The Mining Magazine

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

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

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

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

Vol. XLIX. No. 4. LONDON, OCTOBER, 1933. PRICE ONE SHILLING

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EDITORIAL

FEARS have been expressed for the future of the Imperial Institute, which it is thought may eventually suffer the fate of the Empire Marketing Board. This would certainly be unfortunate, for the institute is an important research centre where work of unquestionable value to producers and manufacturers alike is conducted.

THE Melchett Medal of the Institute of Fuel has been awarded to Sir John Cadman and he is to receive it at the annual dinner on October 18. Sir John delivered the Melchett Lecture before the institute on October 11, choosing as his subject "The Place of Oil in the World of Fuel."

THE Western Australian Government found it necessary last month to contradict rumours that a tax on gold was impending. The Premier (Mr. P. Collier) pointed out that the gold-mining industry was the present standby of the State and they considered it would be ill-advised policy to do anything to check its increasing prosperity.

FOLLOWING the review of conditions in the iron and steel trade in this country in the MAGAZINE last month comes the encouraging announcement of the new Master Cutler that the output from Sheffield is now 27,000 tons per month more than a year ago, while the average monthly output for the whole country for the first eight months of the year was 99,000 tons greater than for 1932.

SIR ALBERT KITSON'S work in Kenya, embodied in his two reports on the Kakamega goldfield, has now been supplemented by some notes on the geological succession, tectonics, and economic geology of the western half of the colony by Mr. R. Murray-Hughes. These notes (Mining and Geological Department Report No. 3, 1933) are claimed to have no more than approximate accuracy, but it is hoped that their publication will stimulate interest in the work of the department.

ONE of the most interesting of the trade exhibitions held in London from the point of view of the mining engineer is that devoted to Public Works, Roads, and Transport, which takes place this year from November 13 to November 18. This biennial exhibition is the occasion for the display of drilling equipment, excavators, crushing and screening machinery, and power plant such as are not seen at any other time or place and is a useful sequel to the recent engineering exhibition at Olympia.

TO commemorate the visit of the Iron and Steel Institute to Sheffield in 1905—in which year he was its president—Sir Robert Hadfield on the occasion of the recent meeting made a gift to Sheffield University of £5,000, expressing the hope that the money will be used for the advancement of metallurgical knowledge. It will be recalled that Sir Robert built and equipped the metallurgical research laboratories of the applied science department of the University, of which he holds the degree of Doctor of Metallurgy.

UNDER the title "Twenty-Five Years' Progress in Metallurgical Plant" Mr. W. R. Barclay, who delivered the Autumn Lecture before the Institute of Metals last month, confined his attention to plant for the fabrication and alloying of metals and did not in any way deal with extraction metallurgy. On more than one occasion we have drawn attention to the rather anomalous use of the word metallurgy and suggested on one occasion the adoption of the terms "Metallurgy I" and "Metallurgy II" as a means of differentiating between the extraction and subsequent treatment sides.

THE rightful tenants of the new Geological Museum in South Kensington—which was hurriedly completed to accommodate the delegates to the World Economic Conference—are at long last to be allowed the occupation of their new home. It has been decided that the need of the Geological Survey and Museum can no longer be ignored and arrangements are in hand for the completion and equipment of the new building in accordance with the original plans. It is expected that the work of re-adaptation to

the Museum requirements will take two or three months to complete, after which a start will be made with the lengthy process of removal from Jermyn Street.

Aerial Surveying in Australia

In the last issue of the MAGAZINE it was announced that preliminary arrangements had been concluded by Austral Development, Ltd., on behalf of the Western Mining Corporation, for an air survey over approximately 88,000 square miles of country in Western Australia. Early this month the aeroplanes to be used in this work were christened at a British aerodrome preparatory to their shipment to Australia, being appropriately named the Gay Prospector and the Golden West. These preparations for intensive work over Western Australian goldfields lend additional interest to the report [1] of Dr. W. G. Woolnough, Geological Adviser to the Commonwealth Government, on aerial survey operations in Australia during 1932, which has just been published.

