 40 metres is satisfactorily shown by an increase of the permeability coefficient, which passes from 0·16 litres/metre/minute to 1·12. Around 25 and 28 metres the resistivity curve shows two maxima, which are located in a region 5 metres in length, where the permeability increases slightly. It is very likely that if this permeability had been measured metre by metre it would have been possible to locate a zone of absorption of water around 25 and 28 metres.

In drill-hole 19 bis (Fig. 6) a distinct discrepancy is observed between the two series of measurements, at a depth of 10–15 metres. This discordance is difficult to explain. On the other hand the increase of resistivity at a depth of 23 metres corresponds clearly to a firmer rock, which absorbs only 0·32 litres-minute-metre, while the rocks above and below permitted 0·48 to 1·2 litres to filter through.

It should be mentioned here that the porosity measurements were not all carried out at the same pressures and the discrepancies between the two systems of measurements can be ascribed to this difference in the water heads. It would not be justified, therefore, to try to establish a mathematical relationship between the results obtained by the two processes. That a parallelism exists, however, is indisputable.

These investigations are the first of their kind. By conducting the porosity tests on shorter lengths of hole and by experimenting with a constant pressure it is very likely that the curves obtained would be very similar to those furnished by the electrical investigations.

Conclusions.—To sum up, it may be said that the experiments at La Truyère show that there exists a definite relationship between the specific electrical resistivity of the granite and its degree of weathering, as well as its permeability to water. This relation seems probable at first sight, since the specific conductivity of a rock (which is the reciprocal value of its resistivity) is approximately proportional to the amount of absorbed water and to the percentage of dissolved salts contained therein. Since granite, when it is weathered and pervious, must contain, *a priori*, a larger percentage of water than compact granite, it must in consequence be more conductive than the latter.

After carrying out about 500 measurements the authors were able to ascertain that the granite on which the Sarrans dam is built shows electrical resistivities larger than 5,000 ohms-m²/m in the zones where it is compact and below that figure in the zones where it is weathered and pervious.

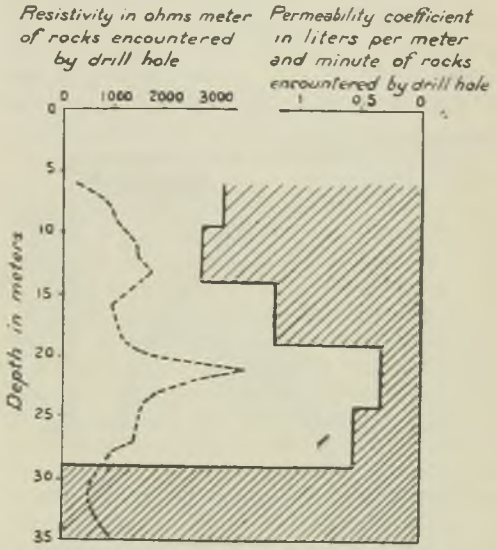


Fig. 6.—Bore-Hole 19 bis at the Sarrans Dam.

Measurements carried out in the drill-holes, on the other hand, showed a definite relation between the resistivities and the coefficients of absorption of the water. It therefore seems evident that the study of the electrical resistivity of the rocks is interesting in connexion with all engineering projects where the question of the water-tight properties of the rocks is of paramount importance. Consequently, electrical prospecting is capable of rendering appreciable services in the studies of dam foundations, tunnel sites, spillways, and other work of this character involved in hydro-electric projects.

The authors wish to thank the Société des Forces Motrices de la Truyère, who authorized the research work, in spite of the fact that it might have constituted quite an inconvenience in the course of the building up of the dam.

THE APPLICATION OF MECHANICAL EXCAVATORS IN MINING

By W. E. SINCLAIR, A.I.M.M.

(*Concluded from the May issue, p. 285*)

Where power is available the common type of electrical system fitted to excavators consists of direct-current motors driving each of the three motions—that is, the hoisting, swing, and thrusting motions. The motors are supplied from three generators and control is effected entirely by variation of the fields of the direct-current motors and generators, giving absolute control of both speed and torque. A volt-ampere characteristic is shown in Fig. 10 and is produced

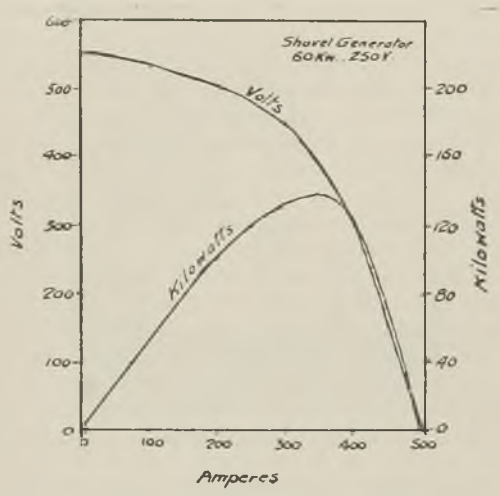


FIG. 10.—VOLT-AMPERE CHARACTERISTICS OF A VARIABLE-VOLTAGE SHOVEL GENERATOR.

by the total effect of a separately-excited shunt field, a self-excited shunt field, and a differential field on each of the generators. This curve, which is designed by Barland,[1] shows that the generator voltage is brought to zero at a predetermined maximum armature current, which fixes the maximum torque that can be developed by the motor receiving the power. This limits the strains thrown on the mechanical equipment and economizes in the general maintenance of the machine. The smoothness and flexibility of electrical drive in excavator work is directly reflected in the long life of the machine and in the increased outputs and low operating costs.

[1] J. E. Barland. *Engineering and Mining Journal*, October, 1932.

According to E. Hunner the electrical equipment on the Mesabi range, over a period of ten years, showed a favourable comparison to the same type of steam shovels in repair cost, the ratio being about one to four.

Combined Diesel-electric drive in small excavators with variable-speed characteristics of electric transmission saves time in operating by giving higher speeds when the load is light and reduced speed at heavy loads, thus effecting a big power saving. This form of drive gives a machine which is compact, mobile, and an absolutely independent unit, operating with as great efficiency as the all-electric type, away from all electric power supplies.

AUXILIARY EQUIPMENT FOR EXCAVATORS.—No matter what the size of an excavator bucket may be the capacity of an excavator is measured by the capacity of its auxiliary plant, a fact that obtains in the case of any machine that is dependent on the synchronism of some other auxiliary plant to maintain its rated capacity. The importance, therefore, of suitable and efficient equipment in conjunction with mechanical excavators, with a view to obtaining the rated bucket capacity, cannot be over emphasized. The prevention of stoppages during working hours is another important factor in this question. The fact that the unit cost of excavator work with a given equipment varies inversely with the output means that all possible delays must be avoided. There are two conditions which go to satisfy this state—namely, systematic organization and suitable equipment. The former point is a matter of method of working, while the latter is a question regarding the careful study of wagons, tracks, and locomotives, or whatever plant is used in conjunction with the excavators.

Pit tracks should be made of 80-lb. section rails. Lighter material is responsible for derailments and "creep" in the tracks. Where sections of the line must be moved up on the benches or levels mechanical track shifters have dispensed with the large gangs necessary for this work. Track grades leading in or out of an open-cut should be limited to a maximum of 2% where possible, with curves of a maximum possible radius.

FIG. 11.—CRAWLER WAGONS FOR HAULING EXCAVATED GROUND.

Excessive grades against the loaded trains have far-reaching effects in causing high haulage costs and delays at the excavator and also are responsible for much maintenance work on the tracks.

Dump wagons must be of a size large enough to allow of quick spotting and easy filling when under the bucket during loading operations. Air-operated railway dump cars (both side and end dumping) are made in sizes ranging from 4 cu. yd. to 30 cu. yd. capacity and suitable for every description of excavating job. A wagon of from 4 to 8 cu. yd. capacity, mounted on caterpillars, is the most recent addition to earthwork equipment. These wagons are usually hauled by motor tractors and are used to convey the ground broken by excavators working on propositions that are not big enough to warrant the expenditure for a railway system with the necessary rolling stock. In several cases where this combination has been installed interesting data affecting the performance of these wagons has been disclosed. In one case the full capacity of a 2 cu. yd. dragline was made available and excavating costs reduced by exactly half by the use of this equipment. Six Western crawler wagons were used in a haul varying from 300 to 1,500 ft. in sand. The dragline excavated and loaded 141,500 cu. yd. in 73¼ shifts, the maximum daily output for an eight-hour shift being 3,200 cu. yd. Crawler wagons are shown at work in Fig. 11.

The various forms of traction in use on railway propositions are steam or electric locomotives, or overhead electric trolley wire locos for use on permanent main approach tracks, with side-arm trolley method on working benches and dumps. Oil-engine locomotives are economical equipment for shunting work in traffic yards. Geared

FIG. 12.—ELECTRICALLY-EQUIPPED WAGON OPERATED FROM CONTROL TOWER.

locomotives are used in work where excessive grades are unavoidable, but the latest practice to reduce haulage costs under these circumstances is to equip ordinary dump cars with electric motors and to run these as single units electrically-operated and controlled from a central control tower. This method of haulage, where electric power is available, promises to afford cheaper haulage costs than the more common methods in use, besides dispensing with the need of locos or the labour usually connected with ordinary haulage trains. On average grades one truck equipped with two 75 h.p. d.c. motors will develop a tractive effort equivalent to that of a 50-ton locomotive and when loaded will pull a train of loaded trucks just as well. The motors are supplied with power by means of a third rail running alongside and parallel to the track. A truck operated in this manner is just leaving the shovel in Fig. 12.

An unusual class of auxiliary plant used in conjunction with mechanical excavators are gravel pumps, which are sometimes employed to elevate and deliver the gravel broken by the excavator in alluvial mining. The choice of suitably-sized pumps is even more important than the care necessary in the combination of other equipment, for other factors besides the question of equal capacities must be considered in this method of working. The method of delivering the broken gravel from the excavator to the gravel pump may be by railway wagons or by sluicing with the aid of water, in which case the water supply is another important factor.

Methods of Working.—There are two fundamental methods of working with excavators which may be considered under the following headings :—

(1) Excavating and dumping the ground back.

(2) Excavating and loading the ground into wagons for transfer elsewhere.

Whichever method is employed a preliminary plan of attack is as important as the method itself. Contrary to the general idea the successful exploitation by means of excavators is not as simple as it appears to be for the reason, principally, that most of the plant employed is continually on the move, either in its work at the face or because of the necessity to advance owing to the encroachment of the machines

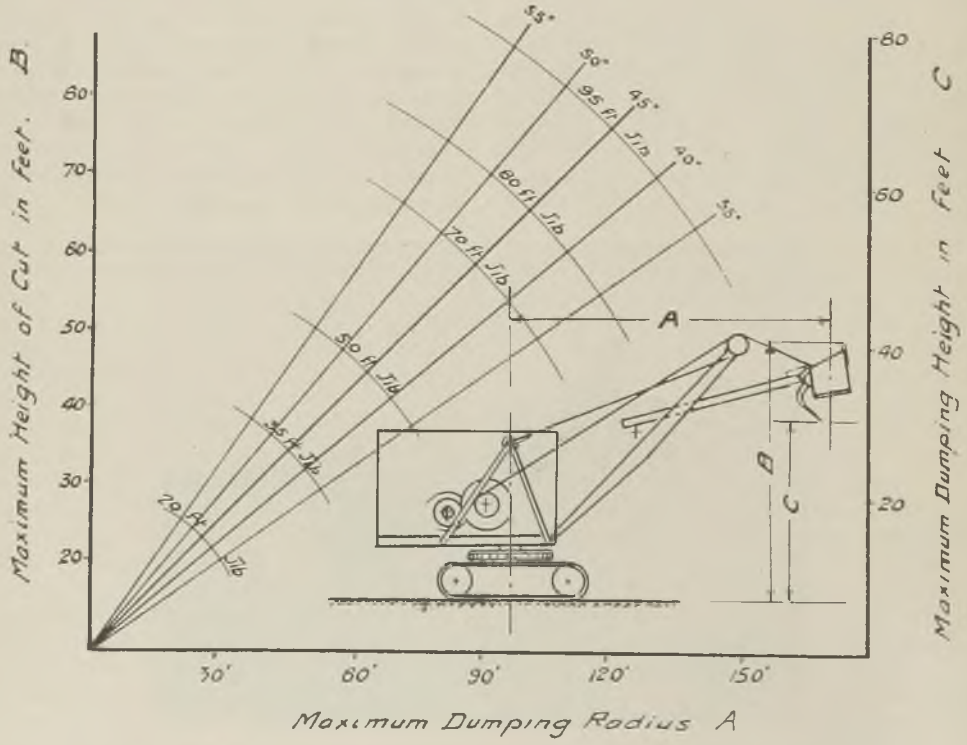


Fig. 13.—Main Working-Range Specifications for Power Shovels.

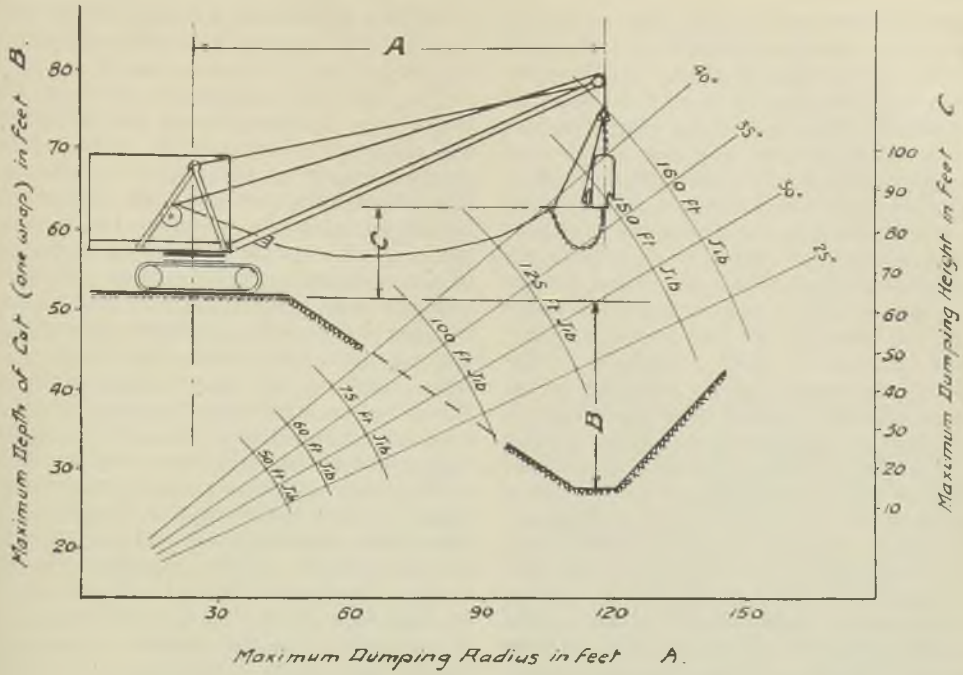


FIG. 14.—MAIN WORKING-RANGE SPECIFICATIONS FOR POWER DRAGLINES.

operating on a lower level. The preliminary layout of the projected method of working is helpful in planning, in organized stages, the opening up of a deposit, the continued success of which then depends on good management and systematic work based on a clear foresight of the present state and future outlook of the deposit.

In the first-named method shovels and draglines are used to strip overburden from horizontal deposits and instead of loading the overburden in cars for disposal on waste dumps some distance from the open-cut the excavator simply dumps the broken ground back into the space previously stripped, from which the exposed ore has already been recovered. Where conditions are satisfactory this method of working will result in low unit costs and, because no other auxiliary plant is working in conjunction with the stripping machine, the latter is enabled to work to full capacity without the usual delays. The advantages in this way are so great that many partial stripping jobs near the boundaries of deposits may be undertaken and a saving effected even when it is necessary to handle the ground twice. The manner of working in a case like this is to strip a deposit in two cuts along its boundary, the width of each cut being equal to the reach of the dragline. The dump from the first cut excavated must be moved back and dumped on barren ground over the deposit boundary to enable the dragline to excavate the second cut, which it dumps against the previous pile, the whole of which will, of course, be clear of the stripped deposit. Many other small jobs, such as roads and railway work and cutting channels and trenches, are accomplished continually at low cost.

Another advantage, besides low working costs in straight excavating work, is that the machines so employed have the benefit of their maximum height and reach and are not confined to a fixed radius and elevation as is the case when loading into wagons.

The graph in Fig. 13 shows some of the more important specifications concerning shovel working ranges, such as maximum height of cut, dumping radius, and dumping height above floor level with various jib lengths inclined at angles of 35, 40, 45, 50, and 55° from the horizontal. Jib and dipper arms are usually made of standard length, especially in the convertible type of excavator. It is not unusual, however, to equip certain machines with a high, medium, or low-lift jib according to the class of duty expected of it. The dumping height and radius of

a shovel is limited to a great extent by the depth of face being excavated, owing to the swell of the broken ground, which under certain circumstances increases in bulk by as much as 40% and consequently is apt to flow back on the machine and cause cramped conditions. This difficulty, naturally, is circumvented when the ground is loaded into trucks and removed from the precincts of the workings. Another consideration makes itself apparent, however, when shovels or draglines are employed cutting and loading ground into wagons, for the dumping height of the machine is fixed according to the height of the wagon and the dumping radius is fixed according to whether the wagon is on a railway or otherwise and if the former by the distance of the rails from the machine.

Fig. 14 is a chart that shows the main working-range specifications for a dragline, in a similar manner to those appertaining to a shovel in Fig. 13. Except for the fact that the dragline works from above, cutting the face in an underhand method, while a shovel works from below, the working principles, so far as dumping height and dumping radius are concerned, are much the same. The swell of the broken ground dumped by a dragline has not the limiting effect on these machines, because of the greater freedom of movement and the possibility in an emergency of double handling excessive amounts to gain dump room. Shovels have an advantage over draglines in their bucket capacities and dumping height for a given length of jib. To command the same bucket capacity a dragline must have a longer jib and therefore it controls a greater digging and dumping radius.

The use of excavators, with railroad wagons for the disposal of overburden and the shipment of ore, is the most common method employed to strip and mine large deposits and this method, when the ore-body has been carefully developed beforehand with regard to track approaches and general plan of working, proves the most satisfactory so long as a fool-proof system of traffic control is organized to keep a continuous supply of wagons at the excavators. The daily output, when working by these methods, is not dependent so much on the capacity of the excavators and depth of cut as on the equipment in use and the traffic service.

The most satisfactory height and slope of bench in open-cut work will depend on the size of the shovels in use and on the nature of the ground. The economic minimum height of banks is about 15 ft. The inclination or slope depends entirely on the nature of the ground or the cutting radius of the shovel bucket and where a number of benches or levels are projected it is important to allow a generous slope and width of bench in the preliminary calculations, for, even if the ground is hard, it will be necessary to blast ahead of the shovel, in which case there will be a tendency for the shattered ground to assume its natural angle of repose. These calculations, necessary to define the slope of shovel benches and the stripping limits in open-cut work, are of great importance in small deep deposits with a heavy capping.

LETTERS TO THE EDITOR

"The Rotary Pan for Diamond Concentration"

SIR,—I was interested in the opinions expressed by Mr. J. Sim in his article in your April issue. He states that centrifugal force cannot play a very important part, but it seems to me if there were little or no centrifugal force there would be little or no vortex, because the vortex is the effect of centrifugal force and is a visible measure of its magnitude. It must not be forgotten, either, that a comparatively small force can play a large part when applied at right angles to the direction of gravity and the body is free to move. Regarding the exact shape of the surface of the vortex, central outflow alone would prevent the formation of a paraboloid of revolution and to all appearances it is a frustum of a cone. This, however, is a point of no importance.

Mr. Sim does not agree that a body will drift towards the centre of a pan when its C.F. falls below a certain figure. My reason may be open to question, but there is no disputing the fact that under certain conditions a body will behave as stated. It may be demonstrated by using a flat-bottomed wash-bowl and a handful of gravel. Professor Truscott, in the discussion on L. Andrews' paper "High velocity hydraulic classification" (*Trans. I.M.M.*, vol. xxxvii, p. 428), says: "Centrifugal effects were most capricious. With a centrifuge what happened? The coarse and heavy material was thrown to the confines and compacted

there. Whereas if one swirled water round in an open vessel one got the very reverse, the coarse material went to the centre."

I suggest that it depends on whether the C.F. acting on the particle is greater or less than the pressure on it towards the centre of the vortex, just as whether a body sinks or floats in water depends on whether the force of gravity on the body is greater or less than the upward pressure of the water. So long as a particle is in suspension and has the same or nearly the same angular velocity as the fluid it cannot migrate towards the centre, but when it has its angular velocity retarded, such as by settling and coming in contact with the bottom of the container, it is in a condition to be driven towards the centre by the difference of pressure. This also explains the reverse effects obtained when it is the container that is rotated. In this case a particle coming in contact with the container would have its angular velocity accelerated instead of retarded.

Regarding concentration in general, it is worthy of note that about 85% of the largest stones (+ 8 mm — 16 mm.) find their way over the tailings discharge gate.

Since writing my article last year I have been informed that the settling of the concentrate at or near the periphery was discovered by accident through the dropping out of a rivet or bolt near the outer wall. The result was a continuous discharge of concentrate from the hole and this, apparently, led to the making of a tapping hole near the outer wall as a part of the design. The previous method was to stop the pan at intervals for "clean up."

C. W. Walker.

Accra, Gold Coast Colony.
May 10.

"Average Width of Ore-Bodies"

Writing under date May 3, Mons. E. Friedel, of Strasbourg, refers to a letter of Mr. R. T. Hancock which appeared in the April issue, in which he mentioned two methods of calculating the mean width of an ore-body that had been put forward by Professor Watermeyer. Of the two methods A and B Professor Watermeyer preferred B to A, whereas Mr. Hancock preferred A to B, considering that only method A fulfilled the condition that if any tonnage of the calculated mean width were added or subtracted the final average would be unchanged. M. Friedel in his letter proves that method B also satisfies the same conditions. At the same time he points out that this method alone can be used to determine the true mean width. Assuming that all the blocks of ore under consideration have the same surface the calculated mean width should be equal to the arithmetic mean of the widths of the various blocks and only the value determined by method B fulfils this condition.

BOOK REVIEWS

Power Plants on Metal Mines. By F. A. W. Thomae. Cloth, octavo, 97 pages. Price 5s. London: Mining Publications, Ltd.

Mr. Thomae has industriously collected and arranged many data of power plants connected with metal mining and dredging, dividing them under the headings, pressure-water, steam, oil and gas, as power producers. The work is not critical, but the history of power plants is traced shortly. Working costs are given and also in some cases the cost of installation, while points that are special to particular plants are mentioned. The book is very free from mistakes. There is a bibliography and an index. The mining engineer will find it worth while to have this little book at hand.

Humphrey M. Morgans.

Elements of Mining. By Robert S. Lewis. Cloth, octavo, 510 pages, illustrated. Price 31s. New York: John Wiley and Sons; London: Chapman and Hall.

The author, who is Professor of Mining in the University of Utah, has aimed at producing a textbook to give the student some idea of the importance of mining in the commerce of the world; secondly, to give a summary of the principal mining methods and engineering appliances used; and, thirdly, to deal with mining on its business side. The work is admittedly to a large extent a compilation from existing technical literature and, as it is mainly intended for American readers, it gives greater prominence to American mining practice than to work done in other continents.

The scope of the work is so wide that within the limitations of a volume of 500 pages it is only possible to deal very briefly with the subjects. The introductory chapters touch upon the international significance of mineral resources, methods of prospecting, and the mineral laws of the United States. The statistics of mineral production, however, only take the reader to 1927 and the sections on geophysical prospecting would have been more valuable had some specific examples been given both of successful geophysical surveys and of the limitations of each geophysical method. The bibliography also contains no mention of the important volume on geophysical prospecting by Broughton Edge and Laby.

The main body of the book contains chapters on support of excavations, blasting, mining methods, hoisting, haulage (including scrapers and mechanical loading), compressed air, and ventilation. The sections on mining methods deal briefly with placer mining, including dredging, open-cut mining, and certain systems of underground mining, but there is no section dealing with the different development layouts suited to the various types of ore-bodies and to the mining method selected. The information on shafts and shaft equipment is meagre, and deep mining problems and practice are hardly mentioned.

The concluding chapters on the business side of mining deal with mine sampling and valuation, computation of ore reserves, the commercial valuation of various metalliferous ores, and organization and management. In the articles on mine sampling and valuation the treatment is academic rather than practical. Matters such as the differences found in practice between the sampled value of the ore reserves and the grade sent to the mill, the limiting factors affecting the rate of output from a mine, and approved methods of mine accounting are not discussed.