It will be recalled that in 1930 Dr. Woolnough was instructed to visit the oilfields of the United States and Argentina and his report,[2] published in the following year, stressed the importance of aerial survey methods, recommending that they should be submitted to test under Australian conditions. His recommendation was accepted and during 1932 experiments were carried out, with the co-operation of the Royal Australian Air Force. Previous tests of aerial photography for geological purposes had been made in connexion with the Belford Dome, in the Hunter Valley of New South Wales, where a small number of low-altitude "oblique" photographs were taken, while C. T. Madigan's work in Central Australia—already well-known—has served an admirable purpose in showing how much geological mapping in such a country can be expedited by a correct use of aerial photography. For the new work undertaken by Dr. Woolnough in 1932 Longreach, Queensland, was selected as the first site and much valuable assistance was rendered by the geologists of Oil Search, Ltd., both in visual observation and in ground control. The survey was eminently successful, revealing many hitherto unsuspected geological features, and, although the results are still held to be of a confidential nature, they led to the extension of the work to most of the other areas enumerated in the report of 1931 as likely to be possible regions for oil development in Australia. Work in Northern Queensland, in the neighbourhood of Darwin, was followed by incidental photography in the Northern Territory and East Kimberley—as far as Fitzroy Crossing—where detailed surveys were made of potentially petroliferous areas and much of the surrounding territory. The operations were continued through Western Australia to Adelaide and later a flight to Tasmania covered typical areas in all parts of the island, excellent results being obtained. The photographic records of all this work were completed by the Air Force authorities and mosaics over considerable areas have been completed. Although the work of interpretation of the results of this survey is likely to be slow and tedious, those obtained in a few type areas of outstanding importance are published in the present report, while at a later date it is hoped that it will be possible to issue supplementary descriptions of other regions that have come under observation.

Dr. Woolnough has much to say concerning the technique of this new weapon that is likely so greatly to expedite the work of field geologists in little-known areas. He points out that the ability to make satisfactory visual observations from the air and to interpret results does not come quickly to the observer and he emphasizes the need for long training in carrying out such work, for he found that he was scarcely able to appreciate the significance of many details noticed until he had completed a fair number of flying hours, at least 100 being the figure named. It has been repeatedly stated—as was borne out by the discussion on Mr. Donald Gill's recent paper before the Institution of Mining and Metallurgy—that aerial survey operations are not a substitute for careful ground work by the geological investigator and the author of the present report sees fit to press this view home once again. Nevertheless it will be quite apparent from the summary of results that are presented that much valuable time and misspent energy can be saved by a correct use of the aeroplane and the aerial camera.

[1] "Aerial Survey Operations in Australia during 1932." By W. G. Woolnough. Canberra: Government Printer.

[2] "Report on Tour of Inspection of the Oil-Fields of the United States of America and Argentina and on Oil Prospects in Australia." By W. G. Woolnough. Canberra: Government Printer.

Gold in Southern Rhodesia

The history of gold mining in Rhodesia dates back to remote times, the activity of the Ancients in their pursuit of the precious metal being evidenced by the large number of old workings that may be found in all parts of the Colony. Many estimates have been made on the evidence of these abandoned excavations of the amount of gold extracted by them, one reliable authority having placed it as high as £75,000,000. Towards the end of last century the reports of traders began to direct attention to the mineral-producing possibilities of the country, the traces of previous exploitation being so evident, and the operations of the early prospectors were greatly facilitated by the use they made of the old workings, for almost all the gold-bearing reefs of any value that outcropped at surface had been worked down to water level. The fame of this part of the African continent as a country of vast potential wealth was soon rapidly growing and from 1880 onwards large numbers of concession hunters had been attracted from all parts of the world. Although the Colony has had a long history as a gold producer it was not until 1907 that regular output figures became available and a record from that year to 1932 has recently been published through the efforts of Mr. Brooke Norris,[1] whose knowledge of the mining statistics of Southern Rhodesia is probably unrivalled. Mr. Norris has prepared a summary of the history of gold mining in the Colony during these years and his work merits attention.

The output of gold from Southern Rhodesia from the commencement of regular crushing in 1898 up to the end of 1906 was, Mr. Norris estimates, 1,989,776 oz., a figure made up from old bullion returns. The declaration value for mill gold was usually 72s. 6d. per oz., but no fixed value was obtained for gold recovered by cyanidation. In 1907, however, arrangements were made with the mining industry which compelled it to make returns in fine gold and these operated from May 1, 1908. The return for 1907 shows an output of 612,052 oz. and it is recorded that the year was one of increasing expansion in the industry, the figures representing a record, largely the result of the growing number of small workers. By 1908 the number of producers had grown to 446, although the output was lower at 606,962 oz. The number of producers had increased by the end of 1909 to 548, a figure which remained as a record until 1932. During the years up to 1914 the production was steadily held at between 600,000 and 700,000 oz. per annum, but the intense effort made during the War resulted in this being increased, the maximum being reached in 1916, when 494 producers were responsible for an output of 930,356 oz. From this time onwards production gradually declined to its pre-War level and by 1930 had fallen to 547,630 oz., the number of producers being 331. That year was marked by the closing down of the Shamva mine as a large producer and the entry of the Wanderer. Crushing operations had started on the Shamva in 1914 and it treated 9,567,000 tons of ore for a gold yield worth £6,492,450 before closing down. In 1931 there were indications that activity in the industry was again growing, the number of gold claims registered being 21,376, as compared with 7,379 in 1930. The increasing interest in gold mining was maintained during 1932, in which year the number of producers reached a record at 782. Although the output was only 574,135 oz., it is evident that the industry continues to expand. It will be recognized, however, that the peculiar conditions that have obtained during the past few years may have temporarily diverted many people from agriculture to mining and improving conditions for the farmer might easily result in a rapid move in the opposite direction.

Over the period reviewed the gold produced by Southern Rhodesia totalled 16,785,520 oz. and it is of interest to note how this was made up. Mines producing over 10,000 oz. per annum contributed 10,464,591 oz., or 62·35% of the total, the remainder being approximately divided equally between those producing 5,000 to 10,000 oz., 2,000 to 5,000 oz., 1,000 to 2,000 oz., and those with a yearly output of less than 1,000 oz. The gold-mining industry in the Colony being entirely lode mining in quartz veins it has naturally experienced vicissitudes, but it is satisfactory to know that the annual output has during the years reviewed been maintained at well over 500,000 oz., especially now that the mineral rights are in the possession of the Colonial Administration.

[1] "The Gold Outputs and Mining Activity of Southern Rhodesia, 1907 to 1932." By S. Brooke Norris, Southern Rhodesia Geological Survey Bulletin No. 25, Price 3d.

Ore Deposition

An unfortunate tendency among economic geologists to speculate on the origin of ore deposits is only too well known and this is particularly true of those prone to express their views in print. Scientific deduction from observed data is, it will be agreed, quite right and proper, but many present-day workers and, indeed, more than one famous man in the past, having found themselves unable to verify the bases of their own theories, have not hesitated to jump to extremely improbable conclusions. We have before ventured to suggest that too much attention is given to the expression of pure conjecture as to the origin of ore deposits and too little to the recording of observations which will serve some day as corner stones in the building of a well-founded theory. To the mining man so much pure guess-work serves only to throw an honourable profession into disrepute, for the practical miner is quite sure that the ore, having been found, will not disappear and that the geologist should concern himself mainly with the structure of the body, in order that it may be found again should it for any reason be lost through running against a fault or other structural feature, and that the formulation of genetic theories is a matter of subordinate importance. Much of the time that has been spent in idle dreaming on the causes of ore genesis is revealed in "History of the Theory of Ore Deposits"[1] and this has now been admirably set forth by Mr. Thomas Crook, Principal of the Mineral Resources Department, Imperial Institute. The history makes fascinating reading and it will very probably set the mining man speculating in spite of himself.