The above comments deal with some of the defects of the book, but, notwithstanding these, the volume will be found of interest and of use both to the mining engineer and to the student, as the individual chapters are clearly written, well illustrated, and provided with a bibliography of each subject treated.

T. PRYOR.

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

NEWS LETTERS

JOHANNESBURG

May 3.

Far West Rand.—Options over the mineral rights on 80 miles of farms on the Far West Rand are held by three new prospecting companies—West Witwatersrand Areas, Middle Witwatersrand Western Areas, and Western Reefs Exploration and Development Co.—and prospecting operations are proceeding practically along the whole line, which extends from the Randfontein Estates to Klerksdorp. The average width of this ground is about five miles. For a further 30 miles in a south-westerly direction, beyond Klerksdorp, the reef is exposed in many places over fairly wide areas. Then there comes a gap of a few miles, where the reef is hidden by the Ventersdorp amygdaloids, and finally there are the last exposures on the properties held by the Far West Rand Exploration Co., in the Wolmaransstad-Lichtenburg area. In addition to the large blocks of farms referred to there are numerous claim holdings and smaller farm areas held by syndicates and others, which very greatly extend the superficies of the potential goldfield of the south-west, including properties along and across the Vaal River from the Schoon Spruit eastwards.

West Witwatersrand Areas.—A progress report covering operations up to March 31, 1933, has been issued by the West Witwatersrand Areas, Ltd. It states that No. 11 bore-hole on the farm Venterspost has conformed to expectation and was in the amygdaloidal diabase of the Ventersdorp system at the end of March at a depth of 2,616 ft., having proved the dolomite series in this area to have a thickness of 1,707 ft. Steady progress has been made with the location of bore-hole sites and drilling, or work preparatory to drilling, has been started at six bore-holes. In the area acquired from Western Areas, Ltd., the original company (Western Rand Estates, Ltd.) had put down a series of nine bore-holes, six of which intersected reef, the remaining three being behind the sub-outcrop. These nine bore-holes were principally concentrated on the eastern section of the farms and there remains a strike distance of approximately 6½ miles, in which only one bore-hole had previously located reef. Although originally it was considered advisable to await the

results of the Venterspost No. 11 bore-hole before proceeding with further bore-holes on the Western Areas, Ltd., farms, it has now been decided to put down additional bore-holes along the 6½-mile strike referred to, since in the light of subsequent magnetometrical geological information it is now apparent that this section of the company's holding represents a particularly favourable area. Two bore-holes have already been laid out, the first of which will be known as No. 12, being situate at a distance of roughly one mile to the south-west of bore-hole No. 11, while the second, which will be known as No. 13, lies approximately a mile to the south-west of bore-hole No. 12.

Survey Work.—Since the formation of the West Witwatersrand Areas, Ltd., detailed magnetometric traverses, entailing 93 miles of traverse and observation at more than 8,000 stations, have been completed by Dr. Krahmann and the augmented staff of assistants working under his direction and these traverses confirm the more general magnetometric traverses previously carried out. A general geological and topographical survey of the whole area is being undertaken by an enlarged staff under the direction of Dr. Reinecke and an area of approximately 60 square miles has been mapped and contoured to a scale of 1 to 20,000, with contour intervals of 25 ft. The value of aerial photographic surveys as an aid to the location of dykes and faults in the large area on which no outcrops exist was recognized at an early stage and an area of approximately 142 square miles has been surveyed by the Aircraft Operating Company. A preliminary examination of the maps helps to confirm the location and direction of many of the major faults which had been provisionally determined by means of magnetometrical and geological survey. The augmented staff in the field under Drs. Reinecke and Krahmann now includes 11 men specially trained in geological and geophysical work.

Two More Large Gold Mines.—It is generally believed that two gold mines will be established on the Lace Proprietary Mines farms Vlakfontein and Spaarwater, which adjoin the Sub Nigel's property on the Far East Rand. Considerable interest has been aroused by the publication of the principal provisions of an agreement, under which a new company is to be formed by the New Consolidated Gold Fields to purchase Vlakfontein and open it up. The Sub Nigel, Ltd., has agreed to test the farm from its new vertical shaft, which will be sunk near the Sub Nigel-Vlakfontein boundary. The new company will be under the administrative and technical control of the New Consolidated Gold Fields. During the negotiations regarding Vlakfontein it was agreed in principle that the Sub Nigel would, at the Lace Proprietary's request and expense, drive into Spaarwater at such points and for such distances as might be desired, subject always to such work not interfering unduly with the Sub Nigel's own operations. The details of this arrangement have not yet been embodied in an agreement, but it will be generally upon similar lines to those applicable to the Vlakfontein farm.

Three New Shafts.—Operations in connexion with the opening up of the Grootvlei Proprietary Mines' property are to be considerably accelerated. The two East Geduld inclines are being extended as expeditiously as possible and it is expected that one of them will reach the boundary early next year. Meanwhile arrangements are being made for the sinking of a vertical shaft in the south-western portion of the Grootvlei property, which will enable the production stage to be reached about three years earlier than would have been possible under the original programme. The sinking of this vertical shaft will be supplementary to and will not in any way supersede the original programme. The directors of the East Geduld Mines have decided to proceed immediately with the sinking of a second vertical shaft on the company's property. Provided that an additional mining area can be secured on the western flank of the mine, the directors of the East Rand Proprietary Mines propose to proceed without delay with the sinking of a six or seven compartment vertical shaft, 5,200 ft. deep, at a point near the present western boundary. The shaft will cost about £675,000, to be spread over the next five or six years.

BRISBANE

April 26.

Mount Isa.—Owing to a breakdown in the machinery there was no production at Mount Isa from March 25 to March 31. The cause of the stoppage was that, as the driver at the main haulage shaft was starting up a generator on March 21 after crib-hour, a short circuit occurred through the stator windings, rendering the motor useless. As

a consequence it was found necessary to shut down all sections of the mine, except the development work in the Black Star sulphide section. Work throughout the mine was resumed at midnight on April 2, while the mill and smelter were started the next day. The following table gives details of ore mined and milled at Mount Isa, with metal products, for the months of February and March :—

	February.	March.
Ore mined, tons	48,165	56,811
Ore milled, tons	47,695	59,203
Assaying—		
Lead, per cent	10·9	10·9
Silver, oz.	7·0	5·8
Lead concentrates produced—		
Flotation, tons	7,419	9,277
Assaying—		
Lead, per cent	43·7	42·9
Silver, oz.	24·5	20·3
Jig, tons	1,611	2,233
Assaying—		
Lead, per cent	49·6	50·1
Silver, oz.	26·0	21·8
Silver-lead bullion produced, tons	3,276	5,215

Mount Coolon.—The Mount Coolon Gold Mines, N.L., in which British interests are concerned and which is operating on the Mount Coolon goldfield, Queensland, has issued a report covering the period of mine preparation from the inception of the company to October 3, 1932. Regular production was begun on November 1 of that year. The directors state that the operations since then have been highly profitable and that they regard the situation of the company as satisfactory. They remind shareholders, however, that some little time must elapse before the mill could be expected to reach its maximum producing capacity and efficiency. An overdraft of £136,630 existed on October 31, 1932, but this has now been all but extinguished. According to Brisbane Press news from the mine up to January last, after a satisfactory run of the new milling plant the machinery was got into regular work and was keeping up to its capacity of between 1,000 and 1,200 tons a week. In a four-weekly period a quantity of 3,135 tons of ore yielded 2,839 oz. of gold.

Mount Wandoo Mine.—Regarding the Mount Wandoo mine, North Queensland, the mining warden at Chillagoe reported in March last that development had been wholly suspended in the Hardman (the principal) shaft during February. The battery had been kept in commission with two shifts continuously, but owing, it was stated, to trouble with the settlers the recovery was disappointing. In his report for April the same official says that all work in the mine and mill had been suspended pending a reorganization. The lease of this mine was originally taken up by Mr. Alexander Macdonald, who visited England last year, but is now held in the name of Gold and Rare Metals, Ltd. This company was registered in Queensland in September, 1932, with a nominal capital of £6,000 and with its registered office at Mount Wandoo, near Chillagoe.

Queensland Gold Discovery.—A gold discovery, which may develop into something important, has been made in North-West Queensland, about 54 miles from Mount Isa. The lode is reported to extend a distance north and south for nearly three miles and colours of gold may be obtained practically anywhere in the vicinity. The find is in a very inaccessible locality, where there is no water within 10 miles, except, perhaps, for two or three months in the year.

Mount Morgan.—During March the Mount Morgan Company produced 7,306 tons of ore and 6,210 tons was concentrated. The yield was 283 tons of concentrates, estimated to contain 1,885 oz. of gold and 30·11 tons of copper. The value of the output, taking gold at £7 per oz. and copper at £37 per ton, is about £14,315.

Reviving Bendigo.—Recommendations for the revival of large-scale gold-mining operations in Victoria have been framed by a committee appointed at the recent conference convened by the State Minister for Mines (Mr. J. P. Jones). The committee will urge that a permanent advisory committee of experts be appointed to assist the Government in carrying out activities that will lead to immediate developments. The historic Bendigo field is considered to offer alluring opportunities. It has been computed that there is yet 100 years of life in this field and that at least 2,000 miles of reefs are really untouched. Attention is being directed particularly to one mine on this field (the Garden Gully United), which gave splendid returns in the past and paid dividends amounting to over £1,000,000. A survey made lately shows that the reefs in the shallow ground in this mine had not been exhausted. Prospectors still working from a shaft at a depth of about 150 ft. are obtaining profitable yields.

Western Australian Leases.—An English company has applied for four leases at Dunnsville, including the Wealth of Nations

mine, which was floated during the Western Australian mining boom. Four leases have been pegged and it is stated that there are thousands of tons of 8-dwt. ore available.

English Capital for Australia.—Following the registration in Melbourne of the Western Mining Corporation, with a capital of £500,000, comes advice from that city that negotiations, extending over four months, have been concluded by Mr. A. V. Keane, formerly member of the House of Representatives for Bendigo, with Dr. H. Basedow, of Adelaide, representing Lindley Duffield and Co., a London financial group, for the flotation in London of a £1,000,000 company to work a group of Victorian gold mines, as well as the Central Australian Silver-Lead and Copper Company's mine. The Victorian properties to be handled by the new concern, which will be known as Minerals Consolidated, Ltd., comprise three at Bendigo, two at Maryborough, one at Spring Gully, four at Tarangulla, two at Inglewood, one at Dunally, and one at Taradale. The silver-lead and copper company controls the Home of Bullion mine at Barrow Creek, which is some miles north of Alice Springs, in Central Australia, and is said to contain a rich copper deposit.

Mining at the Granites.—The only company that has continued to work at the Granites, Central Australia, is the Chapman Gold Mines, N.L., which has lately issued a circular to its shareholders. In this it is stated that for the time being the company's operations are being confined to the group of leases at the western end of the Granites field. Further reports indicate that about 30 tons of ore had been treated up to February 15, resulting in a return of 85 oz. of retorted gold, valued at nearly £600. The company's engineer (Mr. W. Brazenall) has stated that veins of enrichment and their associated values are definitely continuing in a northerly direction towards the Ajax claim and to the southwards.

Prospecting in Solomon Islands.—An Australian mining engineer (Mr. B. Du Faur), who passed through Brisbane from the Solomon Islands a few days ago, says much energy is being expended in prospecting for gold in those islands. Both local and outside capital is being invested in the work. So far this had been confined to prospecting rather than producing, but with gold at such a high price naturally everyone is keen to make a good find.

VANCOUVER

May 10.

Bridge River.—At the time of writing public interest in the Pioneer and Bralorne operations is fairly evenly divided. While in the latter case this interest is still speculative to a large extent, as compared with the proved status of the Pioneer enterprise, reports are current in regard to recent developments on the lower levels of the Bralorne mine that are calculated to establish it upon a basis that is proportionate to its ultimate possibilities. It is said that the King vein has been found to open up into an ore-body of considerable size and of a good grade on the 10th level and that the problems under which the downward continuation of this and other veins on the property have been considered to be uncertain have been solved in the course of an intensive campaign of development. Full details of this work and of the results that have been achieved are promised in the forthcoming annual report of the company and, meanwhile, it is understood that active steps are being taken to increase the capacity of the treatment plant. Ore reserves at the Pioneer have been added to rapidly in the course of this year's development work and the mine is said by the general manager to have a big year ahead. The mill reached its nominal capacity with an average daily amount of 298 tons of ore treated for the month of March and is being stepped up to higher efficiency. Production has been increased month by month and it is estimated that it will reach a total value of over $2,125,000 for the current fiscal year. The recovery is stated to be at the rate of about $18 per ton and from 35% to 50% of the supply of ore is drawn from development headings, the balance being stoped at present from the 8th, 9th, and 12th levels. Since the completion of the new shaft over 5,100 ft. of drifting work has been accomplished, including over 2,000 ft. on the 10th level and 760 ft. on the 7th level east, where the continuation of the vein has been proved beyond a fault area, at which development had been halted previously. The incorporation of the Holland Gold Mines Syndicate, representing Vancouver, Seattle, and Toronto interests, is announced for the purpose of financing developments on a group of 17 claims near the Pioneer holdings. Work has been commenced on the property. It is reported that a number of claims known as

the Divide group that were staked by Howard Cameron last year have been acquired by the Waterloo Gold Mines, Ltd., of Penticton. This company was formed in 1931 to take over the properties of the Waterloo Consolidated Mines, Ltd., at Lightning Peak, in the Arrow Lake district. The Lightning Peak camp was identified formerly with the production of silver-lead-zinc ores and the Waterloo mine was recorded to have made shipments aggregating over 150 tons with a probable average content of about 300 oz. of silver per ton. It is proposed to drive a cross-cut tunnel to explore a vein that was exposed in surface prospecting last year. The Rufus Argenta Mining Company, formerly operating in the Portland Canal district, has acquired the Broken Hill group, in the lower Bridge River area, and it is understood that old workings are to be re-opened.

Cariboo.—Apart from the developments on the consolidated holdings of the larger operating companies and from the incorporation of new syndicates to acquire claims that have been staked already, prospecting activity in lode-gold concerns has given place, temporarily at least, to placer mining operations. The Hixon Creek area in particular is attracting much attention and it is expected that there will be some interesting developments in this section during the current season. Hixon Creek Gold Mines, Ltd., of Vancouver, has acquired the old "Senator Reid" area from J. B. Williams, of Prince George, and a party of miners, headed by J. Matheson, is on its way to the property. The lode-mining situation entered a new phase with the initial production of 1,407 oz. of gold from the Cariboo Gold Quartz mines. No recent information is available in regard to the progress of development at this property. The Burns Mountain Company is making good progress with its cross-cut tunnel, which has been advanced already for a distance of over 400 ft., and, with the installation of additional machinery and equipment, it is planned to speed up this work. Cariboo Consolidated Mines, Ltd., is also making good progress on the Island and Proserpine Mountain properties. On the latter it is stated that two well-mineralized veins have been encountered in the first 100 ft. of the tunnel that is being driven to explore the "Forrest" veins. Keithley Consolidated Mines, Ltd., representing Vancouver interests, of which Colonel A. H. McCulloch is president, is reported to have acquired a group of 120 claims in the southern portion of the area. Tabor Gold Mines (Cariboo), Ltd., of Vancouver, has been formed to work lode and placer properties on George, Skaret, and Corliss creeks and on Tabor and Ahbau lakes. Thirty-two claims are said to be comprised in the holdings and work is to be commenced as soon as weather conditions permit.

Coast.—W. W. Gibson, of San Francisco, has resumed work on the Leora property, in the Kennedy Lake area, on which he commenced to sink a shaft last year. Mr. Gibson operated this property originally about 25 years ago, when he attempted to open up a vein carrying occasional high gold values by underhand stoping. This work was discontinued owing to the amount of water that was encountered. The purpose of the work now in hand is to sink the shaft to a depth of 125 ft. and then drive on the vein, in order to ascertain whether the mineralization is more regular at depth than at surface. Hercules Mining Company, of Vancouver, has commenced work on the old Dorotha Morton property, at Phillips Arm, other interests have acquired the Thurlow and Sonora properties on the other side of the Bay, and the Glacier Mining Corporation is commencing tunnelling work on a vein on the Enid-Julie group, also in the same general area. It is understood that in the last mentioned case the purpose is to ship high-grade gold ore to the Tacoma smelter. The Thurlow and Sonora properties have been under development at various times, but the projected work has not been carried to a conclusion. There are some attractive surface showings and tunnel workings have exposed blind leads, in which occasional high values in gold were found. The values are associated with pyrite, as are the veins on the Dorotha Morton and Alexandra properties, but the distribution of the mineral seems to be erratic. Selected samples have assayed as high as $200 per ton in gold.

Nelson.—According to reports received from the management of the Noble Five Mines the results of the preliminary work that was put in hand about two months ago, following the acquisition by the company of the Venus-Juno-Athabaska groups, have been encouraging. This work was started from an intermediate level on the Juno property, above the main Juno tunnel, and it is said that driving has proved the vein to be about 4 ft. wide, with values as high as $30 per ton. The point at which these values have been encountered is at some distance from surface

exposures on the same vein and about 150 ft. below them and it is anticipated that a good ore-shoot will be developed in this section of the mine. This interior work was undertaken while snow was too deep to permit of launching out upon the ultimate scheme of development, which is understood to comprise the driving of an adit from the Athabaska ground at a considerably lower horizon. The Venus ore system, on which eight tunnels were driven in the old days of the mine, will be opened up also in this development. In the lowest level of this mine the vein is said to be showing up strongly and further deep development was stopped by the lack of facilities for tunnel approach at the time due to conflict of interests. It is largely on these grounds that hopes for the profitable operation of these gold deposits are based upon the amalgamation of the three groups that has been effected in the purchase by Noble Five Mines, Ltd.

Boundary.—R. L. Clothier has now succeeded in obtaining the entire control of the Morning Star group, in the Fairview camp, and it is understood that there are good prospects for the commencement of active mining operations. There is now only the Silver Crown claim between the ground covered by the Morning Star on the belt of veins traversing this northern section of the area and the extensive holdings of the Federal Mining and Smelting Company, which has retained its interest in the Fairview camp for many years and is looked upon as the logical operating organization to conduct the large-scale developments that are called for. At a recent meeting of the Wellington Syndicate, operating in the Beaverdell area, it was stated that substantial profits had been earned with silver at an average price of 27·5 cents per oz. and with the improved outlook in the market considerable optimism is felt in this field. There is some talk of a resumption of operations by the Beaver Silver Mines. The Wellington Syndicate improved the prospects of their property materially as the result of the past year's development and also installed additional power equipment. There is said to be a suggestion that a joint plan of operation may be arranged between the Wellington and Sally Mines. The Sally property lies below that of the Bell, which occupies the summit of Wallace Mountain, and the Wellington is situated below the Sally at a depth of about 1,000 ft. below the Bell outcrops. A programme of deeper development on the Wellington ore-bodies would entail either the necessity for shaft-sinking or the driving of a disproportionately long cross-cut tunnel. There would appear to be a basis for negotiations with a view to co-operation, notwithstanding the disparity in the capitalization of the two organizations.

TORONTO

May 19.

Ontario Gold Production.—The total gold production of the mines in Ontario during April, according to a report issued by the Ontario Department of Mines, had a total value of $3,681,801, a decrease of $377,447 from the high record of $4,059,248 reported for March. A reduced output was shown in all the camps, the Kirkland Lake field showing the sharpest cut in ton recovery. The Porcupine area produced bullion to the value of $1,783,004 from the treatment of 276,879 tons of ore, as compared with $2,049,151 from 285,040 tons in March and $1,624,241 from 272,380 tons treated in April of last year. The total production from the producing mines of the Kirkland Lake field amounted in value to $1,764,347, treating 143,880 tons of ore, compared with $1,858,867 from 141,716 tons of ore in March and $2,043,055 from 146,095 tons of ore milled during April, 1932. For the first quarter of the year the total production value for all fields was $11,198,939, slightly above the figure for the corresponding period of 1932, which was $11,138,340, and the quantity treated during the same period was 1,362,402 tons as against 1,318,349 tons. For the year to date a total of 18 mines are in production as compared with 15 during the first quarter of 1932.

Sudbury.—The plant of the International Nickel Company operating at Copper Cliff has resumed operations, having been idle for over a month. This follows the resumption of the company's activities at the plant at Port Colbourne, where two electrolytic units employing 100 additional men are now in operation, bringing the number of employees at this plant up to 500. The operations at the Orford plant, Copper Cliff, will be necessary to supply nickel sulphides required by the refinery. The smelter has been handling high-grade copper-nickel ore from the lower workings of the Frood mine. The production of refined copper has been finding a good market in Canada and Europe at the prevailing prices—about 6 cents per lb.

Shipments of monel metal matte from Coniston have also been increasing, which may shortly lead to the resumptions of work at Creighton and Coniston. Officials of the company report that business is somewhat better than at this time last year and it is hoped that the present upward trend may continue. Falconbridge Nickel mines has brought its entire plant, including concentrator, sintering plant, and smelter furnace capacity, up to an operating basis of 750 tons daily with satisfactory results. With the completion of this $400,000 expansion work will be provided for the 350 to 400 men who have been engaged in the new construction work. Nickel orders are proving satisfactory, contracts having been received for the company's output of nickel well into the middle of the year. During the year 159,573 tons of ore were hoisted, of which 123,306 tons were treated in the smelter. Sudbury Basin mines reports favourable progress being made in the Western section of the mine and work done here has resulted in increasing the ore reserves to over 2,000,000 tons averaging 2·25% nickel and 93% copper. Work was principally confined to the 350-ft. level. The position of the company has been improved by the acquisition of a large block of the Falconbridge shares. They also have a large share interest in other companies, including Sherritt-Gordon, Marlartic Gold Mines, Sudbury Nickel and Copper Company, and Island Lake Mines. At the Kenty Gold Mines an important stage in the development work has been reached. The No. 1 shaft has been cut to a depth of 250 ft., where good mineralization has been encountered. Good progress is also being made with No. 2 shaft, which has now reached a depth of 200 ft.

Porcupine.—The annual report for 1932 of Hollinger Consolidated Mines shows a net operating profit of $3,962,885, a slight increase over the profits of the previous year which were $3,508,204. After the payment of all dividends a profit of $272,885 was carried forward to surplus account. During the year the company treated 1,754,863 tons of ore, with an average recovery of $6·16 per ton. The mill treated a daily rate of approximately 4,834 tons of ore, while the cost per ton was reduced from $4·23 to $4·17. The ore reserves at the close of the year were 6,049,548 tons, as compared with 5,236,887 tons at the close of the previous year. The ore conditions at the lower levels are proving very interesting. The extension of the ore zone to the west continues to open up new possibilities. Operations are being carried on at all levels down to the 3,950-ft. horizon. Dome Mines, Ltd., reports bullion recovery for April valued at $403,268, a slight decline from the preceding month. The mill rate for the month averaged 46,850 tons. Production for the four months to date at $1,572,075 marks a new high record. A start has been made on the winze at the 23rd level, which will be continued some 400 or 500 ft. below that level to enable the development of the ore-body disclosed by diamond drilling. Production for the first quarter of the year at the Vipond showed the value of bullion at $117,300, exclusive of premium, from the treatment of 28,685 tons of ore—a recovery at the rate of $4·10 per ton, compared with $4.50 for the previous three months. Low-grade ore has been treated for some time past, but it is stated that a new vein has been opened up on the lower levels, giving promise of better values and a new lease of life for the property. Further work will be necessary to determine its possibilities. The Coniaurum Mines is enlarging its programme of mine development and has started sinking from its present depth at the 2,000-ft. level, going to a depth of 3,000 ft. Diamond drilling will be undertaken and exploration work done to locate a new ore system, which is expected to occur about the 2,500-ft. level.