Mr. Crook's narrative begins with the story of the philosophers of old and their conception of the four elements—earth, air, fire, and water—and passes on to Theophrastus, who in his book "Of Stones" wrote the first mineralogy, grouping his minerals as metals, stones, and earths. Writing in the sixteenth century Agricola (G. Bauer) had arrived at the conception of pure minerals and of mixtures and by him metalliferous veins were regarded as fissure deposits in "canales" formed by "erosion" with underground waters. The author then shows that interest in ore deposition tended to flag somewhat until the eighteenth century, when the directors of the famous German mining schools had begun to ponder the question, but it was not until the end of the century that the advent of Hutton and Werner into the field saw the commencement of that famous controversy between the Plutonists and Neptunists. The early part of the next century witnessed the gradual abandonment of neptunistic theory and, as the conception of vulcanism arose, the study of ore deposits became separated, strangely enough, from petrology, a state of affairs that continued up to the present century. The story continues with the rise of the theory of lateral secretion and the new controversy that arose with the igneous theory, which, in modified form, is so widely held at the present day, either in that form which believes largely in the agency of exudations from wet magmas or that advocated by Spurr in his classic work on ore-magmas, although it will have early become apparent to the reader that the author of the work under review has quite different views himself. He says: "It seems likely that, as the significance of geodynamical factors and earth history comes to be more fully understood by students of ore genesis, they will realize more and more that the origin of metalliferous veins is associated with comparatively superficial crustal changes in which meteoric waters rather than juvenile waters have played the dominant role." It may be, but this is only the expression of an opinion.

However fascinating the instructive story so well told by Mr. Crook may be, it is certain that the most important advances in economic geology have been made as a result of careful observation. The theory of deltaic deposition that has proved so useful in the exploration of the Far East Rand embodies years of painstaking research and the careful correlation of observed data. Similarly the knowledge of the zonal distribution of metals with respect to depth is not merely the outcome of speculation, but the sequel to a correct recording of facts. In petrology the narrow path of careful laboratory and accurate field work has long been followed by the student and now that petrology and the study of ore genesis tend to merge once again it is to be hoped that the penchant for speculation does not rapidly overwhelm the petrologist as it has so often tended to engulf his "economic" brother in the past.

[1] "History of the Theory of Ore Deposits, with a chapter on the use of petrology." By Thomas Crook. Price 10s. 6d. London: Thomas Murby and Co.

REVIEW OF MINING

Introduction.—The feeling of confidence in the future that has been gradually gaining ground for some time past has at last found open expression at Geneva, where the League reports issued early this month stress the fact that the production of industrial countries is increasing and unemployment diminishing, while the outlook for primary commodities shows considerable improvement. The trade returns for this country issued early this month are also said to be the best for five years. Metal prices exhibit little change over the month and fears as to the future of zinc have at last been allayed on the news of the renewal of the cartel, following the settlement of the dispute over the method of levying fines on excess production.

Transvaal.—The output of gold on the Rand for September was 851,985 oz. and in outside districts 49,814 oz., making a total of 901,799 oz., as compared with 934,714 oz. in August. The number of natives employed in the gold mines at the end of September totalled 230,774, as compared with 231,341 at the end of August.

The steady progress made in adapting the Rand gold-mining industry to the conditions obtaining since the Union's departure from the gold standard was disturbed last month by the outbreak of strikes of white miners, at the Langlaagte Estate and the Simmer and Jack. After a few days the men were induced to return to work, but that they are not entirely satisfied with conditions is shown by the reiteration of their demand for a shorter working week and increased wages.

The intention of the Union Government to seek revision of the Mozambique Convention regarding native labour recruitment has been formally notified to Lisbon.

The report of the Sub Nigel for the year to June 30 shows a profit of £1,362,665, which, added to the sum brought in, gave an available total of £1,405,184. Of this amount £848,437 was absorbed as dividends, equal to 10s. 6d. per share, and, after making allowances for Government taxes and other items, the balance of £74,456 was carried forward. The ore crushed during the year totalled 447,900 tons, which yielded gold worth £2,144,148. Working costs amounted to £795,421, leaving a working profit of £1,348,727. The ore reserves at the end of the year, calculated with gold at 84s. 9d. per ton, were estimated to be 1,534,000 tons, averaging 17·6 dwt. With gold at 120s. per oz. the pay limit is reduced to 5·0 dwt. and the total reserve on this basis is 1,664,000 tons, averaging 16·7 dwt.