Kirkland Lake.—Lake Shore Mines in its quarterly report shows bullion production at $2,662,175, a decrease of $447,825 from the previous three months, chiefly due to a lower recovery of the ore treated and reduced milling activities. The mine treated 186,121 tons of ore, with an average recovery of $14·30 per ton. This compares with a treatment during the previous quarter of 205,187 tons, with a recovery of $15 per ton. Some difficulty has been experienced in getting full extraction from the ore treated, due to the heavy tailing losses and the reduction of the milling operations, pending changes being made in the mill. A new milling system has been introduced, which it is hoped will do away with the trouble and an increased mill rate with higher recovery is looked for. Teck-Hughes has again encountered high-grade ore on its property, with ore values stated to compare with the best so far opened up. The average grade is understood to run between $12 and $15 per ton. The net returns from operations

compare favourably with those of last year, although a lower grade of ore is being run to the mill. Important developments are taking place at the Sylvanite. A new ore-body on the 800-ft. level has been located running high in gold content. The high-grade sections on the 2,500- and 3,000-ft. levels are steadily expanding. The average gross income for the four months ending with April amounted to $2,609 per day, the actual recovery being approximately $9·25 per ton. The mill averaged 250 tons daily. The Wright-Hargreaves is pushing developments on the new lower level. The cross-cut on the 3,600-ft. level has opened up 13 ft. of high-grade ore. A new flotation unit has been installed, from which a higher extraction of gold content will be secured. The installation of a new hoist is nearing completion and increased mill tonnage is anticipated. An early resumption of activities at the Barry-Hollinger is looked for with the addition of new equipment—a larger compressor and larger motors are to be installed. Kirkland Gold Belt has completed the shaft down to 500 ft. and will cut a station at that level. An electrically-driven plant, including a large compressor, is being installed and a new hoist has been ordered, when an active programme of development work will be carried on.

North-Western Ontario—Parkhill, in the Michipocoten area, is making good progress in development at the lower levels. The mill is handling 40 tons daily of high-grade ore. Millheads are averaging around $25, due to a recent find of high-grade now under development. The mill capacity will be gradually increased to 100 tons per day. In the Central Patricia district Northern Aerial Mineral Exploration is preparing for a big programme of development work in the Pickle Lake Crow River field, a short distance from the property of Central Patricia. Supplies and additional equipment are being sent in, a mining plant, concentrator, and hoisting equipment are to be installed, and a shaft will be sunk to a depth of 550 ft. Central Patricia Mines are carrying on extensive development work on the Springer, including diamond drilling and surface exploration.

North-Western Quebec.—The financial statement for the first quarter of the year of Noranda Mines shows a gold production of approximately $1,838,313, as compared with $2,217,426 for the corresponding quarter of last year, representing a decline of about 17%. The statement shows a falling off also in the copper production. The copper anodes produced are reported at 13,434,629 lb., as against 14,654,262 lb. last year, a decline of 8·3%, the average price for copper per lb. being about 4·75 cents, compared with 5·75 cents for the first quarter of 1932—or a total recovery of $2,476,458 against $3,050,046. At the mine conditions show improvement, the average grade of ore going to the mill is being well maintained, in regard to both the gold and base metal content with the enlarged concentrator capacity, and with the smelter running at full time the future earnings should show steady expansion. Gold production at the Siscoe mines during April showed a decline amounting to $70,971 from the treatment of 60,792 tons of ore—an average recovery of $10·45 per ton. Production for March was $95,360 from the treatment of 4,779 tons of ore with a recovery per ton of $19·93. The mill treated an average of 226 tons per day, which is to be increased shortly to 250 tons.

PERSONAL

William A. Bone has been awarded the medal of the Society of Chemical Industry for his researches in the mechanism of combustion.

W. Carmichael has left for the Gold Coast.

L. Maurice Cockerell has left for New York.

J. V. N. Dorr was in London for a short time before returning to New York.

G. T. Eve has left for Abyssinia.

J. A. L. Henderson has left for Canada.

T. F. O'Sullivan is now on the Gold Coast.

L. H. Ower has left Northern Rhodesia to take up an appointment at the Rhodesian Museum, Bulawayo.

Arthur E. Page is home from Trinidad.

F. G. Payne has returned from New Zealand.

T. Pryor has left on a short visit to South Africa.

H. G. Scott is here from Melbourne.

R. A. Shatford has left for Canada.

E. O. Teale is returning to Tanganyika from Australia.

D. A. Thomson has been here from West Africa and has left for Australia.

C. H. Trezise is returning to Nigeria.

T. A. Wellsted is returning from India.

W. J. Wilson is home from Nigeria.

Arthur E. du Pasquier, who died on May 20 at the age of 59, was on the staff of the Metropolitan-Vickers Electrical Company and was known to a number of mining men as an authority on electric winding. He was president of the South African Institute of Electrical Engineers from 1919 to 1920.

TRADE PARAGRAPHS

J. K. Smit and Zonen, of Sarphatistraat 66, Amsterdam, announce particulars of services which they offer of interest to mining engineers. These include diamonds for diamond drilling, drilling machines, information about geophysical research by the various well-known methods, and a variety of other information about the use of industrial diamonds and carbons.

Commer Cars, Ltd., of Luton, point out that in the reference to their products in the previous issue of the MAGAZINE an error was made in stating that the heavier vehicles from 3 tons upwards are six-wheelers. Actually 1½, 2, 3, 4 and 5, and 6 to 6½ ton vehicles are made as four-wheelers. There is, however, a special long-frame six-wheeler manufactured having a chassis weight of 33 cwt., with a maximum gross load weight of 3½ tons, while another model is an articulated six-wheeler for 4 to 5 ton loads.

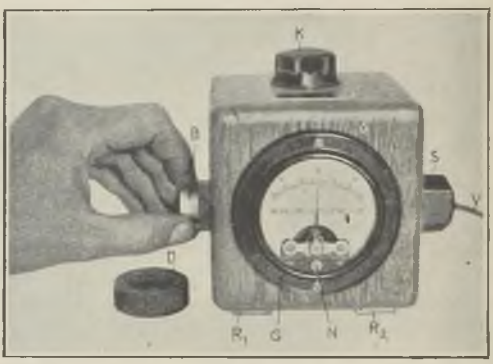
Mining and Industrial Equipment, Ltd., 11, Southampton Row, London, W.C.1, report having received the following orders:—For England: One 3 ft. by 18 in. Hardinge mill and air plant for hard abrasive clinker, one No. 00 Raymond pulverizer for yellow ochre, two 4 ft. by 8 ft. type 400 Hum-mer screens for coal, one 4 ft. by 6 ft. type 72 Hum-mer screen for coal dross, one 2 ft. by 4 ft. type 27 Hum-mer screen for clay and grog, and one Ro-Tap testing sieve shaker. For Wales: One 3-roller Raymond mill for limestone. For South Africa: One 3 ft. by 18 in. Hardinge mill for tin ore.

Holman Bros., Ltd., of Camborne, Cornwall, have issued a well-prepared booklet on the subject of the selection and care of drill-steel bits, shanks, and chucks, which should be in the hands of everyone interested in drilling. The following is a synopsis of the contents:—Drill-steel, its composition and qualities, tests, heating, forging, hot milling, hardening shanks, hardening bits, tempering bits, and the normalization of steel; drill bits, types and sizes and components of a drill bit, cutting edges, reaming edges, wing thickness, shape of hole, and instructions on adhering to a standard and when to resharpen bits; drill shanks, different kinds for different drills—*e.g.*, drifters, sinkers, and stopers—the length of the shank, the fit of the shank, and the care of shanks; unshanked steel, the anvil block versus the bolster, and the wear of drill parts, followed by a general summary.

Hadfields, Ltd., of Sheffield, have sent out a copy of the speech by Sir Robert Hadfield at the company's annual general meeting, in which the chairman made his customary references to world affairs. He also referred specifically to some of the firm's special products and particularly to "Era" manganese steel, which is now largely used for tramway and railway trackwork, and as a consequence of its use important savings have been effected. Reference was also made by Sir Robert to the Cauvery Mettur Dam project, for which the crushing machinery was supplied by his firm. Speaking of the Sydney Harbour Bridge he instanced this as yet a further example of the useful employment of manganese steel trackwork. The firm also issue a leaflet drawing attention to their "Hadmang" welding rods for use on manganese and other steels. This is suitable for effecting electric welded repairs to manganese steel parts and the pamphlet contains examples of the tests which such welded articles have undergone and particulars of how the welding material should be used.

Kinetic Elutriators, Ltd., of 11 Southampton Row, W.C. 1, write us as follows under date May 25: "We wish to draw your attention to certain mis-statements which appear on page 298 of your May issue under the heading, 'William Boby and Co., Ltd.' There is no connexion or similarity between the undercurrent valve mechanism therein referred to and the sand-gate mechanism of the Andrews de-slimer. The two plants are covered by separate valid letters patent and serve entirely different purposes. This company have acquired the rights in all Mr. Andrews' inventions in connexion with elutriating classifiers and all improvements thereon and Mr. Andrews is a director and consulting engineer to Kinetic Elutriators, Ltd. In his private capacity as consulting engineer, however, Mr. Andrews has designed plants for other clients for other purposes and the plant now marketed by Messrs. William Boby is an example of this. It is possible, therefore, that the same basic principles underlie the two plants, but this should not cause confusion as to similarity between the two plants."

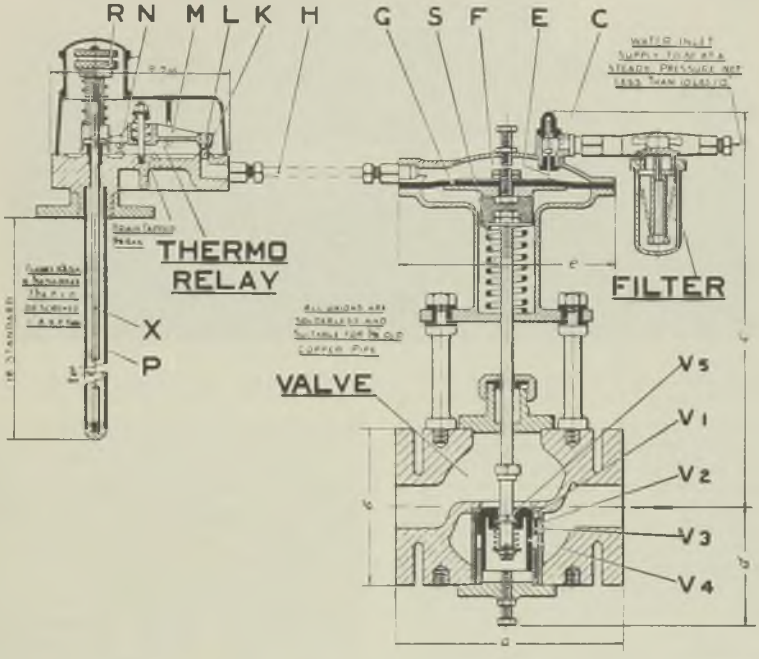
Askania-Werke, A.G., of 87–88, Kaiserallee, Berlin-Friedenau, Germany (London representative: O. G. Karlowa, Abford House, Wilton Road, S.W. 1), have prepared a leaflet which describes a form of electrometer for use in the geophysical exploration of country covered with water. The instrument, which consists essentially of a small dry battery



and galvanometer, is illustrated here, except for the stick-shaped sounding rod which is connected thereto. The sounding rod, which is of a convenient length, consists of two electrodes, so that when it comes in contact with an ore particle in the sand or on the surface of an ore-body washed by water the galvanometer needle will show a deflection, the extent of which depends on the nature of the mineral touched. A table has been prepared showing the potential differences against pure copper in distilled water of a number of common minerals. The cube-shaped box, which is of light weight, can be carried on a belt by means of the strap clamps R 1 and R 2 and contains the galvanometer G with a mechanical zero-adjusting device N, which serves to correct the position of the pointer if the latter on account of temperature or other conditions—*e.g.*, in the tropics—should at the beginning of the operations not be exactly on zero. The double cable V connects the instrument to the

sounding rod by means of the plug S. If the sounding rod is placed in water without touching rock or sand and there is a deflection of the needle it can be brought back to zero a second time by turning the adjusting button K. When not in use this adjusting button should be turned to the stop position, as the battery B, which produces the compensation potential, is thereby relieved. The battery will last for many months and can, after removing the protecting cap D, easily be taken out of the case and replaced.

British Arca Regulators, Ltd., of Windsor House, Victoria Street, London, S.W. 1, publish leaflets describing their various regulators for automatic control in process industries, steam

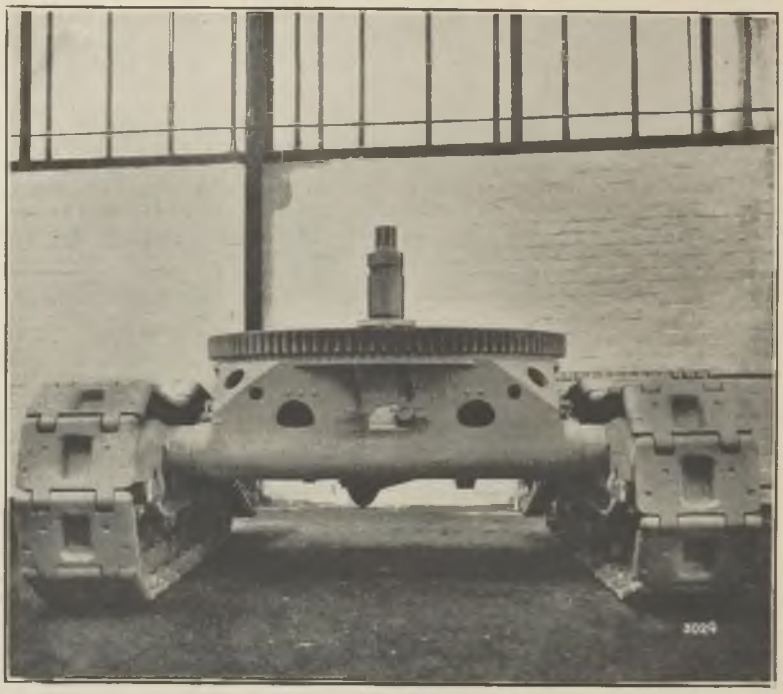


Arca Temperature Regulator.

plant, etc. In referring to the company's exhibit at the British Industries Fair reference was incorrectly made to "traffic" regulators as being one of their products. Mention may here be made of the temperature regulator, which is produced in various types to suit the purpose for which it is required. Thus the steam regulator will have certain essential differences from that used for water or other liquids or for oil or gas. The working principle is, however, the same in each case and it may be understood by reference to the accompanying cross-sections. These show the thermo relay and steam-regulating valve, both of the types most generally used to form a complete temperature regulator. In the thermo relay lever *M* mounted on pivots *N* is connected by the non-expanding steel rod *X* to tube *P*, so that expansion or contraction due to slight changes of temperature acting on tube *P* causes pad *L* to be moved further from or nearer to jet *K* respectively. In the valve operating water enters at *C* and passes the throttling needle *E* into diaphragm chamber *F*. Thence it travels by pipe *H* to jet *K* in the relay. According as pad *L* is nearer to or further away from jet *K*, so the water pressure between throttling needle *E* and jet *K* rises or falls. Such changes of pressure acting on the diaphragm *G*, which is normally balanced by spring *S*, cause the main valve spindle to travel up or down to regulate the flow of steam (or other heating medium) as required. Referring to the bottom half of the valve section, live steam enters on the right-hand side and can pass through the ports *V*2 in the outer liner *V*1 as they become uncovered by the ring *V*3, which forms part of the main valve piston *V*4. The pilot valve *V*5 is formed with the spindle. When the valve is closed (as drawn) live steam pressure builds up under the main piston and holds the valve *V*4 hard on its seat. Downward or opening movement of the spindle opens the pilot valve *V*5, thus equalizing the pressure on either side of the main valve. Further movement of the spindle uncovers the ports *V*2. The area available for the passage of steam through the ports *V*2 is always less than the area through the main valve *V*4. Therefore cutting action, if any, occurs at the ports and not on the main seat. The valve will continue to shut off steamtight for years.

RUSTON-BUCYRUS EXCAVATORS

Arising out of the article by Mr. Sinclair in the previous issue of the Magazine comes an expression of opinion from **Ruston-Bucyrus, Ltd.,** of Lincoln, as to the relative advantages of the chain drive for small excavators, which is interesting as showing the differences of opinion which exist as to the most



UNDERCARRIAGE OF RUSTON-BUCYRUS EXCAVATOR, SHOWING GROUND CLEARANCE.

advantageous design. It will be recalled that the author of the article stated that "on the smaller class of machine the chain drive is dispensed with altogether, experience having shown that a drive by means of direct bevel and spur gearing is superior to the old methods." These makers state that although they formerly used bevel and spur gearing for driving the caterpillar tracks of both small and medium-size excavators they now, "in common with the majority of other makers," have discarded the gearing for chain drive. The reason given for this is that the chains are simpler, more accessible, and give much greater ground clearance, which is a very important point in caterpillar traction as applied to excavators and is illustrated in the accompanying photograph. The firm also inform us that they have delivered four of their new type Diesel excavators which were recently ordered by Stewarts and Lloyds, Ltd., for use in the development of the new steelworks which are being erected at Corby, in Lincolnshire. Quick delivery of these machines was essential and actually two were sent complete by road. All are now hard at work on the site and it is interesting to note that eight Ruston-Bucyrus machines are employed on this new enterprise.

ELECTRIC WELDING IN THE MINING INDUSTRY

Arc welding may be used in the mine not only for maintenance work, but for new construction. On the Rand, for instance, electric arc welding has found many applications and its use has resulted in considerable saving. Until quite recently the mining engineer found it difficult to obtain a very hard metal which could be easily and economically applied to the worn edges of mining implements and in the resurfacing of crushing elements. This demand has now been satisfied by a steel which will respond to case-hardening. In the majority of cases the implements could only with great inconvenience be dismantled and heat-treated. An electrode has recently been placed on the market specially designed to meet these requirements and is known as Hardx and is manufactured by **Murex Welding Processes, Ltd.** The method of working this electrode is normal in every way and no special welding technique is required. The Brinell hardness number of the weld metal, as deposited, is 630 to 670, no quenching or other treatment being required to obtain this high figure. The deposited metal needs no further grinding and another feature of interest and advantage is that, should a pad of appreciable thickness be required, this is readily obtained in one operation. In the U.S.A. hard-facing was introduced to the petroleum industry by the Brothers Stoody. The purposes of the process were twofold: To provide an economical method of rebuilding back to shape the various types of oilfield tools which had become worn in service and a method of processing oilfield drilling tools so that they could withstand the heavy wear in service. The depositing can be done either by electric arc welding or by the oxy-acetylene process. This method may be applied to any material which can be welded and as mentioned above no special working is necessary. Thus in this manner electric arc welding has been used in the construction and repair of welded mine cars, the chassis being constructed entirely by welding, while the process can be applied in the building up of castings subject to very heavy wear. Steel tanks

are now constructed by welding in place of riveting and steel piping can be built up by this method to any desired shape.

In the oilfields electric arc welding is again applied to numerous jobs, perhaps at the present time the most interesting being in the construction of the pipeline for the Iraq Petroleum Co., to which reference was made in the MAGAZINE for March. A further example of oilfield practice is furnished by Apex (Trinidad) Oilfields, Ltd., a report from whose chief engineer says that the development of electric arc welding during recent years has been of vast importance to the field and the welding shop is now a necessary asset to the industry. Extensive research work in the production of suitable electrodes for the welding of the special steels of which drilling tools are made has given the welder and driller complete confidence in this new and economical method of repair. Taking the large fishtail bit as an example, a bit drawn and dressed under the hammer is probably good for only some thirty runs and it is necessary to begin with a new bit that is too long and continue to use it after it is too short. Four men are necessary for the dressing of the larger sizes of fishtails, a power hammer must be installed, and, as temperatures must be closely watched, an anealing oven capable of accommodating several bits should be available. By the building up process a fishtail of correct length is always to hand and the threaded end (the pin) is not damaged by constant heating throughout the entire length of the bit, as in forge-hammer dressing. Cut watercourses can be remedied and the pin can also be built up and rethreaded when not to gauge. The building up of a fishtail occupies about one third of the time required to hammer-dress the same bit and one welder and labourer only are needed for the largest of bits. All tools and plant can be treated in the same manner. Electric welding is also now fully recognized by boiler insurance companies for extensive repair work to boilers of all descriptions, although the oxy-acetylene torch is not. Where drilling equipment is situated at long distances from repair shops and supplies the self-contained engine-driven electric-welding set is able, in the hands of an experienced welder, to cope with many jobs at the wellhead. These sets are usually equipped with a small auxiliary generator for the operation of a flexible shaft grinder, which can also be used for lighting purposes.

METAL MARKETS

COPPER.—The resolute inflationary measures adopted by the United States resulted in electro-copper soaring during May from about 6·00 cents per lb. c.i.f. Europe to 7·75 cents. Considerable buying took place at times on both sides of the Atlantic, users being afraid of still higher values being demanded later on, whilst in Germany especially the close of the month witnessed buying on fears of a possible crash of the mark. Sterling values of standard copper experienced a very pronounced advance. It remains to be seen whether the rise will prove justified. Efforts are being made to get the United States copper industry on a healthier basis.

Average price of Cash Standard Copper: May, 1933, £34 2s. 1d.; April, 1933, £29 12s. 5d.; May, 1932, £28 11s. 11d.; April, 1932, £29 19s. 10d.

TIN.—Prices of tin rose nearly £40 per ton last month, which indicates the powerful forces which have been at work in this market. Heavy American buying has been witnessed, partly of a speculative character although the operations of the tinplate industry there have improved to about 90% of capacity and there has also been an improvement at the motor-car works. Whether the advance will be carried further may depend not only on industrial but also on monetary developments. The statistical position made further progress during May but the improvement was nevertheless not as good as expected. The market may have to withstand "Pool" selling in the near future.

Average price of Cash Standard Tin: May, 1933, £186 5s. 10d.; April, 1933, £158 0s. 4d.; May, 1932, £122 7s. 6d.; April, 1932, £109 0s. 10d.

LEAD.—The tone of this market was quite firm during May, despite occasional setbacks. The price in America made progress in consonance with the general upward movement in commodity values there and this reacted sympathetically on the London market, particularly when German purchasing occurred on fears regarding the safety of the mark. The statistical position, however, remains rather overclouded by the large world stocks, estimated at about 540,000 tons. These, however, would probably be reduced pretty quickly if world consumption gets back to about the 1927 level in the near future, provided producers did not go ahead too hurriedly.

Average mean price of soft foreign lead: May, 1933, £12 4s. 8d.; April, 1933, £10 19s. 11d.; May, 1932, £10 17s. 1d.; April, 1932, £11 7s. 3d.

SPELTER.—The spelter market experienced a moderate rise during May despite the fact that full offers were made by holders at the more advantageous prices obtainable. Possibly this selling is connected with the disposal of the portion of the Cartel stocks earmarked for release under the last agreement. Much interest centres on the question whether the forthcoming negotiations relative to the proposed renewal of the Cartel will prove successful. It seems as if some of the members will press for greater liberty. The statistical position of the metal (outside the United States) continues to improve steadily.

Average mean price of spelter: May, 1933, £15 11s. 7d.; April, 1933, £15 1s. 7d.; May, 1932, £12 11s. 1d.; April, 1932, £11 16s. 3d.

IRON AND STEEL.—The British pig-iron market remained in a cheerful condition during May, with home prices steady, No. 3 Cleveland foundry g.m.b. being quoted at 62s. 6d. per ton delivered Middlesbrough zone. In hematite there is rather a firmer undertone, with makers endeavouring to curtail output, but for the time being East Coast Mixed Numbers are still quoted at the remarkably cheap level of 59s. In British finished steel conditions seem to be developing favourably though the state of individual mills remains patchy. The Continental steel market became stagnant at the close of May, pending the announcement of the official selling prices of the new Continental sales offices on June 1. It is rumoured on the Continent that Britain may eventually join the new International Steel Cartel.

IRON ORE.—The outlook has improved further during the past month, although the actual business passing is not large. Prices are well maintained, with best Bilbao rubio about 15s. 6d. per ton c.i.f.

ANTIMONY.—Generally speaking demand has

LONDON DAILY METAL PRICES.