It was announced last month that an offer made by the New Steyn Estate for the purchase of the mining property and plant of the Roodepoort United had been accepted. The purchase price is £200,000 in cash.

At an extraordinary meeting of Ferreira Estate, to be held in Johannesburg next month after the annual meeting, it will be proposed that the capital of the company be reduced from £154,212 to £125,297 5s., the reduction to be effected by the return of 3s. cash on each 16s. share.

The report of West Witwatersrand Areas for the year ended June 30 last states that the option to acquire the mineral rights of Western Areas, Ltd., has been exercised and that £190,035 of the total amount of £225,000 had been paid at the end of the year. Additional mineral rights on Farm Driefontein No. 105, in the Potchefstroom district, are to be acquired.

Advice from Johannesburg last month with respect to Lace Proprietary Mines was to the effect that the company will shortly offer 95,625 new £1 shares to existing holders at a price of £3 per share. This would raise the issued capital to £478,125.

In the last issue of the MAGAZINE it was announced that negotiations were in progress between the Rooiberg Minerals Development Company and Leeuwpoort Tin Mines regarding the mineral rights of the latter company's farms. These rights on farms Leeuwpoort No. 1336 and Rietfontein No. 1335 have now been optioned by the Rooiberg company for a period of 12 months, the purchase consideration, if the option is exercised, to be £20,000, to be satisfied by the issue of 20,000 £1 shares. The Leeuwpoort company has in addition been promised a 20% interest in any future issue of capital that may be made by the Rooiberg company during the next five years. During the option period up to 6,000 tons of ore may be mined from the two farms.

Shareholders of Northern Transvaal (Messina) Copper Exploration, Ltd., were informed this month of the progress of the development operations in hand. Drilling is stated to be proceeding satisfactorily, while several shipments of high-grade ore have recently been made from shafts put down on old workings.

The report of Onverwacht Platinum, Ltd.,

for the year to June 30 last shows cash and cash assets amounting to £59,957, the amount received from the sale of plant and equipment during the year being £3,971.

Southern Rhodesia.—The output of gold from Southern Rhodesia during August was 56,147 oz., as compared with 54,561 oz. for the previous month and 49,254 oz. for August, 1932. Other outputs for August were: Silver, 10,189 oz.; coal, 47,654 tons; chrome ore, 904 tons; asbestos, 2,520 tons; mica, 1 ton; tin, 1 ton; iron pyrites, 906 tons.

Shareholders of the Globe and Phoenix Gold Mining Company were informed last month that an option had been acquired over a property in the Balla Balla district. Initial exploration work on the new property is in hand.

Northern Rhodesia.—The output of gold from Northern Rhodesia during August was 286 oz., as compared with 251 oz. for the previous month and 59 oz. for August, 1932. Other outputs for August were: Copper, 8,985 tons; zinc, 1,650 tons; manganese ore, 975 tons; mica, 650 lb.; cobalt, 40,029 lb.

It was announced last month that the Rhokana Corporation had in hand preparations for bringing a second mine into production.

Gold Coast.—Shareholders of Konongo Gold Mines, Ltd., were informed this month that the new Edwards shaft on the Awere lode had been concrete lined to 45 ft. and that sinking had been started on the Hardy shaft (Akyenase lode). The inclined shaft has been cleared to 45 ft.

The statutory report of Gold Coast Banket Areas, Ltd., issued last month, shows that the total amount received by the company in cash in respect of shares issued was £86,736, the balance in hand, after allowing for all issue and other expenses, being £43,046. Two new leases have been acquired, known as Akoko Aow and Cheriaman Gold Mines, for the exploitation of which the formation of a new company is contemplated.

Sierra Leone.—The first shipments of iron ore from Sierra Leone recently arrived in Glasgow. The deposits have been for some time in course of development by the Sierra Leone Development Company.

Kenya.—The output of gold from Kenya Colony for July was 1,223 oz., as compared with 872 oz. in the same month of 1932.

A progress report to shareholders of the Tanami Gold Mining Syndicate issued this month contains information relative to developments on the property of the Rosterman Syndicate, in the Kakamega area. Three reefs have been opened up and arrangements have been made for the sinking of a shaft on each of them.