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

	COPPER.				TIN.		ZINC (Spelter).	LEAD.		SILVER.		GOLD.
	Standard.		Electrolytic	Best Selected.				Soft Foreign.	English.	Cash.	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.	d.	d.	s. d.
11	33 16 10⅞	34 0 7½	37 12 6	—	185 13 9	186 2 6	15 6 3	12 1 3	13 10 0	19 1/16	19⅛	123 6
12	34 9 4½	34 14 4½	38 5 0	36 10 0	187 13 9	188 6 3	15 10 0	12 8 9	13 15 0	19	19 1/16	123 3
15	34 7 6	34 11 3	39 5 0	—	183 8 9	184 2 6	15 8 9	12 8 9	13 15 0	18¹⁵/₁₆	18 15/16	123 3
16	33 16 10½	34 0 7½	39 0 0	36 5 0	184 2 6	184 3 9	15 8 9	12 3 9	13 10 0	18 1/16	18⅛	123 0
17	35 1 10½	35 6 10½	39 10 0	—	187 7 6	187 15 0	15 13 9	12 5 0	13 10 0	19	19 1/16	124 0
18	35 3 1⅛	35 6 10½	40 0 0	—	190 12 6	190 18 9	15 15 0	12 7 6	13 15 0	18¹¹/₁₆	18¾	123 2
19	34 13 1½	34 18 1½	39 15 0	37 5 0	189 11 3	189 13 9	15 13 9	12 6 3	13 15 0	18½	18 9/16	123 1
22	34 5 7½	34 10 7½	39 15 0	—	186 17 6	187 7 6	15 7 6	12 1 3	13 10 0	18½	18½	122 8½
23	33 13 1½	33 16 10½	39 0 0	36 10 0	186 3 9	186 11 3	15 7 6	11 17 6	13 5 0	18⅜	18⅜	122 6
24	34 15 7½	35 0 7½	39 10 0	—	190 8 9	190 13 9	15 15 0	12 1 3	13 10 0	18¹¹/₁₆	18⅜	122 8
25	34 13 1½	34 18 1½	39 10 0	—	191 18 9	191 17 6	15 12 6	12 3 9	13 10 0	18¹¹/₁₆	18¹¹/₁₆	122 5
26	35 4 4½	35 8 1½	40 0 0	37 15 0	190 18 9	190 15 0	15 17 6	12 7 6	13 15 0	18½	18 9/16	122 6
29	36 13 9	36 19 4½	41 0 0	—	198 3 9	198 8 9	16 2 6	12 13 9	14 0 0	18¹⁵/₁₆	19	123 3
30	37 11 3	37 15 7½	42 0 0	40 0 0	199 8 9	199 6 3	16 5 0	13 0 0	14 10 0	18¹⁵/₁₆	19	123 8
31	38 5 7½	38 10 7½	43 5 0	—	210 7 6	210 7 6	16 17 6	13 13 9	15 0 0	19 1/16	19⅛	123 10
June.												
1	38 3 9	38 6 10½	43 5 0	—	209 2 6	208 17 6	16 10 0	13 6 3	14 15 0	18⅞	18¹⁵/₁₆	122 11
2	38 1 10½	38 6 10½	43 10 0	40 15 0	209 18 9	209 17 6	16 10 0	13 5 0	14 15 0	19 1/16	19⅛	122 5
6	38 10 7½	38 15 7½	43 15 0	41 0 0	215 8 9	215 3 9	16 12 6	13 12 6	15 0 0	19¼	19¼	122 6
7	37 11 10½	37 16 10½	43 0 0	—	215 12 6	215 13 9	16 11 3	13 7 6	14 15 0	19 1/16	19⅛	122 0
8	37 6 10½	37 10 7½	42 15 0	—	221 7 6	221 7 6	16 16 3	13 10 0	14 15 0	19¼	19 1/16	122 2½
9	37 6 3	37 11 3	42 5 0	40 0 0	227 7 6	227 7 6	17 0 0	13 10 0	14 15 0	19 1/16	19⅛	122 4½

been at a low ebb, but towards the end of May there was more interest shown, and prices were firmer at about £22 10s. to £22 15s. c.i.f. for Chinese regulus for forward shipment. English regulus is now quoted at about £35 to £40 per ton.

Arsenic.—Demand is rather limited and prices have eased to between £16 10s. and £16 15s. c.i.f. for high-grade Mexican, and £16 10s. f.o.r. mines for 99% Cornish white.

Bismuth.—There is still a fairly keen competition amongst sellers, and the official price has been reduced to 4s. 3d. per lb. for 5 cwt. lots and over.

Cadmium.—Only a restricted inquiry is in evidence and prices now stand at about 1s. 3d. to 1s. 3½d. per lb.

Cobalt Metal.—Business is rather poor, but the official price is unchanged at 5s. 6d. per lb. for cwt. lots.

Cobalt Oxides.—Sales continue light, with prices about 4s. 7d. to 5s. per lb. for black and 5s. 2d. to 5s. 5d. per lb. for grey.

Chromium.—About 2s. 8d. per lb. delivered is quoted for 96 to 98%.

Tantalum.—Quotations are without change at about £15 per lb., demand remaining spasmodic.

Platinum.—A better business has been passing in recent weeks and the official price is now £7 15s. per oz. for refined metal.

Palladium.—Interest in this metal is poor, but prices are quotably unchanged at £3 10s. to £4 5s. per oz.

Osmium.—Although sales are limited the undertone is fairly firm, quotations being about £12 to £13 per oz.

Iridium.—The market is slow, with sponge and powder quoted at £9 to £10 per oz.

Tellurium.—Current quotations are about 15s. to 16s. per lb., business being small.

Selenium.—A steady demand is reported at the unaltered prices of 7s. 8d. to 7s. 9d. per lb. (gold) ex warehouse.

Manganese Ore.—A little Japanese demand has been in evidence recently but, on the whole, new business is slow to develop. Prices are without change at 9½d. per unit c.i.f. for best Indian and 8½d. to 9d. c.i.f. for 50 to 52% washed Caucasian.

Aluminium.—Business has tended to improve during the past month, but prices are without alteration at £100 for ingots and bars and £102 for rolling billets, both less 2% delivered.

Sulphate of Copper.—Prices are firmer in consonance with the advance in standard copper, English material now being about £17 to £17 10s., less 5%.

Nickel.—Business has shown some expansion recently, but, owing to exchange considerations, prices have been reduced to £225 to £230 per ton, according to quantity.

Chrome Ore.—Leading interests report a slightly better business, but low-price competition has to be met on occasion. Quotably, however, prices remain at 80s. to 85s. per ton c.i.f. for first quality 48% Rhodesian ore, and 100s. to 105s. c.i.f. for 55 to 57% New Caledonian.

Quicksilver.—Only small quantities are called for and prices are a trifle easier on balance at about £9 10s. per ton net for spot metal.

Tungsten Ore.—Generally speaking the market has been very quiet. Towards the end of May a little more interest developed, and prices recovered to 10s. 9d. per unit c.i.f. for forward.

Molybdenum Ore.—Supplies are a little more plentiful and prices have eased to about 43s. to 45s. per unit c.i.f. for standard concentrates.

Graphite.—The market is quietly steady at about £16 to £18 per ton c.i.f. for 85 to 90% raw Madagascar flake and £15 to £17 c.i.f. for good 90% Ceylon lumps.

Silver.—The market was somewhat erratic during May, no very pronounced tendency being noticeable. The Continent was inclined to sell in the early part of the month and spot bars fell from 20½d. on May 1 to 18 3/16d. on May 16. Senator Pittman's proposals for the rehabilitation of silver caused a sentimental recovery to 19 3/16d. on May 20, but subsequently rather easier conditions developed again and on May 31 spot bars closed at 19 1/16d.

STATISTICS

PRODUCTION OF GOLD IN THE TRANSVAAL.

	Rand.	Elsewhere.	Total.
	Oz.	Oz.	Oz.
May, 1932	919,223	46,421	965,644
June	913,297	45,714	959,011
July	933,947	47,213	981,160
August	943,174	48,148	991,322
September	912,870	48,631	961,501
October	926,686	48,279	974,965
November	930,085	48,631	978,716
December	931,749	48,869	980,618
January, 1933	919,125	48,332	967,457
February	835,931	47,214	883,145
March	896,728	50,135	946,863
April	845,099	49,998	895,097
May	893,464	51,140	944,604

TRANSVAAL GOLD OUTPUTS.

	April.*		May.†	
	Treated Tons.	Yield Oz.	Treated Tons.	Yield Oz.
Brakpan	114,000	£214,492	118,500	£219,061
City Deep	80,000	20,108	97,500	22,205
Cons. Main Reef	77,100	23,911	80,500	24,167
Crown Mines	274,000	83,648	296,000	89,061
Daggafontein	49,500	£116,109	52,500	£120,607
D'rb'n Roodepoort Deep	48,900	13,682	52,000	14,609
East Geduld	63,500	21,597	74,000	25,172
East Rand P.M.	156,000	39,093	166,000	41,252
Geduld	86,600	26,769	91,500	27,910
Geldenhuis Deep	72,500	14,980	77,400	15,916
Glynn's Lydenburg	7,400	2,603	7,600	2,668
Government G.M. Areas	190,000	£486,004	216,000	£529,096
Kleinfontein	51,000	9,481	54,000	9,975
Langlaagte Estate	70,000	£122,980	80,000	£137,183
Luipaard's Vlei	34,100	8,106	36,500	8,499
Modderfontein New	168,000	50,131	179,000	54,179
Modderfontein B	73,000	16,557	77,500	17,570
Modderfontein Deep	42,400	18,240	46,000	19,704
Modderfontein East	72,500	18,928	78,000	19,911
New State Areas	85,000	£246,258	95,000	£265,653
Nourse	70,000	18,352	72,000	18,449
Randfontein	245,000	£394,218	263,000	£432,629
Robinson Deep	95,000	25,696	100,000	26,980
Rose Deep	60,500	11,641	65,000	12,308
Simmer and Jack	85,000	20,133	91,500	20,984
Springs	82,700	£220,936	84,500	£222,528
Sub Nigel	36,900	35,382	38,300	36,103
Transvaal G.M. Estates	20,000	5,223	20,000	5,278
Van Ryn	50,000	£60,833	52,500	£60,732
Van Ryn Deep	70,000	£120,274	77,000	£131,002
West Rand Consolidated	95,000	£144,031	98,000	£150,176
West Springs	83,300	£107,774	84,500	£106,957
Witw'tersr'nd (Knights)	69,000	£67,402	75,000	£73,525
Witwatersrand Deep	44,300	14,622	47,200	15,088

* Gold at 119s. per oz. † Gold at 120s. per oz.

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, 1932	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	2,883,500	27 9	19 5	8 4	1,196,011
May	2,964,100	27 6	19 2	8 4	1,228,198
June	2,927,200	27 9	19 3	8 6	1,241,392
July	2,993,600	27 5	19 0	8 5	1,260,744
August	3,027,700	27 6	19 1	8 5	1,277,923
September	2,940,800	27 6	19 1	8 5	1,234,584
October	2,994,500	27 5	19 0	8 5	1,263,274
November	2,949,050	27 8	19 2	8 6	1,256,717
December	2,972,000	27 10	19 5	8 5	1,255,797
January, 1933	3,029,000	37 10	19 4	18 6	2,802,754
February	2,802,600	37 0	19 9	17 3	2,414,758
March	3,087,860	36 1	19 7	16 6	2,549,179
April	—	—	—	—	2,381,971

NATIVES EMPLOYED IN THE TRANSVAAL MINES.

	Gold Mines.	Coal Mines.	Diamond Mines.	Total.
May 31, 1932	215,926	11,972	—	227,898
June 30	217,077	11,833	—	228,910
July 31	217,525	12,056	—	229,581
August 31	217,658	11,727	—	229,385
September 30	216,398	11,642	—	228,040
October 31	216,298	11,353	—	227,651
November 30	219,024	11,207	—	230,231
December 31	221,008	11,310	—	232,318
January 31, 1933	222,005	11,292	—	233,297
February 28	222,589	11,472	—	234,061
March 31	223,490	11,626	—	235,116
April 30	225,279	11,611	—	236,890
May 31	227,178	11,562	—	238,740

PRODUCTION OF GOLD IN RHODESIA.

	1930	1931	1932	1933
	oz.	oz.	oz.	oz.
January	46,121	45,677	42,706	48,656
February	43,385	42,818	45,082	47,661
March	45,511	42,278	47,239	49,929
April	45,806	43,776	46,487	53,559
May	47,645	43,731	46,854	—
June	45,208	44,118	48,441	—
July	45,810	44,765	47,331	—
August	46,152	43,292	49,254	—
September	46,151	42,846	50,198	—
October	45,006	44,260	50,416	—
November	44,351	44,516	48,082	—
December	46,485	50,034	52,096	—

RHODESIAN GOLD OUTPUTS.

	April.		May.	
	Tons.	Oz.	Tons.	Oz.
Cam and Motor	25,600	9,523	25,600	9,576
Globe and Phœnix	6,096	5,493	6,080	5,395
Lonely Reef	11,000	2,102	11,500	1,327
Luiri Gold	—	—	—	—
Rezende	6,500	2,397	6,500	2,402
Sherwood Star	6,400	£7,837	6,800	1,892
Wanderer Consolidated	13,200	3,566	10,000	3,653

WEST AFRICAN GOLD OUTPUTS.

	April.		May.	
	Tons.	Oz.	Tons.	Oz.
Ariston Gold Mines	6,608	£20,864	7,173	£23,944
Ashanti Goldfields	13,448	14,739	13,610	14,809
Taquah and Abosso	10,038	3,282	10,458	3,131

AUSTRALIAN GOLD OUTPUTS BY STATES.

	Western Australia.	Victoria.	Queensland.
	Oz.	Oz.	Oz.
May, 1932	53,928	—	692
June	50,079	—	920
July	53,585	—	1,391
August	51,536	—	1,026
September	54,427	—	1,160
October	51,236	—	2,169
November	53,956	—	4,386
December	52,282	38,612†	4,602
January, 1933	45,755	9,133	4,005
February	47,281	—	4,365
March	47,105	—	—
April	52,909	—	—
May	—	—	—

† Period Jan.–Nov. 1932.

AUSTRALASIAN GOLD OUTPUTS.

	April.		May.	
	Tons.	Value £	Tons.	Value £
Associated G.M. (W.A.)	5,101	4,456	5,267	5,476
Blackwater (N.Z.)	3,200	1,637*	4,100	1,932*
Boulder Persev'ce (W.A.)	6,712	13,261	7,009	3,225*
Grt. Boulder Pro. (W.A.)	6,942	5,174*	6,884	5,361*
Lake View & Star (W.A.)	38,611	73,644	42,796	78,933
Sons of Gwalia (W.A.)	11,550	15,430	11,540	15,577
South Kalgurli (W.A.)	9,341	13,766	9,517	13,489
Waihi (N.Z.)	16,893‡‡	{ 5,046* / 28,866†	—	{ — / —
Wiluna	34,019	8*885*	—	—

* Oz. gold. † Oz. silver. ‡‡ To Apr. 15.

GOLD OUTPUTS, KOLAR DISTRICT, INDIA.

	April.		May.	
	Tons Ore.	Total Oz.	Tons Ore.	Total Oz.
Champion Reef	8,580	4,904	9,290	5,282
Mysore	14,375	7,425	14,860	7,669
Nundydroog	18,575	11,754†	18,094	9,689*
Ooregum	11,752	4,200	11,804	3,997

* 1,134 oz. from 932 tons Balaghat ore. † 1,273 oz. from 1,146 tons Balaghat ore.

MISCELLANEOUS GOLD, SILVER, AND PLATINUM OUTPUTS.

	April.		May.	
	Tons.	Value £	Tons.	Value £
Bulolo Gold	—	153,271*d*	—	—
Chosen Corp. (Korea)	10,960	14,068	12,460	19,549
Frontino Gold (C'bia)	4,450	26,184	4,690	24,885
Fresnillo	65,657	2,367*d*	—	—
New Goldfields of Venezuela	8,192	2,017*	—	—
Oriental Cons. (Korea)	—	80,370*d*	—	84,683*d*
St. John del Rey (Brazil)	—	42,200	—	38,000
Santa Gertrudis (Mexico)	17,637	3,932*d*‡	—	—
Viborita	—	—	—	—
West Mexican Mines	1,530	21,000*d*	—	—

d Dollars. * Oz. gold. ‡ Loss.

PRODUCTION OF TIN IN FEDERATED MALAY STATES.

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

July, 1932	1,437	January, 1933	2,312
August	1,164	February	2,154
September	1,123	March	1,506
October	2,273	April	2,589
November	2,242	May	1,917
December	1,590	June	—

OUTPUTS OF MALAYAN TIN COMPANIES.

In Long Tons of Concentrate.

	Mar.	Apr.	May.
Ayer Hitam	—	68½	29½
Batu Caves	—	22½	—
Changkat	55	60	55
Gopeng	72½*	—	—
Hongkong Tin	105*	—	—
Idris Hydraulic	—	20¾	—
Ipoh	—	54¾	40¾
Kampar Malaya	—	—	—
Kampong Lanjut	—	—	—
Kamunting	173	145	146
Kent'(F.M.S.)	—	—	—
Killinghall	86½*	—	—
Kinta	34½*	—	—
Kinta Kellas	38½*	36½	—
Kramat Tin	78	85	80
Kuala Kampar	—	—	—
Kundang	—	—	—
Lahat	7½	12⅕	11⅔
Lower Perak	—	—	—
Malaya Consolidated	—	—	—
Malayan Tin	—	68½	80
Malim Nawar	—	—	—
Pahang	78	72	72
Penawat	39	45	40½
Pengkalen	67*	—	—
Petaling	151	152	100
Rahman	—	23	—
Rambutan	—	—	—
Rantau	—	39½	—
Rawang	42	23	20
Rawang Concessions	16	23	40
Renong	23½	27	28¼
Selayang	—	—	—
Southern Kampar	—	75	—
Southern Malayan	51½	53½	47½
Southern Perak	—	51	—
Southern Tronoh	18	17	17
Sungei Besi	—	—	—
Sungei Kinta	—	—	—
Sungei Way	—	56½	47½
Taiping	11½	12½	—
Tanjong	—	—	—
Tekka	39*	—	—
Tekka Taiping	65*	—	—
Temoh	—	—	—
Tronoh	39	37	37
Ulu Klang	—	—	—

* 3 months to Mar. 31.

OUTPUTS OF NIGERIAN TIN MINING COMPANIES.

In Long Tons of Concentrate.

	Mar.	Apr.	May.
Anglo-Nigerian	17½	17½	21⅞
Associated Tin Mines	106	110	110
Baba River	3	3	3
Batura Monguna	—	—	—
Bisichi	20	25	—
Daffo	—	—	—
Ex-Lands	—	—	—
Filani	—	—	—
Jantar	9	12	—
Jos	7½	8½	—
Juga Valley	5½	5½	5½
Kaduna Syndicate	11	11	—
Kaduna Prospectors	5	6	—
Kassa	3	3	4½
London Tin	75	86	80
Lower Bisichi	3	3½	—
Naraguta Extended	—	—	—
Nigerian Consolidated	—	5	—
Offin River	—	—	—
Ribon Valley	10	9½	12
Tin Fields	—	—	—
United Tin Areas	9	9	11
Yarde Kerri	—	—	—

OUTPUTS OF OTHER TIN MINING COMPANIES.

In Long Tons of Concentrate.

	Mar.	Apr.	May.
Anglo-Burma (Burma)	23	21¾	24¼
Aramayo Mines (Bolivia)	99	108	98
Bangrin (Siam)	51½	61½	44
Beralt	24*	24*	26½*
Consolidated Tin Mines (Burma)	73	72	61
East Pool (Cornwall)	47¼	44	—
Fabulosa (Bolivia)	37	32	31
Geevor	55	52	66
Kagera (Uganda)	25	25	—
Kamra	—	—	—
Malaysiam Tin	14½	13½	13½
Mawchi	225*	224*	—
Patino	—	—	—
Pattani	—	—	—
San Finx (Spain)	—	—	—
Siamese Tin (Siam)	118½	140	94
South Crofty	51¼	52	58⅜
Tavoy Tin (Burma)	47½	45¼	67½
Tongkah Harbour (Siam)	35	32	30
Toyo (Japan)	68½	71	80½
Zaaiplaats	12½	—	—

* Tin and Wolfram.

COPPER LEAD, AND ZINC OUTPUTS.

		Apr.	May.
Britannia Lead	Tons refined lead	4,466	4,594
	Oz. refined silver	222,320	217,194
Broken Hill South	Tons lead conc.	4,507	5,679
	Tons zinc conc.	5,047	6,481
Burma Corporation	Tons refined lead	5,880	5,880
	Oz. refined silver	500,755	520,909
Electrolytic Zinc	Tons zinc	—	—
Indian Copper	Tons copper	400	400
	Tons yellow metal	470	505
Messina	Tons copper	684	733
Mount Isa	Tons lead bullion	4,636	4,906
Mount Lyell	Tons concentrates	2,777*	2,900‡
North Broken Hill	Tons lead conc.	4,850	5,380†
	Tons zinc conc.	4,298	4,992
Rhodesia Broken Hill	Tons Zinc	1,680	1,655
	Tons V_2O_5 conc.	—	—
Roan Antelope	Tons blister copper	—	—
Sulphide Corporation	Tons lead conc.	1,280	—
	Tons zinc conc.	1,728	—
Trepca	Tons lead conc.	3,626	5,560
	Tons zinc conc.	4,638	7,229
Zinc Corporation	Tons lead conc.	5,162	—
	Tons zinc conc.	3,637	—

* To Apr. 19. † To May 20. ‡ To May 17.

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

		Mar.	April.
Iron Ore	Tons	218,261	252,315
Manganese Ore	Tons	5,982	8,840
Iron and Steel	Tons	96,963	70,891
Copper and Iron Pyrites	Tons	24,099	23,648
Copper Ore, Matte, and Prec.	Tons	1,090	3,594
Copper Metal	Tons	10,113	40,547
Tin Concentrate	Tons	3,145	2,730
Tin Metal	Tons	755	200
Lead Pig and Sheet	Tons	20,059	24,382
Zinc (Spelter)	Tons	5,076	6,339
Zinc Sheets, etc.	Tons	1,547	973
Zinc Oxide	Tons	72	93
Zinc Ore and Conc.	Tons	—	10,529
Aluminium	Cwt.	9,294	6,850
Mercury	Lb.	73,100	231,511
White Lead	Cwt.	6,183	5,363
Barytes, ground	Cwt.	25,677	22,056
Asbestos	Tons	1,539	1,575
Boron Minerals	Tons	1,719	681
Borax	Cwt.	15,720	6,144
Basic Slag	Tons	—	450
Superphosphates	Tons	8,927	7,796
Phosphate of Lime	Tons	19,670	26,077
Mica	Tons	102	102
Tungsten Ores	Tons	339	304
Sulphur	Tons	5,813	4,484
Nitrate of Soda	Cwt.	—	20
Potash Salts	Cwt.	280,039	180,751
Petroleum: Crude	Gallons	25,254,908	38,849,347
Lamp Oil	Gallons	19,467,893	21,478,195
Motor Spirit	Gallons	116,014,311	83,067,288
Lubricating Oil	Gallons	9,878,865	8,520,338
Gas Oil	Gallons	7,342,402	13,285,295
Fuel Oil	Gallons	50,356,989	42,382,095
Asphalt and Bitumen	Tons	7,924	7,161
Paraffin Wax	Cwt.	67,806	52,804

OUTPUTS REPORTED BY OIL-PRODUCING COMPANIES.

In Tons.

	Mar.	Apr.	May.
Anglo-Ecuadorian	16,011	15,024	15,852
Apex Trinidad	49,030	47,990	47,700
Attock	1,421	1,242	1,233
British Burmah	5,091	5,225	4,854
British Controlled	39,599	37,945	—
Kern Mex.	857	857	873
Kern River (Cal.)	7,429*	3,187	3,485
Kern Romana	140	207	156
Kern Trinidad	3,099	3,937	4,571
Lobitos	21,454	21,614	22,221
Phœnix	65,388	63,255	65,400
St. Helen's Petroleum	—	3,797	3,850
Steaua Romana	90,399	88,084	90,457
Tampico	2,437	2,378	2,442
Tocuyo	1,153	1,042	1,095
Trinidad Leaseholds	31,650	32,450	30,450

* Includes St. Helen's Petroleum.

QUOTATIONS OF OIL COMPANIES' SHARES.

Denomination of Shares £1 unless otherwise noted.