Australia.—In the return for August shareholders of the Wiluna Gold Corporation were informed that diamond drilling has recently been started in order to test the Bulletin lode at depth, the three holes completed to date having revealed continuous lode material.

It was announced last month that Western Gold Mines had exercised its option over the Mararoa mine, at Reidys, near Cue. It is proposed to form a company in Australia, under the title Triton Gold Mining Co., with a capital of £600,000 in 10s. shares, in order to acquire and operate the property.

The new lode discovered in the Great Boulder Proprietary in section 29 has been opened up by driving south for 60 ft., the ore averaging 15 dwt. per ton over a width of 6 ft.

The report of Associated Northern Blocks (W.A.), Ltd., for 1932 shows a loss of £668, increasing the debit balance brought in to £5,513. The whole of the expenditure on the Mexican property—El Refugio—has now been written off. The sale of the Iron Duke Lease, at Kalgoorlie, to the Gold Fields Australian Development Co. was announced in the MAGAZINE last month.

Malaya.—The report of Pelepah Tin Dredging for the year to March 31 shows that the erection of the dredge was completed in August last and it is now engaged in deepening and widening its paddock. Negotiations are in hand with the Johore Government, which have in view the securing of an increased assessment for the State in order that the dredge will be able to compete with producers in the Federated States.

During the year to March 31 last the Kinta Kellas Tin Dredging Co., Ltd., suffered a loss of £5,761 after allowing for depreciation, the total amount at debit of profit and loss being now £13,969. The output of tin concentrates amounted to 142·22 tons, which realized an average of £88 1s. 8d. per ton, as compared with £69 18s. 7d. per ton in the previous year.

Siam.—Shareholders of Tongkah Harbour Tin Dredging have been notified of a further call of 1s. per share, required to meet the company's debt to the banks in Penang.

Burma.—The report of the Burma Corporation for the three months to June 30 shows a surplus of receipts over working expenditure amounting to £250,395, as

compared with a surplus of £105,360 for the three months to March 31. The increased revenue reflects the improved demand for lead and the general rise in metal prices. The Marmion shaft has been sunk 154 ft. below No. 12 level.

Siberia.—Shareholders of the Tetiuhe Mining Corporation were informed last month that £68,800 had been received from the sale of U.S.S.R. Government bonds, the amount representing part of the purchase consideration for the company's concession in Eastern Siberia.

Cornwall.—Further developments on the East Pool mine were announced by the general managers last month. A diamond bore-hole put out south from the main west drive on the Rogers lode at the 1,600-ft. level entered lode material at 251 ft. and continued to 269 ft., the last 3 ft. averaging 58 lb. black tin, 30 lb. wolfram, and 50 lb. arsenic per ton. This is believed to be the same lode previously intersected by the 1,700-ft. main north cross-cut.

Imperial Smelting Corporation.—Arrangements have been concluded for the acquisition by the Imperial Smelting Corporation of the Sulphide Corporation's works at Seaton Carew and of the share capital of the Delaville Spelter Company, of Birmingham.

Murex.—The accounts of Murex, Ltd., for the year to June 30 last show a profit of £68,677, which, added to the sum brought in, gave an available total of £102,881. Dividends equal to 3s. per share have been declared, absorbing £41,966, and after allowing for preference dividends and other expenditure there remained a balance of £44,150 to be carried forward. At an extraordinary meeting held following the general meeting this month a resolution proposing that the capital of the company should be increased to £275,000, by the creation of 50,000 new 10s. shares, was approved.

Copper.—The incorporation of the Copper Development Association as a company was announced last month. Sir Auckland Geddes, Mr. A. Chester Beatty, and Sir Harry D. McGowan are honorary presidents of the new company, which will be directed by a council, of which Mr. D. Owen Evans is chairman. Detailed business will be conducted by a management committee, of which Mr. A. D. Storke will be chairman. Efforts are to be concentrated for the present on the development of extended uses for copper rather than on research work. At Geneva early this month representatives of Canada, the United States, Peru, Chile, and Belgium were present at a meeting having in view the calling of an international copper conference.