	May 10, 1933.	June 9, 1933.
	£ s. d.	£ s. d.
Anglo-Ecuadorian	11 0	12 6
Anglo-Egyptian B	1 11 9	1 10 0
Anglo-Persian 1st Pref.	1 6 3	1 9 0
,, ,, Ord.	1 15 0	1 15 6
Apex Trinidad (5s.)	1 3 6	1 3 3
Attock	10 0	10 0
British Burmah (8s.)	4 3	4 9
British Controlled ($5)	6 0	4 6
Burmah Oil	3 1 3	3 7 6
Kern River Cal. (10s.)	2 6	3 9
Lobitos, Peru	1 16 9	1 16 9
Mexican Eagle, Ord. (4 pesos)	7 0	7 3
,, ,, 8% Pref. (4 pesos)	6 9	7 0
Phœnix, Roumanian	10 0	10 0
Royal Dutch (100 fl.)	19 0 0	20 5 0
Shell Transport, Ord.	2 6 9	2 7 6
,, ,, 5% Pref. (£10)	11 10 0	11 15 0
Steaua Romana	8 6	8 9
Trinidad Leaseholds	2 16 3	2 11 3
United British of Trinidad (6s. 8d.)	5 6	4 9
V.O.C. Holding	1 13 0	1 15 0

PRICES OF CHEMICALS. June 12.

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

		£ s. d.
Acetic Acid, 40%	per cwt.	1 0 9
,, ,, 80%	,,	1 18 5
,, ,, Glacial	per ton	59 0 0
Alum	,,	8 7 6
Aluminium Sulphate, 17 to 18%	,,	6 15 0
Ammonium, Anhydrous	per lb.	1 1
,, 0·880 solution	per ton	15 10 0
,, Carbonate	,,	27 10 0
,, Nitrate (British)	,,	16 0 0
,, Phosphate (Mono- and Di-)	,,	58 0 0
,, Sulphate, 20·6% N.	,,	6 10 0
Antimony, Tartar Emetic, 43/44%	per lb.	10
,, Sulphide, golden	,,	9
Arsenic, White (foreign)	per ton	18 0 0
Barium, Carbonate (native), 94%	,,	4 10 0
,, Chloride	,,	10 0 0
Barytes	,,	8 5 0
Benzol, standard motor	per gal.	1 8½
Bleaching Powder, 35% Cl.	per ton	8 15 0
Borax	,,	16 10 0
Boric Acid	,,	26 10 0
Calcium Chloride, solid, 70/75%	,,	5 5 0
Carbolic Acid, crude 60's	per gal.	3 0
,, ,, crystallized, 40°	per lb.	10½
Carbon Disulphide	per ton	30 0 0
Citric Acid	per lb.	9½
Copper Sulphate	per ton	16 0 0
Creosote Oil (f.o.b. in Bulk)	per gal.	3½
Cresylic Acid, 98–100%	,,	1 2
Hydrofluoric Acid, 59/60%	per lb.	6
Iodine Resub. B.P. (28 lb. lots)	,,	14 11
Iron, Nitrate 80° Tw.	per ton	6 0 0
,, Sulphate	,,	1 12 6
Lead, Acetate, white	,,	31 10 0
,, Nitrate (ton lots)	,,	27 10 0
,, Oxide, Litharge	,,	28 0 0
,, White	,,	37 10 0
Lime, Acetate, brown	,,	9 10 0
,, ,, grey, 80%	,,	15 10 0
Magnesite, Calcined	,,	9 10 0
Magnesium Chloride	,,	6 10 0
,, Sulphate, comml.	,,	5 0 0
Methylated Spirit Industrial 61 O.P.	per gal.	2 0
Nitric Acid, 80° Tw.	per ton	21 10 0
Oxalic Acid	per ton	48 0 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	30 0 0
,, Chlorate	per lb.	4
,, Chloride, 80%	per ton	9 10 0
,, Ethyl Xanthate	per 100 kilos	7 8 0
,, Hydrate (Caustic) 88/90%	per ton	40 0 0
,, Nitrate	,,	30 0 0
,, Permanganate	per lb.	8½
,, Prussiate, Yellow	per ton	75 0 0
,, ,, Red	per lb.	2 0
,, Sulphate, 90%	per ton	10 10 0
Sodium Acetate	,,	22 10 0
,, Arsenate, 45%	,,	23 0 0
,, Bicarbonate	,,	10 10 0
,, Bichromate	per lb.	4
,, Carbonate (Soda Ash), 58%	per ton	6 0 0
,, ,, (Crystals)	,,	5 2 6
,, Chlorate	,,	32 0 0
,, Cyanide, 100% NaCN basis	per lb.	8
,, Ethyl Xanthate	per 100 kilos	7 0 6
,, Hydrate, 76/77%	per ton	14 0 0
,, Hyposulphite, comml.	,,	9 2 6
,, Nitrate (refined)	,,	8 10 0
,, Phosphate, comml.	,,	12 0 0
,, Prussiate	per lb.	4½
,, Silicate	per ton	9 10 0
,, ,, (liquid, 140° Tw.)	,,	8 10 0
,, Sulphate (Glauber's Salt)	,,	2 15 0
,, ,, (Salt-Cake)	,,	3 3 6
,, Sulphide, Conc., 60/65%	,,	10 15 0
,, Sulphite, pure	per cwt.	14 0
Sulphur, Flowers	per ton	9 10 0
,, Roll	,,	9 10 0
Sulphuric Acid 168° Tw.	,,	4 5 0
,, ,, free from Arsenic, 140° Tw.	,,	3 0 0
Superphosphate of Lime (S.P.A. 16%)	,,	3 4 0
Tartaric Acid	per lb.	11¾
Turpentine	per ton	62 10 0
Tin Crystals	per lb.	1 0
Titanous Sulphate (Stabilized)	,,	9
Zinc Chloride	per ton	9 10 0
,, Dust, 90/92%	,,	20 0 0
,, Oxide (White Seal)	,,	35 0 0
,, Sulphate	,,	9 0 0

SHARE QUOTATIONS

Shares are £1 par value except where otherwise noted.

GOLD AND SILVER:	May 10, 1933.	June 9, 1933.
SOUTH AFRICA:	£ s. d.	£ s. d.
Brakpan	6 7 6	5 10 0
City Deep	1 8 9	1 5 6
Consolidated Main Reef	2 11 9	2 3 9
Crown Mines (10s.)	9 13 9	8 5 0
Daggafontein	3 19 3	3 7 6
Durban Roodepoort Deep (10s.)	1 19 3	1 12 6
East Geduld	5 6 3	4 17 6
East Rand Proprietary (10s.)	1 7 0	1 7 6
Geduld	6 8 9	5 17 6
Geldhenhuis Deep	1 6 3	1 7 6
Glynn's Lydenburg	1 12 6	1 0 0
Government Gold Mining Areas (5s.)	2 7 6	2 5 6
Grootvlei	3 1 3	2 15 0
Langlaagte Estate	1 8 9	1 8 9
Luipaard's Vlei (2s.)	9 0	9 6
Modderfontein, New (10s.)	3 10 0	3 3 9
Modderfontein B (5s.)	1 1 6	18 0
Modderfontein Deep (5s.)	19 9	18 0
Modderfontein East	3 7 6	2 17 6
New Kleinfontein	1 11 3	1 3 6
New State Areas	3 2 6	3 1 3
Nourse	2 1 3	1 17 6
Randfontein	2 15 9	2 10 9
Robinson Deep A (1s.)	13 9	13 9
" " B (7s. 6d.)	1 14 3	1 9 9
Rose Deep	1 0 0	1 1 9
Simmer and Jack (2s. 6d.)	7 9	7 9
Springs	5 11 9	4 18 9
Sub Nigel (10s.)	8 15 0	7 17 6
Van Ryn	1 6 9	1 5 0
Van Ryn Deep	1 15 0	1 12 6
Village Deep (9s. 6d.)	1 3	1 3
West Rand Consolidated (10s.)	1 2 6	1 1 9
West Springs	1 14 3	1 8 9
Witwatersrand (Knights)	1 1 3	1 1 3
Witwatersrand Deep	1 8 9	1 7 6
RHODESIA:		
Cam and Motor	2 5 0	2 8 0
Globe and Phœnix (5s.)	19 6	17 0
Lonely Reef	10 0	10 0
Luiri Gold (5s.)	9	9
Rezende (17s. 6d.)	1 8 9	1 8 9
Sherwood Starr (5s.)	12 3	11 9
Wanderer	16 3	18 9
GOLD COAST:		
Ariston (2s. 6d.)	7 0	7 9
Ashanti (4s.)	2 2 0	2 7 0
Taquah and Abosso (4s.)	10 3	11 0
AUSTRALASIA:		
Associated Gold (4s.), W.A.	3 0	3 3
Boulder Perseverance	—	2 6
Golden Horseshoe (3s.), W.A.	4 0	4 0
Great Boulder Propriet'y (2s.), W.A	7 0	7 9
Lake View and Star (4s.), W.A.	17 9	19 0
Sons of Gwalia (10s.), W.A.	19 9	1 2 0
South Kalgurli (10s.), W.A.	1 6 0	1 7 6
Waihi (5s.), N.Z.	18 6	18 3
Wiluna Gold, W.A.	2 2 3	2 4 0
INDIA:		
Champion Reef (10s.)	1 1 3	1 3 0
Mysore (10s.)	13 9	14 0
Nundydroog (10s.)	2 4 9	2 8 3
Ooregum (10s.)	7 0	6 9
AMERICA:		
Camp Bird (2s.), Colorado	4	8
Exploration (10s.)	2 9	3 6
Frontino and Bolivia, Colombia	1 6 3	1 7 3
Mexican Corporation (10s.), Mexico	5 0	6 6
New Goldfields of Venezuela (5s.)	5 3	6 6
St. John del Rey, Brazil	1 1 6	1 1 6
Santa Gertrudis, Mexico	5 9	6 0
Viborita (5s.), Colombia	3 6	3 6
MISCELLANEOUS:		
Chosen, Korea	10 0	12 6
New Guinea	5 0	5 0
COPPER:		
Bwana M'Kubwa (5s.), Rhodesia	5 3	5 9
Esperanza	6 3	6 3
Indian (2s.)	1 9	2 0
Loangwa (5s.), Rhodesia	1 6	1 9
Mason and Barry	11 3	12 6
Messina (5s.), Transvaal	8 3	11 3
Mount Lyell, Tasmania	18 3	18 0
Namaqua (£2), Cape Province	3 6	3 6
Rhodesia-Katanga	10 0	10 0
Rio Tinto (£5), Spain	17 10 0	18 0 0
Roan Antelope (5s.), Rhodesia	18 9	1 3 0
Tanganyika Concessions	14 3	14 3
Tharsis (£2), Spain	3 7 6	3 8 9

LEAD-ZINC:	May 10, 1933.	June 9, 1933.
	£ s. d.	£ s. d.
Amalgamated Zinc (8s.), N.S.W.	8 9	8 3
Broken Hill Proprietary, N.S.W.	1 5 9	1 6 9
Broken Hill, North, N.S.W.	3 2 6	3 5 0
Broken Hill, South, N.S.W.	2 1 3	2 2 6
Burma Corporation (10 rupees)	12 9	13 6
Electrolytic Zinc Pref., Tasmania	11 3	16 0
Mount Isa, Queensland	9 6	9 0
Rhodesia Broken Hill (5s.)	2 0	2 0
San Francisco (10s.), Mexico	10 3	13 6
Sulphide Corporation (15s.), N.S.W.	8 0	8 0
ditto, Pref.	10 3	11 3
Trepca (5s.), Yugoslavia	9 6	12 3
Zinc Corporation (10s.), N.S.W.	1 3 9	1 4 0
ditto, Pref.	3 15 0	4 0 0
TIN:		
Aramayo Mines (25 fr.), Bolivia	16 3	17 6
Associated Tin (5s.), Nigeria	6 0	6 6
Ayer Hitam (5s.), Malay	13 0	13 6
Bangrin, Siam	17 0	17 6
Bisichi (10s.), Nigeria	7 0	7 6
Consolidated Tin Mines of Burma	3 6	4 3
East Pool (5s.), Cornwall	1 2	1 0
Ex-Lands Nigeria (2s.)	1 9	2 6
Geevor (10s.), Cornwall	5 3	7 0
Gopeng, Malay	1 12 6	1 13 9
Hongkong (5s.), Malay	14 3	15 0
Idris (5s.), Malay	6 6	7 0
Ipoh Dredging (16s.), Malay	1 1 0	1 1 6
Kaduna Prospectors (5s.), Nigeria	5 0	7 0
Kaduna Syndicate (5s.), Nigeria	13 9	16 0
Kamunting (5s.), Malay	9 0	9 3
Kepong, Malay	7 6	10 0
Kinta (5s.), Malay	6 3	6 6
Kinta Kellas (5s.), Malay	5 0	6 0
Kramat Pulai, Malay	18 9	1 0 6
Kramat Tin, Malay	1 8 6	1 11 6
Lahat, Malay	—	—
Malayan Tin Dredging (5s.)	1 1 6	1 3 9
Naraguta, Nigeria	10 0	10 0
Pahang Consolidated (5s.), Malay	6 6	7 3
Penawat ($1), Malay	1 6	2 0
Pengkalen (5s.), Malay	9 0	10 0
Petaling (2s. 4d.), Malay	12 9	13 3
Rambutan, Malay	5 0	5 0
Renong Dredging, Malay	1 0 6	1 2 9
Siamese Tin (5s.), Siam	12 3	12 9
South Crofty (5s.), Cornwall	3 6	3 9
Southern Malayan (5s.)	12 0	13 0
Southern Perak, Malay	1 6 3	1 6 9
Southern Tronoh (5s.), Malay	6 3	6 3
Sungei Besi (5s.), Malay	10 9	11 3
Sungei Kinta, Malay	11 3	11 0
Tanjong (5s.), Malay	8 6	7 0
Tavoy (4s.), Burma	5 3	6 0
Tekka, Malay	9 3	10 0
Tekka Taiping, Malay	10 6	11 3
Temoh, Malay	14 0	15 0
Toyo (2s. 6d.), Japan	3 0	3 0
Tronoh (5s.), Malay	16 6	17 6
DIAMONDS:		
Consol. African Selection Trust (5s.)	18 9	1 5 0
Consolidated of S.W.A. (10s.)	5 9	6 6
De Beers Deferred (£2 10s.)	5 1 3	5 16 3
Jagersfontein	1 5 0	1 7 6
Premier Preferred (5s.)	2 0 0	2 0 0
FINANCE, ETC.:		
Anglo American Corporation (10s.)	19 6	16 6
Anglo-Continental (10s.)	5 0	5 0
Anglo-French Exploration	1 1 3	1 2 6
Anglo-Oriental (5s.)	7 3	7 3
ditto, Pref.	14 6	15 6
British South Africa (15s.)	17 9	19 3
Central Mining (£8)	16 17 6	15 17 6
Consolidated Gold Fields	2 12 6	2 17 6
Consolidated Mines Selection (10s.)	11 6	11 3
Fanti Consols (8s.)	9 3	10 6
General Mining and Finance	1 18 9	2 0 9
Gold Fields Rhodesian (10s.)	5 3	6 3
Johannesburg Consolidated	2 4 3	2 6 3
London Tin Corporation (10s.)	12 3	14 0
Minerals Separation	4 2 6	4 10 0
Mining Trust	4 9	5 0
National Mining (8s.)	3	9
Rand Mines (5s.)	6 2 6	5 10 0
Rand Selection (5s.)	16 3	14 9
Rhodesian Anglo American (10s.)	14 0	16 0
Rhodesian Selection Trust (5s.)	7 6	9 0
Rhokana Corp.	6 5 0	6 5 0
Tigon (5s.)	2 9	3 9
Union Corporation (12s. 6d.)	4 8 9	4 6 3
Venture Trust (6s. 8d.)	6 6	7 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.

ASHLEY GOLD MINE, MATACHEWAN GOLD DISTRICT, ONTARIO

In Information Circular 6707 of the United States Bureau of Mines W. H. Emens and C. F. Jackson describe the methods and costs of developing and equipping the Ashley gold mine, in the Matachewan gold district, Ontario. The authors say that the Ashley mine is in the north-west corner of Bannockburn Township, Matachewan gold district, about 32 miles in a straight line from railhead at Elk Lake, or 42 miles by winter road. In the vicinity of the property the surface is gently rolling and is marked by low ridges with intervening swampy lowlands. It is covered by a heavy growth of birch, jack pine, spruce, and occasional white pine. Although timber and cordwood are thus plentiful, they are expensive because of being within the Booth timber limit and in the Temagami Forest reserve, which entails the payment to the timber company and the Province of Ontario of combined fees of $2·40 per cord for all cordwood cut and $14·50 per thousand for jack-pine saw timber on the stump. After adding the cost of cutting, teaming, and wasteage, the cost per thousand for rough sawed lumber is about $38 and the cordwood cost is about 5·65 per cord.

The Matachewan gold area straddles the height of land and drainage is partly to the north into Nighthawk Lake and partly to the east into the west branch of the Montreal River. There are numerous lakes and small meandering streams. One of these small streams or creeks flows within half a mile of the Ashley property and furnishes a plentiful supply of water for the mine. Most of the heavy supplies and equipment were hauled in during the winter from Elk Lake to Moyneurs, a distance of 25 miles, and from Moyneurs to the Ashley property, an additional 17 miles, over a rough winter road, or a total haul of 42 miles from railhead at Elk Lake. The hauling was done either on a cost-plus or on a contract basis. The contract price was $45 per ton during the first winter and $27 per ton during the second winter. The first winter hauling did not start until February, and as the remaining season was short, speed rather than price was the first consideration. Railway freight during the second season amounted to $9,109 or $6·25 per ton and the hauling cost amounted to $38,299. Of the 1,457 tons handled in 1931 about 45 tons were taken in by plane, leaving a balance of 1,412 tons hauled. Thus the cost of hauling was $27·12 per ton, equivalent to $0·645 per ton-mile.

Aeroplane service from Elk Lake started immediately after the discovery in October, 1930, and has continued ever since except for about a month during the autumn freeze-up and a month during the break-up in the spring when service is interrupted.

General Geological Features of the Deposit.—The Ashley property now embraces 23 mining claims covering 951·7 acres, on one of which the original discovery was made by Bert Ashley in October, 1930. This occurred at a point where a white quartz vein was exposed on the west flank of a north and south ridge and about 15 ft. above the level of a muskeg swamp. The quartz was about 2 ft. wide and showed pyritic mineralization, free gold, and some telluride (probably lead telluride). The walls are basalt, and the vein strikes a little west of north. About 100 feet north of the discovery the vein disappears below the swamp and 25 ft. to the south the outcrop again goes off the side of the ridge. Four trenches, cut across the vein and spread over a distance of 150 ft. along the strike, disclosed the vein, whereas one farther south and another farther north failed to uncover it. The vein dips toward the west under the swamp at an angle of about 50° so that the hanging-wall could not be prospected by trenching.

Samples of the exposed sections of the vein returned good assays, some streaks being of very high grade. In some places the pyrite mineralization is quite coarse and in others it is fine-grained. The gold seems to favour the coarser pyrite. High assays have been obtained from quartz showing but little pyrite, however. A long east–west trench farther north was dug somewhat later, beginning near the line of strike of the vein and going east, and it revealed 200 ft. of basalt, 100 ft. of diorite, and 200 ft. more of basalt. A red granite porphyry intrusion about 100 ft. wide cuts across the strike of the vein about 200 ft. to the north of the discovery. This may be a dyke or the narrow top of a larger granitic mass. The fracture in which the vein occurs continues through and beyond this dyke; in the underground workings the vein is not ore-bearing in this formation, though low assays are obtainable.

As the result of the early exploration, subsequent diamond drilling, and underground exploration, a narrow but high-grade quartz vein has been developed which dips at 50° to 55° to the west near the discovery, steepens at depth going north and flattens to about 30° on the bottom level (500 ft.) going south. The vein thus occupies a warped fracture plane. The gold occurs in quartz which fills a fracture or series of closely-spaced fractures in altered basaltic lava flows with small, irregular seams or stringers making off into the footwall for short distances at numerous points. These are generally quartz stringers which may or may not carry appreciable values in gold. On the hanging-wall side of the vein there are stringers of white calcite and quartz which are usually barren. Occasional bands of lime-iron carbonate occur in or along the gold-bearing quartz vein.

A "mud seam" comes in at a flat angle (in plan) from the hanging-wall side of the vein near the shaft cross-cuts, follows the vein a short distance,

and then branches off into the hanging-wall again. This seam probably represents a reopened fracture along which there has been some movement which has formed a reverse fault of small displacement.

The disclosures made in the first trenches warranted further trenching and exploration by diamond drilling. It was soon found impracticable to explore the hanging-wall side of the vein under the muskeg by trenching, and it was, therefore, decided to bring in two diamond-drill outfits to test the vein below the outcrop and under the swamp as quickly as possible. Meanwhile surface trenching was continued until some 875 linear ft. of trench had been dug, including the original trenching. In the following year considerable more trenching was done.

Diamond-Drill Exploration.—Diamond drilling was started on December 24, 1930, and by January 7, 1931, four shallow holes had been completed. These holes were 88 to 109 ft. deep and totalled 395 ft. of drilling. Much difficulty was experienced in these and later holes in getting down to bedrock. Further difficulty was encountered in drilling the rock, which was seamed and fractured; carbon loss was exceptionally high, some of the holes had to be cemented, and core recovery was poor. It was, therefore, decided about this time to sink a small prospect shaft and have a look at the vein in place at depth. Drilling was continued, however, and holes 5 to 10, inclusive were put down. These holes were completed by February 27, 1931, and comprised a total of 1,314 ft. of drilling. Individual holes ranged from 139 to 291 ft. in depth. Drilling was then temporarily suspended on the Ashley claims; and the drills were moved to the adjoining Garvey claims, also part of the company's property. Four holes totalling 474 ft. in length were drilled on these claims, the drills were then moved back to the Ashley, and holes 15 and 16 were drilled.

This drilling was all done on a cost-plus basis, and was very expensive because of the difficulties encountered and the high carbon loss. The total footage drilled in holes 1 to 16, inclusive, was 2,743 ft. Later on three more holes were drilled from surface to test the vein and determine its dip, to cut the vein respectively at what would be the 500-, 625-, and 750-foot levels of the mine. These three holes comprised a combined footage of 2,044 ft., the deepest being 750 ft. deep; they were sunk at a contract price of $4 15 per foot for drilling, with extra charges for cementing, etc., and cost $4·56 per foot on the average. The company furnished fuel for the drills, which were steam driven.

Underground Exploration and Development.—The results of trenching and diamond drilling were not altogether satisfactory, although they were indicative of a narrow vein carrying good values over a considerable length. It was, therefore, early decided to continue the exploration by underground methods. By the time preparations were

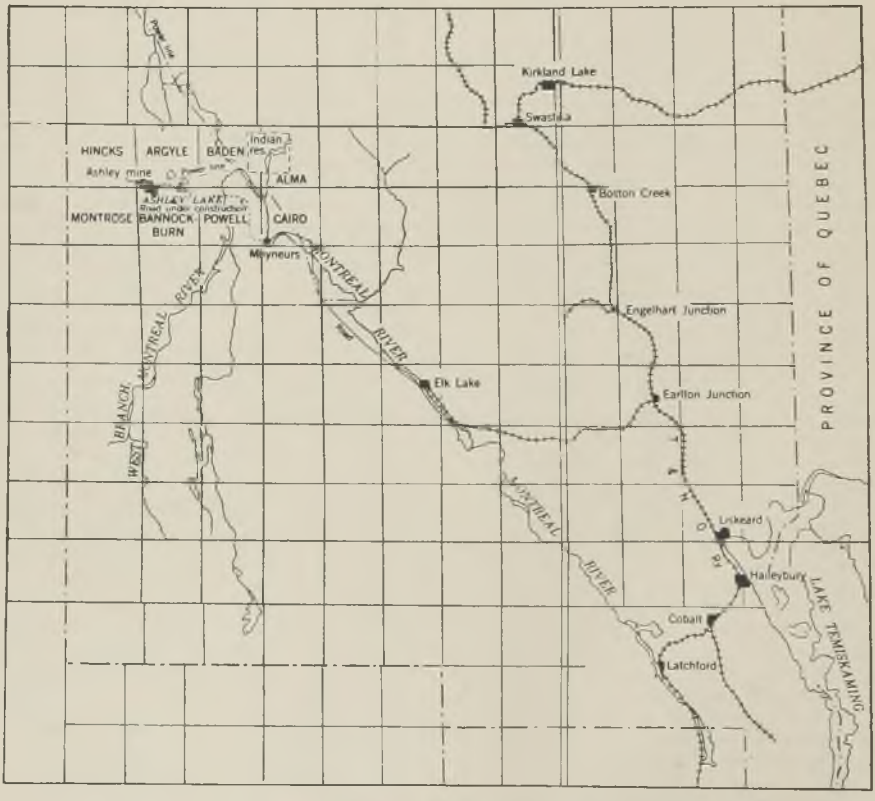


Fig. 1.—Sketch Map Showing Location of the Ashley Mine.

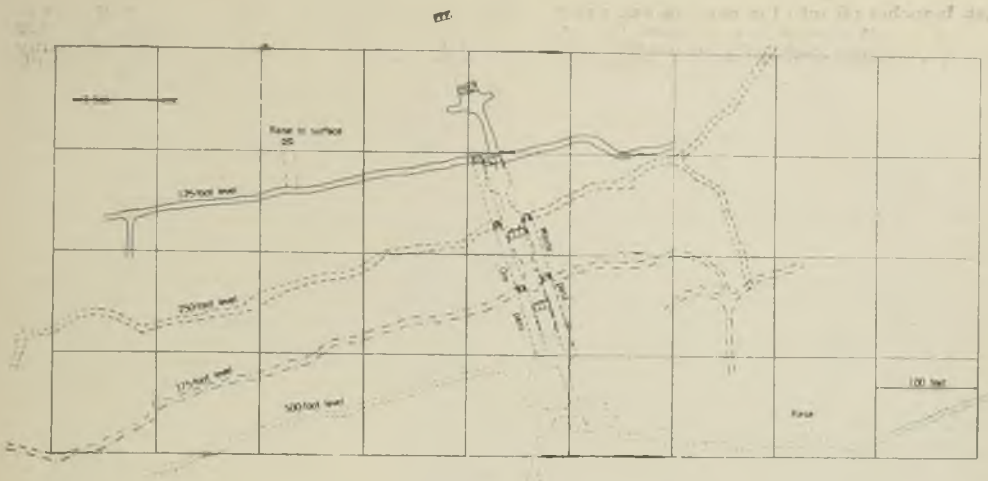


FIG. 2.—PLAN OF LEVELS, ASHLEY MINE, AUGUST 15, 1932.

completed for sinking, it had been decided to put down a three-compartment shaft, which would be of suitable size for a working shaft, at least during the early productive period of the operation. A vertical shaft in the foot-wall would have entailed driving long cross-cuts to intersect the vein at the lower levels. A vertical shaft in the hanging-wall would, on the other hand, have to be sunk in the swamp to be near the vein and, since diamond drilling had indicated that the hanging-wall rocks were badly fractured and probably wet, it was decided to sink an inclined shaft from the top of the ridge east of the vein and parallel to the dip. The shaft was sunk from a point which would place it approximately 60 ft. in the foot-wall of the vein at an inclination of 53° from the horizontal. An inclined shaft is generally not as satisfactory as a vertical shaft from an operating standpoint, especially for a large production, but the incline shaft was decided upon since a small daily tonnage was anticipated, a lower cost for cross-cutting would be required, and the vein could be attacked underground on each of the four contemplated levels in a shorter length of time.

The shaft was started on February 16, 1931, and was sunk in several different stages with intervening interruptions during which cross-cuts were driven to the vein. Thus when the 125-ft. level was reached a station was cut, a cross-cut was driven to the vein, a few rounds were taken out of the vein, and a loading pocket was partly completed. Sinking was then resumed to the 250-ft. level, where another station was cut and another cross-cut driven to the vein. The section from the 250- to the 500-ft. level was sunk in one operation. The 500-ft. level was, therefore, not reached until November 29, 1931. The shaft was deepened to 504 feet on December 1 and lateral development was then undertaken on the various levels. Later on the shaft was deepened to 585 feet to make room for sump and loading pockets below the 500-ft. level.

Until April, 1931, power was furnished by a petrol-driven compressor which supplied air for drilling and for operating an air-driven hoist. From then till July, 1932, when electric power was available, steam power generated in wood-fired boilers was used.

The shaft is 17 ft. by 6 ft. 2 in. outside the timbers and was sunk with 3 shifts of 6 shaft men to the shift. Four machines were employed for drilling off the round. The shaft men were all miners and each shift took up the work where the preceding one left off, whether that work was drilling and blasting, mucking, or timbering. The shaft is timbered with 7 by 7 in. framed timber and is divided into 3 compartments, two for hoisting in balance with skips and the other for pipes, power lines, and ladderway. Sets were placed on 8-ft. centres and were lagged over the top with split-pole lagging. The ladderway is separated from the adjacent skipway by 2-in. rough-sawed sheathing. The shaft was usually advanced 40 ft. beyond the last set of timber before the timber was carried ahead. Four sets of timber were thus installed during each timbering cycle; permanent 30-lb. rails were laid on 6 by 8 in. stringers placed flat on the bottom timbers of the shaft sets, and pipe lines and ladders were extended. When sinking below the timbers temporary rails were laid in the middle compartment on sprags, so that the 1-ton skip employed in mucking could be run to the bottom.

In drilling the shaft rounds two bars were placed across the shaft, on each of which two machines with arms were mounted. All the holes could be drilled from these set-ups. A centre cut of eight holes with four inside easers or "baby cuts" on the hanging-wall side were employed. Cut holes were drilled with 8-ft. steels and the square-up holes with 7-ft. steels. Drifter machines were employed. Thirty-six holes were drilled for a complete round. The entire round was fired in one blast with delay electric exploders in delays from 0 to 10. The rounds each averaged a little better than 5 ft. of advance and each cycle (drilling, blasting, and mucking) was completed in about 32 hours. The broken rock was shovelled into a skip of 21-cu. ft. capacity. It required nearly 24 hours to muck out a round, 6 hours of which were used up in clearing smoke, preparation,

Legend

1. Three-compartment inclined shaft
2. Steel waste chute and gate
3. Steel mine bin, 15 by 28 feet. Capacity 170 tons of ore and 70 tons of waste
4. Steel ore-chute gate
5. 15 by 24 inch Universal crusher
6. 14-inch conveyor belt, 41-foot centers
7. Magnet
8. Motor 3 kilowatt
9. 4-foot cone crusher
10. 14-inch bucket elevator, 50-foot centers
11. 4 by 6 foot Niagara screen
12. Steel mill bin, capacity 125 tons
13. 16-inch feeder conveyor
14. 5 by 16 foot tube mill
15. 8 by 26 foot duplex classifier
16. Three corduroy tables
17. 10-inch bucket elevator
18. No. 1 agitator 30 by 10 feet
19. No. 2 agitator, 30 by 10 feet
20. No. 1 thickener
21. No. 2 thickener
22. 4-inch diaphragm pump
23. Bucket elevator from mill sump
24. 11 by 9 foot steel preynant-solution tank
25. Clarifier tank, 18 leaves
26. Triplex clarifier pump
27. 12 by 16 foot steel tank for clarified pregnant solution
28. 3-inch centrifugal booster pump
29. Venturi meter
30. 4 by 8 foot Crow vacuum tank
31. 5 1/2 by 7 inch precipitation pump
32. Zinc mixing cone
33. Zinc feeder
34. Crow vacuum pump
35. Precipitation presses
36. Barren-solution launder
37. 15 by 11 foot barren-solution tank
38. 3-inch barren-solution pump
39. 28 by 10 foot steel grinding-solution tank
40. 3-inch grinding-solution pump
41. Primary leaf filter
42. Filtrate receiver
43. 3-inch filtrate pump
44. 34 by 72 inch foam trap
45. Vacuum pump
46. Emulsifier
47. Secondary leaf filter
48. Filtrate receiver
49. Filtrate pump
50. Foam trap
51. Vacuum pump
52. Tailings launder

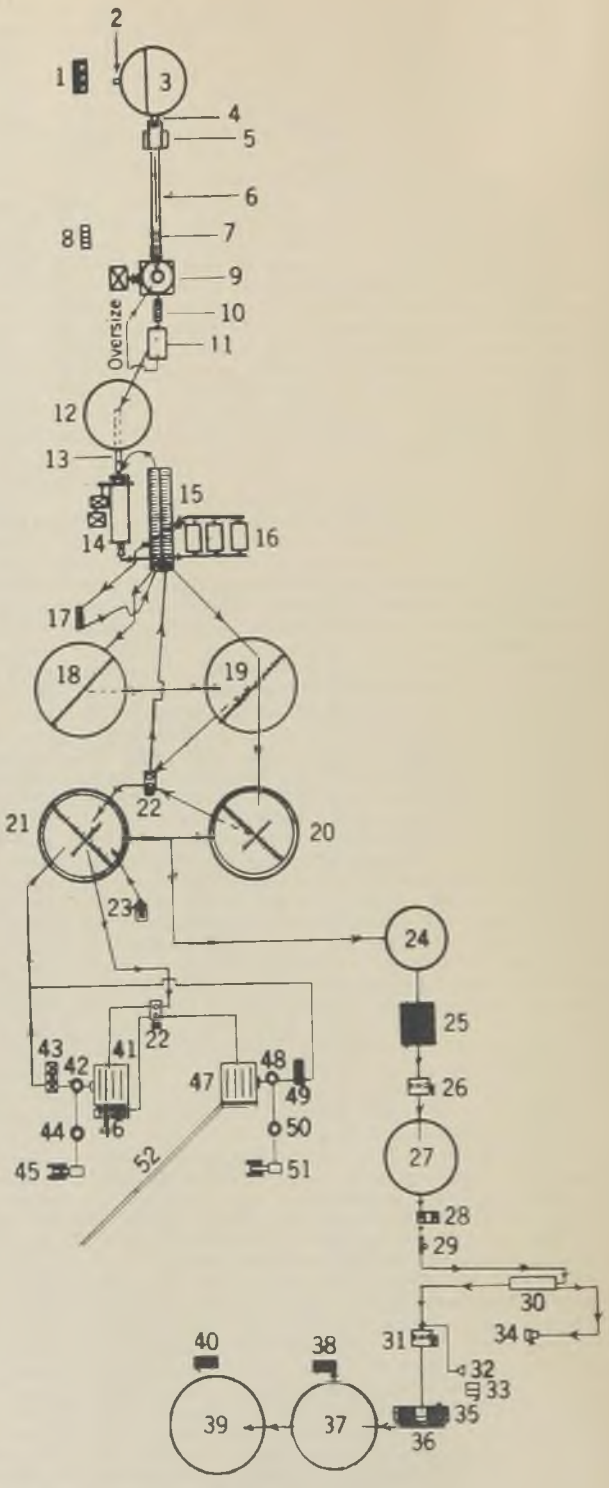


FIG. 3.—FLOW-SHEET OF THE ASHLEY MILL.

picking bottom, etc. Due to the inclination and size of the shaft only a few men could work to advantage at a time.

When timbering, four shifts were required to place 4 sets, lag them over, and extend the rails, ladders, and pipes. Powder consumption averaged about 125 lb. of 50% gelatin dynamite per round or a little less than 25 lb. per foot.

Cost of Sinking.—Due to the fact that sinking was done intermittently with intervening periods of lateral development work and because, when shaft sinking was in progress, all the overhead costs were charged to the shaft, sinking costs were higher than they would otherwise have been. Sinking costs for direct labour (shaft crew) and explosives during the period from May to December, 1931, inclusive, during which the shaft was advanced 436 ft., were as follows:

	Cost per foot.
Wages	$34·00
Bonus	10·19
Explosives	5 46
Total direct labour and explosives	49·65

These costs do not include those for the upper part of the shaft where sinking was somewhat irregular due to the loose nature of the rock, nor for the section below the 500-ft. level.

Lateral Development.—Lateral development was first carried on during the shaft-sinking period at intervals during which sinking was temporarily suspended. From the beginning of the operation until August 15, 1932, lateral development totalled 3,887 linear feet of driving and slashing and 690 ft. of cross-cutting, including station cross-cuts. In addition an ore pass and a separate waste pass had been driven between the 500- and 125-ft. levels by rising, with transfer chutes installed at the 250-, 375-, and 500-ft. levels. Loading pockets were completed below the 125- and 500-ft. levels and a rise was driven from the 125-ft. level to surface. Total rising amounted to 721 ft. A station had also been excavated for a winze on the 500-ft. level with room for hoist, tracks, etc. Total station excavations amounted to 16,208 cu. ft. and loading-pocket excavation to 8,088 cu. ft.

Drives were 5 by 7 ft. in cross section, shaft cross-cuts 6 by 7 ft., rises 5 by 10 ft., and shaft stations 25 by 18 by 8 ft. The two loading pockets have a combined capacity of 8,088 cu. ft. No timber was required for supporting the ground in drives, cross-cuts, and rises, the only timber used being for staging and manways in driving rises.

Some stoping was done in August, 1932, to provide feed for the mill which it was planned to start in the latter part of the month. Development ore had been placed on a separate dump on surface and this stope ore was used to fill the ore passes and pockets prior to starting up the mill.

Milling Plant.—On May 17, 1932, excavation was started for a mill designed to handle eventually 200 tons per day. The grinding section of the building is 45 by 48⅔ ft. and forms an end bay of the main mill building which is 152½ by 67¾ ft.; the total length is thus 197½ ft. The superstructure is erected on concrete foundations carried to bed-rock and is of steel frame and trussed steel roof construction. The frame is sheathed with 2-ply lumber separated by hair-felt lining and covered on the outside with J. M. Flextone siding and roofing. The side walls are carried to a height of 17 ft. above the foundations and the ridge of the roof is 17 ft. higher. The concrete floor slopes from each end and is 3 to 5 ft. below the top of the wall foundations.

The refinery occupies a separate building south of the south end of the mill. The building is 26 by 36 ft. in plan with hollow-tile walls on concrete foundations. The side walls extend 10 ft. above the top of the wall foundations, while the peak of the roof is 16½ ft. above the foundations. The roof is carried on steel and is covered with corrugated iron.

The mill is designed to treat 200 tons of ore per day by continuous cyanidation. Some additional grinding equipment will be required, however, to bring the mill up to its full capacity. Corduroy tables are introduced between the ball-mill discharge and the classifier to catch free gold. The concentrates from the tables will be treated by barrel amalgamation.[1] Figure 3 is a flow sheet of the mill.

[1] The tables were subsequently discarded.

GRAVEL PUMPING

An article by W. E. Sinclair on placer mining by centrifugal pump appears in the *Engineering and Mining Journal* for May. The author, who deals largely with Nigerian practice, says that water pumps are made as single-stage or multiple-stage units. A centrifugal pump for elevating gravel is of the simple, single-stage type and in general respects is much the same in constructional design as the water single-stage pump, differing only in special details. The gravel-pump impeller is made wider than its water counterpart and the space between the impeller blades and casing is greater. This space, or whirlpool chamber, is a factor in gravel-pump design that influences performance. Impeller blades are set at typical curves or angles, calculated from data that give maximum efficiency. These curves, which vary according to the size of the pump, are calculated from the peripheral speed of the tops of the impeller blades and the velocity of the pulp mixture relative to that speed. Adjustment is possible on some makes of pumps by inserting wedges under each blade or shoe to create a curve giving a higher or lower speed according to the head to which it is desired to pump. The advantages gained by altering the setting in this way are usually achieved at the cost of disadvantages in running conditions. If the wedges are not made exactly uniform and if each is not of the same weight the result is likely to be unsatisfactory. Makers of pumps have given much thought to the all-important question of blade setting, pump speed, and other factors such as the ratio of diameter to width of impeller which also has an important bearing on pump efficiency. Greater speeds are made possible by reducing this ratio. Although

greater lifts are thus made feasible the advantage is offset by reduced pump capacity.

Gravel pumps are usually made in the following four sizes of suction-pipe diameter: 6, 8, 10, and 12 in. They are generally signified only by their size, although pumps of the same size may differ in essential details. The principal types comprise (1) pumps having a removable manganese liner that fits inside the pump casing and protects it from wear; the casing cover or door is protected by a liner, similarly fixed to it; the impeller is fitted with adjustable or renewable shoes or blades; and (2) pumps that have no liners but are constructed with an extra-heavy manganese casing; impellers are cast in one piece with fixed blades. In most other details all pumps resemble one another. The great difference in the types mentioned in the foregoing is reflected in initial and in maintenance costs more than in work performed which, except for variations in different makes, is much the same for varying heads. The effect of local conditions and the nature of the ground being handled have a bearing on pump performance. Variation in total lift has a greater effect on pumping efficiency than is immediately shown in capacity or output. In pumps of different sizes the ratio of water to gravel varies as the quantity of gravel delivered varies according to the head or to the speed of the pump. Similarly, the consistence of the pulp mixture affects the quantity pumped and the rate of pumping. Greater capacity is obtained with the least possible lift or head. The stated speed of a pump will give the specified efficiency. Increased speed, however, will generally result in greater efficiency for a given head. If ample power is available, and other conditions are suitable, this factor can be arranged to give the most satisfactory pumping economy for any given head specified for a particular size of pump.

Gravel pumps are commonly used for elevating and delivering gravel from placer paddocks or river beds to sluice boxes or washing plants at some higher elevation. In the same manner swamps are successfully reclaimed or the swampy ground is removed by the use of such pumps. Three methods of applying the gravel pump as a pumping unit in placer-mining operations are described

(1) Where the pump is erected on the bedrock of a deposit or at the lowest level of the ground being worked delivering the broken ground from a sump to a higher elevation.—In placer mining the pump must be erected at the lowest convenient position with regard to the average working level of the paddock, and also in a position against the sump, which is excavated so that ground sluices can be easily graded to allow the material to gravitate from the working faces. To insure a good site for the sump and therefore for the pump in the initial layout of a gravel-pumping plant a contour plan of the bedrock elevations of a deposit is essential. The sump and pump site is also placed, if possible, in a central position in relation to the general shape, in plan, of the ground being worked. Broken ground and water may thus be led radially from working faces in every direction, and the number of pumps to be moved in a deposit reduced to a minimum.

(2) Where a pump is erected on a pontoon in swampy ground or in river-channel placer deposits.—This method of working is not the same as the system of cutter dredging. The latter plant is a unit that operates afloat, the ground being excavated by a specially designed cutter, working under water, which delivers the broken ground to the pump suction suspended alongside it. Although the suction cutter dredge—to give this type of plant its descriptive title—is a compact and useful unit if correctly utilized, it has not found great favour in placer work and for this reason it is not included.

The pontoon-mounted pump operates on bedrock in the same way as the example previously described. It is mounted on a pontoon merely to facilitate moving the plant from one position to another, which is effected by flooding the paddock or working. This floats the pontoon, which is then hauled to the desired new position, where the gravel pump is utilized to drain the working paddock thus automatically lowering the pontoon to the bottom, where the plant is ready to work again, without having undergone the usual dismantling and manhandling and the loss of time common in these operations. The pontoon type of plant is an ideal unit for working river beds or swamps, where a sufficient supply of water is available for floating the pontoon when required.

(3) Where two pumps are employed in tandem to elevate gravel from a depth beyond the capacity of a single pump.—Two pumps of approximately equal capacity may be utilized in such a compound plant, for then the lower pump may be made to deliver into the upper unit, thereby dispensing with an auxiliary sump at the upper pump. The system makes for increased working costs, but the advantages are obvious where one pump of sufficient capacity is unavailable, or where two light units are more easily handled in deep workings.

In each of these systems the delivery pipes from the pump to the sluice boxes are usually carried on trestles, which may be conveniently made from rough wooden poles or old 4-in. pipes. In placer work, the delivery point—where sluice boxes or washing plant is erected—is on that part of the bank that is intended to be left intact; and allowance must be made for the stacking of tailing at the end of the sluices, especially if no flowing water is available to assist in flushing away an accumulation. In estimating dump room for tailing allow for at least 40% swell of the solid ground when this is broken. Less friction and wear and greater pumping efficiency result when delivery columns are inclined at angles of from 40 to 50°. As this angle flattens the friction and wear on the pipes increase. A horizontal delivery leading for some distance from the pump and then terminating in a vertical or steeply inclined lift is not satisfactory in practice, as the elbow or bend in the line acts as a baffle, and causes a heavy load on the pump. Premature damage to delivery pipes, from excessive wear on one side, may be obviated if pipes are turned round at regular intervals thereby equalizing the abrasive action of the gravel. Friction and slip in a long delivery line have an adverse effect on the efficiency of a pump and must be allowed for in the lift.

Gravel pumps are successfully utilized in river-bed deposits and in swampy ground and under such circumstances they handle with ease alluvium and clays carrying high water content. A dredge is the only other type of equipment that can be effectively employed in swampy ground or on placers under abnormally wet conditions. A dredge, however, is not an economical unit for comparatively small areas, or for patchy alluvial deposits. Large

undertakings are necessary for dredging to warrant the initial capital outlay for this class of plant. A gravel-pumping plant, however, can be installed at a comparatively low initial cost; and in placer work, where narrow "leads" must sometimes be followed, it proves the most portable plant of its kind.

Steam-operated plants are usually belt driven from a horizontal engine mounted on a portable locomotive-type boiler, which is easily drawn from one position to another without dismantling. Electric or Diesel motive power is easily handled or moved from one site to another.

The only limitation to the class of ground successfully handled by a gravel pump is that which is strewn with boulders of a size greater than the suction bore of the pump. Occasional boulders of any size of smaller diameter than the pump suction are easily handled, although an excessive amount of stones in the gravel over a continuous length of pumping time reduces capacity. To prevent this, place a grizzly on the sluice leading to the pump sump, from which oversize boulders may be removed.

In clayey ground, where valuable concentrate is subjected to loss because of balling of the clay in the sluices, the gravel pump serves the same purpose as the puddler or log washer. Even if the clay balls are not broken up by the churning action of the gravel and water mixture in the sump, the centrifugal action of the pump itself is an efficient pulverizer. In some cases it is also useful in breaking up cemented gravels, thereby releasing minerals that otherwise would be lost in the tailing.

Water is essential in gravel pumping. The ratio by weight of water to solids, to attain a pulp of the desired fluidity, varies from 2 to 5, or averages about 80% of moisture by weight, according to the nature of the gravel and the size and capacity of the pump. Excess of water in the pulp reduces the load on the pump and results in lower gravel output; too little water taxes the pump capacity and may cause choking, "sanding-up," and stoppage. The correct feed of water to form the mixture to the pump sump must be regulated by the stream of water supplied from monitors and sluices used in breaking the ground or in conveying the ground to the pump. If the supply of water is not regulated, the running speed of the pump must be continually altered to cope with an excess of water or otherwise; and the result is erratic running and poor returns.

The cost of gravel pumping is extremely variable, because the charges are generally seriously affected by working conditions, particularly in the methods employed to break the ground. As the gravel pump is essentially a unit for elevating and delivering gravels from a river bed or other low-lying deposit, the method employed to break the ground usually determines the general method of working. Unfortunately, the rate of breaking ground is often responsible for low pump output. To analyse the cost of pumping, therefore, one must consider, in detail, the various ways of breaking ground in the methods applicable to this class of plant. The author then gives examples of Nigerian practice, classifying his remarks under the following heads:

(1) *Ground sluicing.*—Where water can be brought over the top or along the face of the gravels being excavated, the ground, if of moderate hardness, can be easily and cheaply broken. Sluices are cut in the bedrock to lead the broken gravel to the pump sump.

(2) *Shovelling in.*—Where water cannot be brought over the ground, or where the depth of gravel is too great to admit of ground sluicing methods, hand excavating is employed and the broken ground shovelled into sluices by means of which it is conveyed to the pump. The cost of breaking ground by this method in Nigeria varies from 3 to 10d. per cubic yard, depending on the distance the ground must be shovelled to the sluice.

(3) *Breaking and tramming ground by hand.*—The cost in pence per cubic yard of an operation where a gravel pump was handling ground broken and trammed to the pump by hand was 19.04 pence per cubic yard.

(4) *Hydraulicking.*—Breaking ground by this method compares favourably with the lowest working-cost methods, such as ground sluicing, but the initial cost of a hydraulic installation, together with gravel pumps, makes a high total cost; also, the large outputs are beyond the capacity of any reasonable pumping equipment, except when applied to large-scale, long-life workings yielding a substantial return.

Pumping water to monitors for hydraulicking has been tried but, as this operation in itself is costly, the richest ground could probably be exploited profitably by gravel pumps as well. The advantage claimed for this method of working is that the water used in the monitors can be circulated and re-used.

The gravel pump, as a working machine, is said to be inefficient, but this may usually be traced to carelessness in set-up and layout of the plant and to slackness in running. Some of the reasons for inefficient working are discussed.

To avoid difficult starting and to insure maximum efficiency of a pump a low suctional lift is essential, for no pump will pick up gravel the same height that it will water. The pump should be set up at the lowest level consistent with safety and as near as possible to the edge of the sump. Capacity of a sump should be attained by increasing area rather than be increasing depth. Suction pipes may be of any desired length, but except for the necessary bend into the pump, they should be without such obstructions, so as to reduce friction to a minimum.