Tin.—The tin statistics available at the end of September show a further considerable improvement in the position, the visible supplies at the end of the month amounting to 35,859 tons, a shrinkage of 4,095 tons on the month. At a meeting of the directors of Cornish tin mines held last month in London it was agreed that the principle of restriction should be extended to Cornwall, the proposed flat-rate quota of 2,200 tons of metallic tin per annum being accepted as a reasonable figure. Negotiations for bringing other outside countries into the scheme are under way and it is expected that the adhesion of French Indo-China will be announced at an early date.

General View of the Lake View and Star Surface Plant.

ORE TREATMENT AT THE LAKE VIEW AND STAR

By T. B. STEVENS, M.I.M.M.

A description of the methods adopted at this Western Australian property to deal with ore containing free gold, gold tellurides, and gold associated with pyrite.

It is generally recognized that the gold in the sulphide ore [1] at Kalgoorlie occurs in three ways—*i.e.*, as (*a*) free gold, which is soluble in cyanide solution and can also be saved by amalgamation or strakes, (*b*) tellurides of gold, which will only yield to intensive cyanide treatment in the raw state but readily after roasting, and (*c*) gold associated with pyrite, which will not give a satisfactory cyanide extraction without roasting. The proportion of the total gold which occurs in each of the three ways varies considerably in the different lodes, but for any treatment process to be satisfactory it must be able to treat all of them equally well. Three different methods of treatment have been used by the Lake View and Star company since its formation in 1910 and a comparison of them is informative, as it shows how treatment methods have been modified to make them more suitable for the nature of the ore and also to reduce working costs.

In the first plant the ore was crushed wet by stamps and tube-mills and a concentrate amounting to about 10% of the weight of the ore was separated by Wilfley tables. The concentrate was roasted and cyanided and a good extraction was obtained. The tailings from the concentration still contained about one-half of the mineral and one-half of the gold contained in the original ore and they were treated either by prolonged agitation with cyanide solution or else by cyanogen bromide. This process was used on ore of about 26s. value [2] for some years, but it had the failing that when higher-grade and consequently more heavily mineralized ore was treated there was always an abnormal rise in the residue from the raw treatment of the tailings. The recovery was dependent on the amount of mineral left in the tailings after concentration and although an elaborate classification and concentration plant was erected it was found impossible to save more than 50% of the concentrate by gravity concentration. This caused the process to be abandoned when economic conditions brought about by the War made it necessary to treat a smaller tonnage of higher-grade ore.

In the second plant the ore was crushed dry and all of it was roasted and cyanided. The extraction was high and was not greatly affected by the grade of ore or the mineralization, but the cost of treatment was also high. The high cost was due to the inefficiency of dry crushing and high consumption of fuel for roasting. A further disability of the dry-crushing process was that the amount of water used underground for drilling operations had to be limited and this increased the cost of breaking ore and also created unhealthy conditions.

In the third plant, which has just been completed, a return has been made to the wet crushing, but flotation is used for the separation of the concentrate instead of gravity concentration. By this means the tailings from the concentration are brought so low in value that they can be discarded without cyanide treatment. Over 90% of the mineral content of the ore is concentrated into 7% of concentrate and 93% of the ore is discarded without cyanide treatment. The flotation concentrate is roasted and cyanided as it was in the first plant, but now the sulphur content is so high that no external fuel is necessary. Another modification of the process is in the separate collection of free gold. In the first plant it was caught on the Wilfley tables, but with the flotation process it is not so easily collected, and a better saving has been effected by installing corduroy strakes before the flotation plant. The extraction obtained by these combined processes is not quite as high as was obtained by the dry-crushing process, but this loss in extraction is very much more than balanced by a large reduction in working costs.

Experimental work was carried on with the flotation process for some years before its adoption. A pilot plant was erected in 1925, but from the results obtained it was difficult to decide if the higher extraction obtained by dry crushing would not balance the saving in cost effected by flotation. This point was not definitely proved until

[1] For analyses of Kalgoorlie ores and descriptions of early treatment methods the reader is referred to "West Australian Metallurgical Practice," published in 1906.