In belt-driven pumps the engine should be erected at a higher elevation than the pump, so as to obviate the danger of flooding. A long belt drive is more effective than a short one, resulting as it does in more flexible and elastic driving. Belt slip may be eliminated and driving efficiency increased by covering the pump belt pulley with a length of Balata-type belting equal to the circumference of the pulley and of the same width. The pulley face is drilled with conveniently spaced ½- to ¾-in. holes, and the belt is riveted on by means of brass countersunk bolts, such as are often used on brake bands.

Motive power for gravel pumping may be electric, Diesel, or steam, direct coupled or belt driven. A straightforward layout and a good practical set-up goes a long way toward avoiding unsatisfactory working conditions in gravel-pumping plants. By organizing systematic running, with a careful record kept of all running operations, efficient and successful working is achieved.

In common with any other plant dependent on

some other unit for synchronous running, the capacity of a gravel pump, up to a point, is measured by the rate at which the broken ground can be delivered to the sump. The stoppage time, which represents 33% of the total, includes many periods when the pump was waiting for wash, but also includes time spent in oiling and for repairs. One of the most insignificant operations, a cause of much loss of time in this work, is the process of starting up the plant after a stoppage or shutdown. This item, not always recorded, is often responsible for a great deal of delay, the amount depending on the methods of priming and starting employed. The process of priming the pump would seem to be the main cause of the trouble. On steam-driven plants priming by ejector has not been found entirely satisfactory, because of waste of steam. On low-powered plants steam pressure is reduced when it is most needed. An air-tight delivery line with an air-tight valve in it, besides an air-tight foot valve, causes complications that require much attention. The quickest and most satisfactory method has been found to be the ordinary common one of filling the suction and the pump with water, allowing the complete escape of air by opening the petcocks on the suction pipe and pump. Water required for this purpose may gravitate from a storage at a higher elevation than the pump ; or it may, as is usual, be supplied under pressure from a service pump, which, on starting the pump, is switched over to its normal duty of supplying the water seal at the stuffing-box packing around the impeller shaft. A specially designed foot valve for the suction, easily operated by hand, has been found a valuable adjunct.

Makers continue to give serious consideration to constructional details, and especially to the question of the reduction of friction and the consequent wear on the internal surfaces of gravel pumps, such as covers or doors, throat and impellers, liners and casings. The excessive wear on gravel pumps before the introduction of magnanese-steel wearing parts was responsible to a great extent for the popular prejudice against them. The use of hard steel has materially reduced costs under this item. The most recent suggestion is to line with rubber the wearing parts subjected to abrasion. The use of rubber linings would also facilitate the operation of replacing worn parts, which is often the cause of serious delay.

Excessive wear in pumping plants is sometimes caused by forcing a pump to run over stated speeds in an attempt to deliver above the given head. Besides the wear and low capacity resulting from this practice, the pump is likely to take air and " sand-up " by losing the water, necessitating continual restarting, with attendant loss of pumping time.

GEOLOGY OF THE SWAYZE GOLD AREA, ONTARIO

A preliminary report by H. C. Rickaby on the westward extension of the Swayze township gold area, Sudbury district, Ontario, was summarized in the Mining Digest for December last. A longer paper by the same author appears in the *Canadian Mining and Metallurgical Bulletin* for May, dealing with some geological features of the district. The author says that the Swayze area lies between the main lines of the Canadian National and Canadian Pacific railways and it may be reached by good canoe routes from either line. For Halcrow township and the western part of the area the Kinogama River from mileage 107 on the C.P.R. is probably the best water route. For the central and eastern parts the two best routes make use of the Woman River and its tributaries and the Groundhog River. The former route starts from Ridout on the C.P.R. and the latter from Groundhog on the main line of the C.N.R. A fairly good wagon road for light freighting has been completed from Sultan, on the C.P.R., to the Kenty mines. During the past year an almost daily airplane service to Swayze has been maintained from Chapleau and other points.

General Geology.—The oldest rocks of the area are volcanic flows of Keewatin age, with which are associated sediments occurring probably at two horizons with respect to the Keewatin, and known locally as the *Ridout Series* and the *Swayze Series*. These rocks are intruded by dykes and bosses of basic igneous rocks, possibly of Haileyburian age, by granites and porphyries of Algoman age, and by diabase dykes of two or more ages. The actual age relationships of some of the rocks of the area are not yet definitely known, but the following is a tentative geological column :

Keweenawan : Quartz diabase, olivine diabase.

Algoman : Acid intrusives, granite, granodiorite, quartz porphyry, lamprophyres.

Haileyburian (?) : Basic intrusives, gabbro, diorite, diabase.

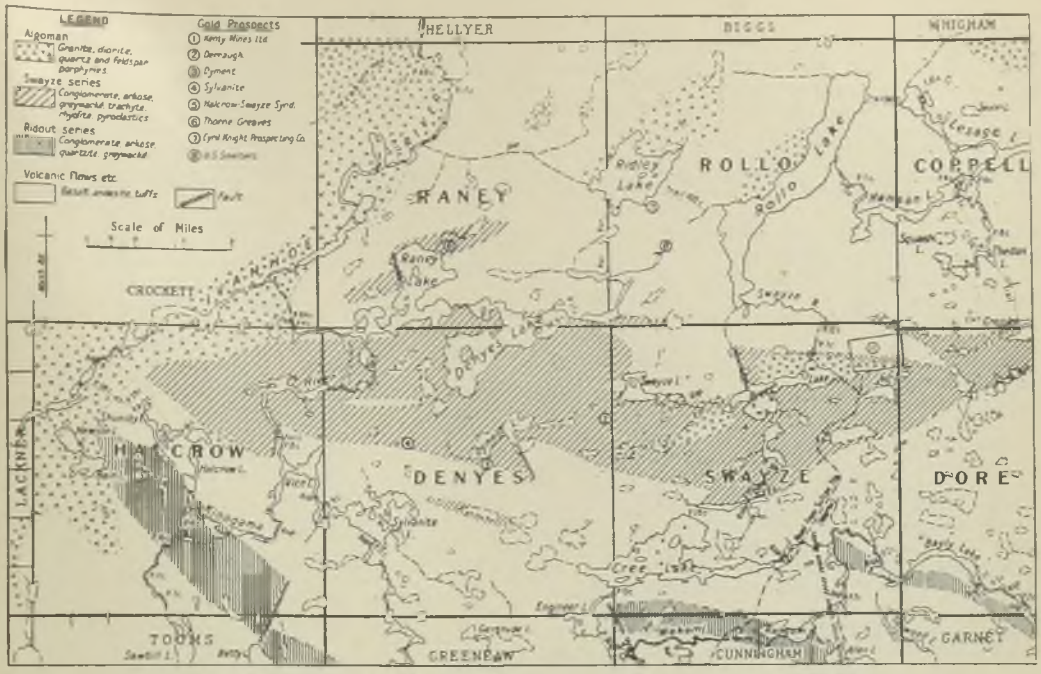
Timiskaming (?) : Swayze series—Sediments including conglomerate, greywacke, etc., with intermediate to acid lavas, trachyte, rhyolite, and pyroclastics.

Keewatin : Ridout series—Sediments including conglomerate, arkose, greywacke, etc. Iron Formation. Basalt, andesite, rhyolite, tuffs, hornblende schist, etc.

Keewatin.—(*a*) *Volcanics* :—Most of the flows in the Keewatin are andesitic, but more basic as well as more acid types occur interbedded with the andesite. Pillow lavas are widespread, but the rocks generally have been so much disturbed that original features, such as spherulites and amygdales, have been destroyed, and it is difficult to identify flow tops with any degree of certainty. Typical greenstones of the Keewatin are composed chiefly of quartz, chlorite, uralite, kaolin, and carbonates. More coarsely crystalline diorites or gabbros apparently represent thick flows, but these are difficult to distinguish from later basic intrusives. Dynamic metamorphism has altered much of the Keewatin rocks to greenstone schists, and along the west boundary of the area, near the granite, the greenstones and related sediments have been altered to hornblende schists and gneisses.

(*b*) *Iron Formation* :—Typical iron formation was observed in only one locality—viz., the south-east corner of Halcrow township, where a small outcrop showed a rock consisting of banded chert and red jaspilite. G. D. Furse mentions the occurrence of similar rock in the south-west part of Swayze township.

(*c*) *Ridout Series* :—A prominent band of sedi-



General Geological Map of the Swayze Gold Area, Ontario.

mentary rocks, known as the Ridout Series, extends almost all the way along the south side of the triangle mentioned at the beginning of this paper. It is known to continue at least as far east as the Canadian National railway. It occurs in the south parts of Dore and Swayze townships, but lies to the south of Denyes in Greenlaw township. In Tooms township it is shown as being faulted to the north and the faulted portion extends northwestward across the township of Halcrow, at the west side of which it is cut off by granite and gneiss. In Halcrow township, the band, approximately one mile wide, consists of conglomerate greywacke, quartzite, and related beds. Emmons and Thomson concluded from their study of this series that it is monoclinal in structure, the beds dipping to the north, with flow rocks overlying them on the north side. The general attitude of the beds in Halcrow township indicates a similar relationship with the greenstones. In part of the area mapped as Ridout Series, beds of the sediments alternate with flow rocks similar to the main Keewatin flows.

Timiskaming (?).—*Swayze Series* :—Some narrow bands of sediments occurring near the north boundary of the townships of Denyes, Swayze, and Dore, were provisionally designated the Swayze Series by Furse. Adjacent to these sediments on the south side is a wide band of rather acid lavas and pyroclastic rocks, with which the sediments are closely associated. The term "Swayze Series" is retained, but it here includes both the sediments and associated lavas. These rocks form a band with an average width of from 1½ to 2 miles, extending from the east side of Dore township, near its north boundary, westward across the northern parts of the townships of Swayze, Denyes, and Halcrow, where it is cut off by the granite and gneiss. The rock is dominantly volcanic in origin, but the band includes numerous beds of ordinary sediments such as conglomerate and greywacke, as well as water-lain tuffs and breccias. The flows of this series are highly porphyritic rocks, in which well defined phenocrysts of felspar are distributed through a fine-grained groundmass of felspar, chlorite, sericite, and carbonates. In chemical composition, the rock corresponds to a soda trachyte or rhyolite. The conglomerate, as well as the other sedimentary members and the tuffs, form lens-shaped beds apparently interbedded with the flows. On the west side of the Kinogama River, in Halcrow township, the conglomerate has a thickness of over 1,000 ft. The pebbles in this conglomerate are largely of a porphyritic rock not unlike the associated lavas. There are also some of greenstone and chert, but very few granite pebbles were seen.

This band of Swayze Series rocks appears to be synclinal in structure. Along its northern margin the bedding dips steeply to the north, but grain determinations and the relationship of cleavage to bedding show that the tops of the beds face to the south. Using the same criteria it is found that along the southern edge of the band the tops of the beds are to the north. The axis of the main syncline strikes approximately east and west and dips steeply to the north. In the north-eastern part of Swayze township, dragfolds indicate that the axis of the folding pitches to the east. There may be some minor folds within the major syncline. Narrow, linear beds of greenstone, some of which show good pillow structure, occur within the Swayze Series, and it is not known whether they are the result of close folding or interbedding. Several other small areas of rocks similar to the Swayze Series occur both to the north and to the south of the main belt. These are linear bodies striking approximately parallel to the main belt, but they

have not been studied in detail. All the rocks of the Swayze Series have been steeply folded and much altered, with the development of chlorite, sericite, and carbonates.

The Swayze Series occupies a position stratigraphically above the basic Keewatin lavas and may be Timiskaming in age. However, since the rocks included in the series appear to be dominantly volcanic in origin, and since no positive evidence was seen of an uncomformity between the basic lavas and the Swayze Series, there is some doubt as to their age classification.

Algoman.—The granites around the west edge of the Swayze area are largely medium-grained, pink to grey, biotite granites. Much of the granite is massive, but there are also areas of foliated granitic rocks and gneisses, some of which may be metamorphosed sediments or lavas. No attempt was made to separate the types or to determine their relative ages.

The greenstones and sediments throughout the area are cut by numerous dykes and bosses of granite, diorite, and porphyry. Only the larger bosses and dykes are shown on the accompanying map. In general the more granitic types occur in the vicinity of the main granite mass to the north and west, while the intrusives which characterize the central part of the area are usually porphyritic. Two large bosses of porphyry occur on Brett Lake, one at the east end and the other at the west end. On fresh surface this porphyry is reddish to grey and shows prominent phenocrysts of felspar and usually of quartz. Such porphyries occur as dykes over a wide area in Swayze. Where they cut the basic lavas they are easily identified, but where they occur in the Swayze Series it is difficult to distinguish them from the porphyritic trachyte and rhyolite of the latter.

Structure.—Possibly during, and certainly subsequent to, the deposition of the greenstones and associated sediments, these rocks have been folded along an east–west axis, resulting in the formation of synclinal and anticlinal folds, as is shown by observation of the dip and strike of the bedded sediments, which occur at intervals across the Swayze area, from north to south. The main band of the Swayze Series is an example of a synclinal fold and, as previously mentioned, the folding has been of such magnitude that the north limb appears to be slightly overturned. The beds of the Ridout Series dip at rather steep angles to the north, and the other narrow bands of sediments all show steep dips. The axis of folding of the Swayze Series appears to plunge to the east in the north-east part of Swayze township, but this feature of the folding has not been studied in detail elsewhere in the area. As a result of the folding, the rocks of the Swayze area have been rendered schistose to a marked degree, the strike of schistosity being approximately parallel to the axis of major folding, and for the most part within 15° of east and west. Certain bands appear to lend themselves to shearing more than others, but these bands are not confined to any particular part of the area.

Faulting took place in the area in at least two periods. Two faults of large displacement are indicated on the accompanying map, both with a north-west–south-east strike. One of them crosses Swayze township and the other Denyes township. They are shown at intervals, but it is probable that they affect all the greenstones and sediments and are post-Algoman in age. The other faulting is post-mineral, the faults being of slight displacement. They are best illustrated in connexion with the Kenty vein system.

Gold Deposits.—The gold-bearing veins of the Swayze area all occur within the greenstones or sediments in the vicinity of intrusive porphyries or granitic dykes. No gold-bearing veins have as yet been found in the main granite along the contact nor in the smaller granite bosses in the northern part of the area. Occurring as they do over a wide area, they show considerable variation. From the standpoint of structure, they may be divided into three groups—viz., (1) Lode deposits, (2) fissure veins, and (3) shear-zones. In nearly all the veins, the most prominent gangue minerals are quartz, ankerite, and pyrite. Other minerals occurring in varying amount are chalcopyrite, galena, sphalerite, specularite, calcite, and tourmaline. The gold is present for the most part in the free state. No tellurides have been identified as yet in any of the deposits of the Swayze area.

Kenty Gold Mines, Ltd.—The Kenty veins belong to the lode type of deposits, consisting of a series of parallel veins or vein systems, each showing a main quartz leader, with subsidiary parallel quartz veinlets and replaced country rock intervening. They occur in the lavas or volcanic sediments, or in the diorite, porphyry, or lamprophyre which intrude the older rocks. The average strike of the veins is approximately N.60°E. and the dip varies from 45° to 70° to the south-east. Surface work up to date indicates five parallel veins sytems running out from the north side of the eastern nose of the main porphyry body. A series of post-mineral faults intersect the veins, but these faults are of comparatively small displacement. The veins occur in fractures in the country rock, with practically no schisting. The greatest width of vein material disclosed up to date is ten feet, with an average width for all the veins of from four to five feet. The typical vein shows one or more main quartz leaders, usually not over one foot wide, of white quartz containing a little pyrite. The wall-rocks show considerable replacement by carbonates, chiefly ankerite, and are heavily mineralized with pyrite. Tourmaline is prominent in the quartz, and other gangue minerals noted are calcite, galena, specularite, graphite, chalcopyrite, and a little felspar. Coarse native gold is visible in fractures in the main quartz or in the narrow veinlets paralleling the main quartz. Almost every vein has visible gold and in places it is present in spectacular amount.

Two shafts, approximately 1,900 ft. apart, are at present being sunk to a depth of 500 ft., on which level they are to be connected and lateral work carried out.

Derraugh Property.—The country-rock consists of altered arkosic sediments and flow rocks, cut by dykes of quartz porphyry. The discovery vein consists of a series of quartz lenses along a fracture which strikes approximately north and south and dips steeply to the east. The fracture has been traced by stripping for approximately 400 ft., and is reported to show widths from 8 to 22 ft. of quartz and included country-rock. The quartz is mineralized with pyrite, chalcopyrite, a little galena, and carbonates. Lenses of the quartz are heavily mineralized with fine chalcopyrite and this material shows high values in gold. No native gold was seen, but all of the vein quartz

gives, on assay, appreciable values in gold. Twelve hundred feet west of the discovery vein is another vein, which was uncovered during the past winter. It shows a width of 30 ft. of vein material, consisting of sheared country-rock containing lenses of quartz mineralized with pyrite and carbonates. Where exposed, the schist has a strike of approximately N.20°E., but since it has only been stripped in one place its actual strike and attitude are not yet known. The vein is reported to show appreciable values in gold over good widths.

Considerable surface trenching was done last autumn on the discovery vein and during the past winter eleven shallow holes have been drilled with an aggregate length of 2,000 ft. The results of this drilling have not yet been announced.

Halcrow-Swayze Mines, Ltd.—The principal showing consists of a shear zone in an impure quartzite or greywacke belonging to the Ridout Series. The shear zone, which has a width up to 15 ft., strikes approximately N.60°W. and has been trenched over a distance of 1,000 ft. Along the shearing, the rock has been silicified and carbonatized, and heavily mineralized with pyrite. Considerable chalcopyrite is present and fine native gold in thin leaves is to be seen along the shear planes of the schist. Approximately 250 ft. north of the shear zone and parallel to it is a dyke of quartz diorite or quartz monzonite, with which the deposit appears to be closely associated. The dyke is from 60 to 100 ft. wide and is reported to be traceable for over a mile in length. It consists essentially of felspar, biotite, and quartz, and contains numerous small stringers of quartz. Between the dyke and the main shear-zone are a number of small shear-zones and lenses of quartz, some of which are well mineralized and carry good values in gold across narrow widths. The quartz lenses, striking at various angles, appear to represent tension cracks. Some narrow dykes of mica lamprophyre appear also to be associated with the deposits, but they have not been mapped in detail.

The various showings have been exposed by trenching and test-pitting. A 500-ft. section of the main shear-zone is reported to have indicated an average grade of $4·00 per ton in gold over widths of from six to eight feet. The management have announced plans for the sinking of a shaft to a depth of 250 ft. for underground exploration of the deposits.

General Remarks on the Swayze Area.—The writer or his assistants visited six other gold discoveries in the area, nearly all of which were made during the past summer. None of them had received more than a preliminary examination, but all of them showed features suggesting the advisability of further work in the way of prospecting. They are mostly fissure veins occurring in the vicinity of intrusive rocks, usually porphyry.

Including the three properties described, gold discoveries have been made in Swayze over an area roughly 15 miles long, in an east–west direction, by 10 miles wide. This area is part of a larger area, approximately 35 miles long by 18 miles wide, which is underlain by Keewatin greenstones, and associated sediments. According to the various reports covering this larger area, these rocks are rather highly folded and otherwise distorted, with the resultant development of schistose bands and fracturing, structural features favourable for gold deposition. Intrusive porphyries, granites, and related rocks of Algoman age occur plentifully throughout the area. In its ore deposits, geological structure, and other features, this area has much in common with the better-known gold camps of northern Ontario and Quebec. Consequently, the Swayze area would appear to hold out considerable hope for the development of economic gold deposits. At any rate, it constitutes an area of some 600 square miles, no part of which can be neglected by the prospector in search of gold.

DEPARTMENT OF MINES MINERAGRAPHIC LABORATORY, OTTAWA

In Memorandum Series No. 58 of the Canadian Department of Mines W. B. Timm and M. H. Haycock describe the equipment of the mineragraphic laboratory that has been added to the equipment of the ore-dressing and metallurgical laboratories of the Mines Branch.

Introduction.—The authors in their introduction say that microscopic examination and spectrographic analysis have been found to be of immense value as a guide and an aid in investigating methods for the treatment of ores. The examination of typical samples of ore under the microscope, before concentration or other treatment experimental tests are undertaken, gives the investigator information in advance regarding the mineral constituents, their relationships, and grain size. The determination of the minerals, coupled with the spectrographic analysis of the ore sample submitted to the chemical laboratory for quantitative determination, provides the chemist with virtually a complete qualitative guide. With the results of the microscopic examination and the chemical analysis before him, the investigator is enabled to conduct the investigation with a minimum number of experimental tests. Quantitative microscopic determination carried out on the mill products furnishes the investigator with further information concerning the grain size of the products, their relationships, and the percentages of freed and locked minerals, the relative proportions of the valuable and valueless constituents, the shape of the mineral grains, and the degree of surface oxidation and corrosion. This information is especially valuable when the examination is performed on the various fractions from screen and elutriation tests of the mill products, as it assists the investigator in the control of the grinding and in determining the manner of re-treating the middling products.

Spectrographic analysis too plays an important part during the investigation. Precipitates and solutions obtained in the chemical laboratory during quantitative separations are identified or examined for their purity and assays are checked for the presence of metals other than those expected as, for example, those belonging to the platinum group. In addition, because spectrographic methods are particularly applicable to the detection of minute quantities of minor constituents which defy detection by ordinary chemical methods, the

presence of elements which may interfere either in certain of the experimental tests or in the chemical analysis may be revealed. For the same reason the spectrograph is of great value in determining the mode of occurrence of the precious metals, such as gold in pyrite or arsenopyrite, or silver in galena and tetrahedrite.

The examination of ores and mill products both microscopically and spectrographically thus serves not only to reduce the number of experimental tests to be made in the ore dressing laboratory, but also provides a valuable qualitative guide to quantitative chemical analysis.

In carrying out microscopic and spectrographic studies in the mineragraphic laboratory the sample is first mounted in bakelite and polished. The polished section is then examined under the reflecting microscope and optical, etching, microchemical, spectrographic, and quantitative-microscopic methods are combined in determining the characteristics. Photomicrographs are taken to illustrate the significant features of both the ore and mill products and the polished sections representing the typical samples are filed for future reference.

Equipment for Preparing Specimens for Examination.—(*a*) *Rough Grinding Unit.*—The rough grinding unit consists of an iron-framed table in which are set two revolving 16-in. laps. The first lap is of cast iron and, using No. 120 carborundum as the abrasive medium, is used for grinding the specimen to the desired shape and size. The second lap is of copper and with No. FFF carborundum produces a smooth matte surface and eliminates the larger pits developed during the first grinding. After completion of the rough grinding process the specimen is ready for mounting. In order to avoid the use of coarse abrasives near the microscopic equipment the grinding unit is located in the main ore-dressing laboratory.

(*b*) *Mounting Unit.*—This unit comprises a mould and a press. The mould was made in the Department of Mines' machine shop, the design being adopted with slight modifications from that developed in the laboratory of mining geology of Harvard University. Four specimens are mounted in one operation, the finished mount being a block of bakelite, 1½ in. by 1⅛ in. by ⅝ in., in which the sample is embedded. The press is a small hydraulic laboratory press manufactured by Fred S. Carver, New York. It has a capacity of 20,000 lb. and is equipped with electrically-heated plates. A moulding temperature of from 150° C. to 160° C. is ordinarily used at a pressure of 4,000 lb. per mount.

(*c*) *Polishing Units.*—Two polishing units are installed in the laboratory. The first unit is a type similar to that widely used for polishing ore specimens, and consists of a ½-h.p., 1200-r.p.m. electric motor, the shaft of which extends on both sides and is fitted with two 9-in. fibre discs covered with canvas, linen, or billiard cloth. The polishing is carried out by hand with a mixture of abrasive and water. The average time required per specimen is about 15 minutes.

The second polishing unit was manufactured by the Mann Instrument Company of Cambridge, Massachusetts. The design of this machine was developed in the laboratory of mining geology of Harvard University under the direction of Professor L. C. Graton and the principle departs radically from that commonly employed in that the complete polishing process is carried out on metal laps. The machine consists of a revolving table with interchangeable cast iron and lead laps. The specimens, six in number, are held on the laps by means of a revolving head, which also rotates the specimens by means of a planetary gear. The polish produced is far superior to that obtained by any other known method, and the machine has the distinct advantage of automatic operation. The average time required per specimen is about 1¼ hours.

Equipment and supplies are kept on hand for impregnating porous and friable specimens with bakelite varnish, preparing and mounting thin sections, and for mounting mill products for examination in unpolished state for surface features, etc.

Equipment for the Microscopical Examination of Prepared Specimens.—(*a*) *Ore Microscope.*—The microscope used for the examination of polished surfaces is a model MOP ore microscope manufactured by E. Leitz of Wetzler, Germany. Equipped for use with polarized light and with an adequate supply of air and oil immersion objectives it provides for a range in magnification from 30 to 2,200 diameters. Other attachments include a traversing stage, a Wright bi-quartz wedge attachment, and a Leitz "Ultropak" illuminator, the last being used for examining finely-ground mill products in diffused oblique light. The light source is a low-voltage, high-amperage lamp, which produces illumination sufficiently intense for the use of polarized light.

The polished section is first examined for the purpose of identifying the mineral constituents. After this has been accomplished as far as is possible by the use of optical, etch, microchemical, and spectrographic methods, the relationships of the minerals are recorded.

(*b*) *Micro-borer.*—Samples of mineral grains for microchemical and spectrographic tests are obtained from the polished surface by means of the micro-borer. At first designed and roughly constructed in the department of geology, Princeton University, a second improved instrument was designed in this laboratory and built in the Department of Mines' machine shop. It consists of an adjustable brass stand that supports an ordinary sewing needle rotated by means of a flexible shaft driven by a small, variable-speed, electric motor. The mineral grain is brought into contact with the needle point by raising the stage to the microscope.

(*c*) *Petrographic Microscope.*—For certain investigatory tests it is important that the nature and identity of the gangue minerals be determined, particularly for their bearing on crushing and flotation problems. Polished sections do not lend themselves readily to the determination of transparent minerals, and for this reason it is necessary to prepare a thin section and examine it under a petrographic microscope. The petrographic microscope used in this laboratory is a Seibert. It is used also in microchemical analyses for observing the precipitates in transmitted light.

Equipment for Spectrographic Analysis.—Although spectrographic methods are used for approximate quantitative analysis, it is in the field of qualitative analysis where the spectrograph is of greatest use in this laboratory. It is particularly sensitive in detecting the metals, especially when these are present in minute quantities. The spectro-

graph is used in the mineragraphic laboratory for the determination of :—

(1) The elements in minerals present in minute grains and which provide only a very small sample.
(2) The valuable metals in minerals.
(3) The elements in ore samples, to serve as a control for quantitative chemical analysis.
(4) The minor constituents in ore samples and in minerals and for checking.
(5) Chemical precipitates for purity and identification.
(6) Assays for the presence of small amounts of metals such as those of the platinum group.

Quartz Spectrograph.—The quartz spectrograph is the medium-sized instrument manufactured by Adam Hilger, London, England.

Motor-Generator Unit.—The motor-generator unit was manufactured by the Lancashire Dynamo and Motor Company of Canada. It was designed especially for producing a direct-current arc for use in spectrography. The unit consists of a motor, generator, and exciter, and is capable of a range in voltage from 100 v. to 250 v. at a maximum current of 10 amperes. The current is controlled through a switch board.

Spark-Unit.—The spark unit was furnished by the makers of the quartz spectrograph and is the standard equipment for producing spark spectra. The control of this unit is also located on the main switch board.

Viewing Table.—The photographic plates on which the spectra are recorded are examined under a binocular microscope. The table, designed and built in the Department of Mines' machine shop, differs from the ordinary microscope table only in being provided with a slit through which light from incandescent bulbs can be thrown from below through the plate. In certain cases where the spectra are exceedingly complicated and the lines closely grouped on the plate, the image is projected on a screen by means of a balopticon and the analysis made on the greatly enlarged image.

Equipment for Photomicrography.—(*a*) *Metallographic Microscope.*—The large metallographic microscope is of Leitz manufacture and so is adapted for all the oculars and objectives used on the ore microscope as well as the "Ultropak" illuminator. The range of magnification with various optical combinations is from 25 to approximately 12,000 diameters.

(*b*) *Photomicrographic Camera.*—This camera is used in combination with either the ore microscope or the petrographic microscope, particularly when photographs of polished sections in polarized light or of thin sections are desired. The instrument is of Leitz manufacture and has a range in magnification of from 25 to over 2000 diameters.

Equipment for Filing Specimens and Photographs.—Filing space in especially designed cabinets is provided for 3,500 polished sections, 1,000 photomicrographs, and 800 spectrograph plates. Card indexes of sections and plates in conjunction with the field specimens provide a complete and permanent record of the work done in the laboratory.

Dredging Sand and Gravel.—The unusual combination of river dykes, pump dredges, and aerial ropeway transport in connexion with the dredging of sand and gravel in Oregon are described in Information Circular 6,696 of the United States Bureau of Mines by O. E. Perkins. The paper describes the construction by the Ross Island Sand and Gravel Company of a dyke between the mainland and an island in the Williamette River to protect the gravel deposit from river currents. Owing to local conditions the treatment plant is constructed in the river and the finished material delivered to the retail bins on the mainland by aerial tram. Cost tabulations are included, showing details for each operating step.

Bench Mining an Alluvial Cone Gravel Deposit.—The exceptional thickness of some of the alluvial cone gravel deposits in the Western United States presents some problems in mining methods not found at plants in the central or eastern portion of the country. The methods employed and costs obtained at the Durbin plant of the Consolidated Rock Products Company are discussed by Harry D Jumper in Information Circular 6607 of the United States Bureau of Mines. Following a short description of the history of the company and the geology and physical characteristics of the deposit, the author presents in considerable detail the methods of prospecting, mining, plant transport, and treatment methods. Detailed costs of all operations are tabulated, including an interesting comparison between dragline and steam shovel operation.

Mining and Washing Gravel.—The mining and washing methods employed by the Pacific Coast Aggregates, Inc., at their Eliot plant are described in detail by Edward B. Kendall in Information Circular 6705 of the United States Bureau of Mines. By means of line-drawings supplementing the text of his report, the author presents many unique applications of mining and concentrating practice to the production of sand and gravel. Detailed cost tabulations cover all operating steps.

SHORT NOTICES

Shaft Sinking.—A digest of some of the tabular information in Bulletin 357 of the United States Bureau of Mines by E. D. Gardner and J. F. Johnson, is given by Mr. Johnson in *Mining and Metallurgy* for May.

Underground Transport.—M. J. Elsing deals with the costs of storage-battery, compressed-air, and petrol-locomotive transport underground in *Engineering and Mining Journal* for May.

Underground Loading Machines.—Continuing his series of articles on mine equipment in the *Engineering and Mining Journal* for May, L. Eaton discusses underground loading machines.

Dredger-Excavator for Overburden.—A description of a 1·44 cu. yd. overburden bucket dredger-excavator for brown-coal work in Germany appears in *Engineering* for April 14.

Gold in Alaska.—R. H. Ogburn describes the practice of thawing and dredging for gold at Fairbanks, Alaska, in *Mining and Metallurgy* for May.

Shaft Sinking on a Bore-Hole.—A description of the method of sinking a shaft on a churn-drill hole is given by H. A. Neustaedter in the *Engineering and Mining Journal* for May.

Stope Surveying.—In the *Engineering and Mining Journal* for May, S. Tainter discusses the use of compass surveys for stope-contract settlements.

Wire Rope.—J. B. Petrie discusses the care of wire rope in the *Canadian Mining Journal* for May.

N'Kana Power Plant.—A description of the power plant at the N'Kana mine, Northern Rhodesia, by J. Fowler Brown appears in the *Journal* of the South African Institution of Engineers for May.

Ball-Milling.—A discussion of the correct weight of a cu. ft. of balls in a ball-mill by A. M. Gow is published in the *Engineering and Mining Journal* for May.

Large Ball Mill.—Particulars of a large ball-mill constructed for the Mount Lyell Mining and Railway Company are given in the *Chemical Engineering and Mining Review* of Melbourne for April 5.

Diamond Drilling.—In Information Circular 6708 of the United States Bureau of Mines M. G. Hansen describes diamond-drilling practice at the United Verde mine, Jerome, Yavapai County, Arizona.

Bore-Hole Surveying.—A digest of a paper by J. Thomson, read before the Association of Colliery Managers in India, on the surveying of bore-holes, in which special reference is made to the Brigg's Clinophone method, appears in the *Iron and Coal Trades Review* for May 19.

Kilchipur State, India.—In the *Quarterly Journal* of the Geological, Mining, and Metallurgy Society of India for December, 1932, D. P. Chandoke gives an account of the economic deposits of Kilchipur State, C.I.

Minerals in the Erzgebirge.—Dr. F. Schumacher discusses the genesis of the Erzgebirge mineral province in *Metall und Erz* for May 1.

Frood Ore Deposit.—In *Economic Geology* for May B. C. Freeman discusses the origin of the Frood ore deposit.

Gold in British Columbia.—An article by F. A. Kerr on gold in Northern British Columbia appears in the *Canadian Mining Journal* for May.

Granada Gold Mine.—In Information Circular 6709 of the United States Bureau of Mines R. L. Loofbourow describes mining methods and costs at Granada Gold Mines, Ltd., Rouyn, Quebec.

Beryllium in Brazil.—L. Moraes in *Economic Geology* for May gives some notes on the occurrence of beryllium minerals in Brazil.

Beryllium.—The uses of beryllium are discussed by W. H. Bassett in *Mining and Metallurgy* for May.

Silicosis.—In Technical Paper 552 of the United States Bureau of Mines R. R. Sayers, F. V. Meriwether and A. J. Lanza discuss the incidence of silicosis and tuberculosis among miners of the Tri-State District for the year to June 30, 1929.

Portable Lamps.—E. Lyon considers the various methods of defining the illumination given by portable lamps in *Colliery Engineering* for June.

Spectrographic Determination of Tin.—A quantitative estimation of the impurities in tin by means of the quartz spectrograph is described by C. S. Hitchen in Technical Publication No. 494 of the American Institute of Mining and Metallurgical Engineers.

Cobaltite and Apatite on the Rand.—In a paper read before the Geological Society of South Africa on November 14 last E. Mendelssohn gives some notes on a vein containing cobaltite, gold, and apatite, which was found in the southern part of the Government Gold Mining Areas.

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.*

26,834 of 1931 (389,865). F. B. Jones and Minerals Separation, Ltd., London. Gold ores are ground and mixed with a solid carbonaceous material and a halogen to a temperature between 450° C. and 800° C., the gold being subsequently recovered by a froth flotation process.

28,461 of 1931 (390,545). D. Tyrer and Imperial Chemical Industries, Ltd., London. The temperature of combustion of ferrous sulphide in air is controlled by feeding to the reaction zone relatively cool gas consisting of sulphur dioxide, nitrogen, and oxygen, obtained by cooling combustion gas.

31,731 of 1931 (390,246). Société Oxythermique, Luxembourg. Process for the production of iron or iron and cement in a blast furnace characterized in that ore and flux is fed into alternate layers with coke, the layers being of such thickness that only one layer of ore can come into the fusion zone at one time.

4,120 of 1932 (389,963). Heraeus-Vacuumschmelze A.-G., and Dr. W. Rohn, Hanan am Main, Germany. Chromium is produced on a commercial scale by reducing chromium oxide with the aid of circulating hydrogen.

5,896 of 1932 (389,976). "Miag" Mühlenbau und Industrie, A.-G., Braunschweig, Germany. Roasting or drying apparatus comprising a rotating drum having a gas-permeable wall and a permeable layer of filling through which the material to be treated has to travel.

11,588 of 1932 (390,330). American Smelting and Refining Co., New Jersey. Arsenic compounds are introduced into a rotating bath of molten lead for alloying purposes.

15,978 of 1932 (390,353). Norsk Hydro-Elektrisk Kvaelstofakt., Oslo. Improvements in the nitric acid process of leaching phosphate rock.

22,337 of 1932 (390,049). A. Folliet and N. Sainderichin, Paris. Ferruginous materials are converted into spongy iron after mixture with finely-divided fuel, while travelling in a reaction chamber heated by hot air jets.

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.

Hydraulic Machinery. By Daniel W. Mead. Cloth, octavo, 396 pages, illustrated. Price 24s. London: McGraw-Hill Publishing Co.

Ores and Industries in the Far East. By H. Foster Bain. Cloth, octavo, 288 pages, illustrated. Price $3. New York: Council on Foreign Relations, Inc.

Die Primäre Erzverteilung, auf den Erzlagerstätten und ihre geologischen ursachen. By Dr. F. Wernicke. Paper covers, 173 pages, illustrated. Price RM. 7·50. Halle (Saale): Wilhelm Knapp.

Imperial Institute : Report for 1932. Paper covers, 51 pages. Price 2s. London : H.M. Stationery Office.

Canadian Limestones for Building Purposes. By M. F. GOUDGE. Paper covers, 196 pages, illustrated. Price 30 cents. Ottawa : Department of Mines.

Canadian Department of Mines : Investigations of Fuels and Fuel Testing, 1930 and 1931. Paper covers, 166 pages, illustrated. Ottawa.

Gold Coast : Revised Map of part of the Colony and Ashanti, showing the positions of the gold and diamond mining properties. Price 2s. 6d. London : C. D. Syndicate, Ltd.

Lake Tanganyika: The Hydrology of Lake Tanganyika. By C. GILLMAN. Bulletin No. 5 of the Geological Survey Department, Tanganyika. Paper covers, 25 pages, illustrated. Price 1s. Dodoma : Geological Survey Department.

Mazoe Valley Gold Belt, Rhodesia : Geology of the Central Part. By R. TYNDALE-BISCOE. Southern Rhodesia Geological Survey Bulletin No. 22. Paper covers, 120 pages, illustrated, with map. Price 3s. 9d. Salisbury : Geological Survey.

Mineral Resources of the United States, 1931. Part I, pp. 351–375, Lead, by E. W. PEHRSON ; pp. 417–436, Ore-Concentration Statistics, by T. H. MILLER and R. L. KIDD. Part II, pp. 215–235, Asphalt and Related Bitumens, by A. H. REDFIELD ; pp. 289–296, Barite and Barium Products, by R. M. SANTMYERS and B. H. STODDARD ; pp. 297–329, Stone, by A. T. COONS. Washington : Superintendent of Documents.

Federated Malay States Chamber of Mines : Year Book, 1932. Paper boards, 333 pages. Ipoh : F.M.S. Chamber of Mines.

American Bureau of Metal Statistics : Year Book, 1932. Paper covers, 112 pages. Price $2. New York : Bureau of Metal Statistics.

COMPANY REPORTS

Lonely Reef.—This company was formed in 1910 and works gold-mining properties in the Bubi district, Southern Rhodesia. The report for 1932 shows that a total of 96,924 tons of ore was milled and gave a recovery of 15,825 oz. of gold as against 25,253 oz. from 83,100 tons in 1931. In addition 146,000 tons of accumulated slimes was retreated, against 172,500 tons in the previous year, 11,778 oz. of gold being recovered, against 13,044. The profit for the year was £65,632, which, added to the balance brought in, gave an available total of £82,812. Of this amount £36,162 was distributed as dividends, equal to 12½%, while £22,601 was absorbed in tax payments and £5,434 in depreciation allowance. After making other allowances a balance of £17,711 was carried forward. The interest acquired in the Charliesona property proved disappointing and has been abandoned, but the Peter Pan mine, it is stated, continues to open up well and ore-treatment should commence at the Lonely mine when plant additions are completed about the present month. The ore reserves in the Lonely mine at the end of the year were estimated to be 15,600 tons, averaging 13·7 dwt. in value, while there are, in addition, upwards of 500,000 tons of low-grade ore in the stopes awaiting reclamation. The fully-developed reserves in the Peter Pan mine are estimated to be 70,000 tons of an average value of 3·5 dwt. per ton over 284 in.

Naraguta Karama Areas.—This company was formed in 1926 and operates alluvial tin properties in Northern Nigeria. The report for 1932 shows that under restriction conditions the output fell from 191¾ tons in the previous year to 107½ tons, the revenue per ton being £77 4s. 4d., against £71 18s. 10d. The accounts show a profit on the year's working of £1,550, which, added to the sum brought in, gave a total of £9,524. After making allowance for income-tax there was a credit balance of £8,954, from which a dividend equal to 2½% has been paid, absorbing £2,000, leaving £6,954 to be carried forward.

Naraguta Korot Areas.—Formed in 1925, this company operates alluvial tin properties in Northern Nigeria. The report for 1932 shows the year's output to have been 87¼ tons, against 120 tons in the previous year when restriction was less severe. The average price obtained for the tin sold was £77 11s. 8d., against £71 9s. 6d. in 1931. The year's working resulted in a profit of £1,427, decreasing the debit balance brought in to £55,461.

Boulder Perseverance.—This company was formed in 1923 and works gold-mining properties in the East Coolgardie goldfields, Western Australia. The report for the year 1932 shows that 87,504 tons of ore was treated, including 6,897 tons from outside sources, the bullion produced realizing £227,388, while other receipts totalled £17,888, giving a total revenue of £245,276. Expenditure amounted to £167,973, leaving a profit of £77,303. After making allowance for note interest and redemption and for taxation and depreciation, the sum of £48,861 was allocated to holders of the profit-sharing notes, the balance remaining being £24,430. This, added to the sum of £17,786 brought in, gave an available total of £42,216, of which a dividend equal to 30% will absorb £37,438, leaving a balance of £4,778 to be carried forward. It is stated that work on the new lode discovered by diamond-drilling below the 1,100-ft. level, East Branch off Perseverance lode, is opening well, while a diamond drill-hole on the 1,450-ft. level has intersected the East Boundary lode and shows favourable values and widths.

Waihi Grand Junction.—This company was formed in 1897 and owns gold-mining property in the Upper Thames district, New Zealand. The report for the year 1932 shows that 25,475 tons of ore was treated by the Waihi Gold Mining Co., Ltd., the amount received by the Junction company, under the terms of agreement, being £12,664. After making allowances for taxation and allocation to reserve there was a credit balance of £7,001, which, added to the sum brought in, gave an available total of £9,939, of which £6,906 is absorbed in the payment of a dividend equal to 4d. per share, the balance of £3,033 being carried forward. The ore reserve at the end of the year was estimated to amount to 15,884 tons, valued at 31s. 6d. per ton.

Pengkalen.—This company was formed in 1907 and works alluvial tin-property in the Kinta district, F.M.S. The report for the year to September 30 last shows that the 640,400 cu. yd. treated yielded 267¼ tons of tin ore, the sales of ore realizing £22,223. These figures show the effect of restrictions for 1,570,290 cu. yd. was treated in the previous working year. The accounts show a profit for the year of £4,900, which, added to the balance brought in, gave an available total of £26,812. Of this amount, £10,032 has been written off property account, while a preference dividend absorbs £3,500, leaving £13,280 to be carried forward.

Tekka-Taiping.—This company was formed in 1919 and works alluvial tin property in the Larut

district, Perak, F.M.S. The report for the year to October 31 last shows that 1,023,000 cu. yd. of ground was treated, against 2,269,000 cu. yd. in the previous year, the tin ore recovered amounting to 261¼ tons. The revenue from ore sales was £21,187 and the accounts show a profit of £4,671, which, added to the balance of £20,383 brought in, gives an available total of £25,054. Of this amount £4,000 has been written off for depreciation and the balance is carried forward.

Kinta Tin Mines.—This company was formed in 1900 and works alluvial tin property in Perak, F.M.S. The report for 1932 shows that under restriction conditions 611,700 cu. yd. of ground was treated, against 867,740 cu. yd. in the previous year, the tin produced amounting to 162 tons, against 257 tons, the production including an amount produced under arrangement with Tanjong Tin Dredging, Ltd. The revenue from ore sales amounted to £13,970 and the total working profit was £2,401, the accounts showing a net profit for the year of £527.

Tanjong Tin Dredging.—This company was formed in 1926 and owns alluvial tin property in the Kinta district, F.M.S. The report for 1932 shows that the dredge was in operation for only three months in the early part of the year, producing in that period the quota up to August, while the quota for the remainder of the year was produced by Kinta Tin Mines, Ltd. The accounts show a profit of £1,723, increasing the balance brought in to £4,671. Of this amount £1,702 has been written off for depreciation, leaving £2,969 to be carried forward.

Fabulosa Mines.—Formed in 1921, this company operates a group of lode-tin properties to the north of La Paz, Bolivia. The report for the year 1932 shows that owing to restriction conditions the total production for the year was only 468 tons of fine tin, against 597 tons in the previous year. Production costs, including interest charges, amounted to £157 13s. per ton, while the average price received for the ore was only £136 18s. 9d. per ton, the accounts showing a net loss of Bs. 154,069, increasing the debit balance brought in to Bs. 1,165,953. Work in the Union mines has been suspended while that in the Milluni and Fabulosa groups has only been possible on a restricted scale, the company's monthly output quota having been fixed at 23¾ tons.

Geevor Tin Mines.—This company was formed in 1911 and is working lode-tin properties at Pendeen, St. Just, Cornwall. It will be recalled that in December last it was agreed that the nominal value of the company's shares should be reduced from 10s. to 5s. and the capital now stands at £82,125 in 5s. shares. The report for the year to March 31 last shows that the scale of operations was gradually increased, the tonnage treated in March being 4,350, against 2,524 in September last. Altogether 38,785 tons of ore was treated (12,928 tons from the Wethered section and 25,857 tons from the Victory section), the output of black tin amounting to 632 61 tons. The debit balance outstanding at the end of the previous year, together with a further loss of £2,490 for the five months to August 31, 1932, was written off in February last, the profit for the remaining seven months of the year under review being £9,827. The ore reserves at the end of the year were estimated to amount to 165,076 tons, of which 77,339 are in the Wheal Carne section.

DIVIDENDS DECLARED

Apex (Trinidad) Oilfields.—7½d., less tax, payable July 15.

Ariston.—3d., less tax, payable June 14.

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

Boulder Perseverance.—£5 notes, 128s. 9d., payable July 1 ; Ord. 3⅜d., less tax, payable June 19.

Changkat Tin.—1s., less tax, payable May 19.

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

Golden Horse Shoe.—6d., less tax, payable July 14.

Malayan Tin.—2½d., less tax, payable June 10.

Naraguta Karama.—3d., less tax, payable June 9.

North Broken Hill.—1s. (Australian currency), less tax, payable June 29.

Oriental Consolidated.—50 cents, less tax, payable June 10.

Pattani Tin.—2%, less tax, payable June 14.

Pengkalen.—Pref. Ord. 3d., less tax.

Sungei Way.—2½%, less tax, payable May 31.

Tekka.—3d., less tax, payable May 31.

Trepca.—6%, less tax, payable June 19.

Waihi Grand Junction.—4d., free of tax, payable June 9.

West African Diamond.—1½d., less tax, payable May 31.

Witpoort Gold.—9⅜d. (liquidation), payable June 6.

Zinc Corporation.—Pref. 2s. 6d., Ord. 6d., less tax, payable July 3.

NEW COMPANIES REGISTERED

Cripple River Syndicate.—Capital : £300 in 5,000 "A" Ordinary and 1,000 "B" Ordinary shares of 1s. each. Objects : To acquire any gold mines, mining rights, claims, etc., in United States and elsewhere.

Gold Corporation.—Capital : £100 in 5s. shares. Objects : To carry on the business of gold and other mineowners, miners' financiers, concessionaires, etc.

Konongo Gold Mines.—Capital : £500,000 in 2s. shares. Directors : J. Howeson, R. Annan, S. F. Baddeley, H. R. Edwards, and Louis Hardy. Offices : 55–61, Moorgate, E.C. 2.

Malayan and General Trust (1933).—Capital : £200,000 in 4s. shares. Objects : To acquire the assets of the Malayan and General Trust (incorporated in April, 1926) and Kamra Tin Dredging. Directors : Lord Ampthill, John H. Cordner-James, Henry S. M. Harrison-Wallace, Edward Hooper, Ernest B. Ridsdel, and Cowan Shankland. Office : 411–19, Salisbury House, London Wall, E.C. 2.

Western Reefs Exploration and Development Company.—Capital : £600,000 in 5s. shares. Company was incorporated in the Union of South Africa on April 11, 1933, to acquire claims, mineral properties, and mining, water and other rights. The Anglo American Corporation of South Africa are vendors of property proposed to be purchased or acquired by the company. Directors : Sir Ernest Oppenheimer, Richard B. Hagart, William H. A. Lawrence, William A. Mackenzie, and Leslie A. Pollak. British Office : 5, London Wall Buildings, E.C. 2.