[2] All assay values in this article refer to the ton of 2,000 lb. and to gold at 85s. per oz.

the erection of the first unit of the present plant three years ago. In the large plant the extraction obtained in the pilot plant has been only slightly improved on, but the working costs have been considerably lower than was estimated in every part of the treatment.

The capacity of the plant is now 45,000 short tons a month. With the exception of the coarse crushing department it is in continuous operation for seven days a week. A great deal of the old dry-crushing plant has been utilized in the construction of the present wet-crushing plant and the roasting and cyaniding plants have also been modified in order to make them suitable for the treatment of concentrate instead of ore. Owing to the nature of the ore-bodies the grade of the ore milled varies considerably in value from day to day. The value of ore for the past year has averaged 35s. and the data in the present article refer to ore of that value.

Coarse Crushing.—The ore supply for the mill is drawn from three shafts, Chaffers, Lake View, and Ivanhoe, about one-half of the tonnage being supplied from the Chaffers shaft, which is situated close to the plant and is connected to it by belt conveyor. The remainder comes from the Lake View and Ivanhoe shafts, which are situated about half a mile away. Delivery is made to the mill in side-tipping trucks of two-ton capacity, which are drawn by steam locomotives.

The capacity of the coarse-crushing plant (Fig. 1) is 200 tons per hour. For primary crushing there are two No. 7½ Gates gyratory rock-breakers. One is used for Chaffers ore and is fed from a small bin into which the skips are tipped, the other is used for the ore which is brought in by trains. They are set to break to 5 in. and have belt-conveyors beneath, which deliver the ore to the secondary crushing plant. For secondary crushing two 4-ft. Symons cone crushers are used. Before going to them the ore passes under two electro-magnets for the removal of tramp iron and over two Sherwen screens for the removal of fines. The removal of the fine material increases the capacity of the crushers and allows of a finer setting. In crushers of this type there is a tendency for the fine ore, especially when damp, to form into hard cakes, which choke the discharge and reduce the capacity.

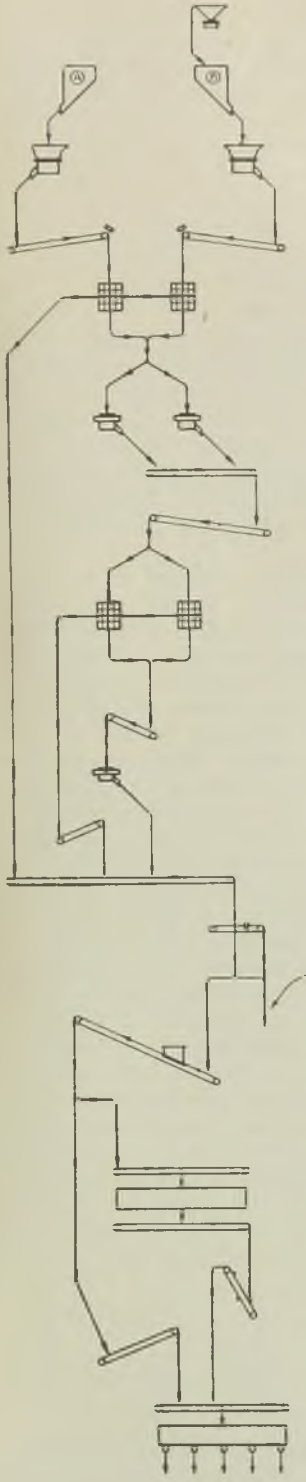
The Sherwen screens are 6 ft. long by 4 ft. wide and they are fitted with screens of 6 gauge wire and have apertures 1¼ by 1½ in. Grizzlies were formerly used in place of the screens, but they were unsatisfactory, as they constantly choked. Although the size of the rock is large the wear on the screens is not excessive. They are supported on springs made of hickory and are vibrated electrically at the head, direct current being used for the operation and the trembler mechanism being similar in principle to that of an electric bell.

The discharge from the Symons cone crushers, together with the screen undersize, is elevated by a belt to two secondary Sherwen screens, which are fitted with screens having ⅞ by ¾ in. apertures. The oversize from the screens is again elevated to a 4-ft. Symons shorthead machine, which is used for tertiary crushing. The discharge from this crusher, together with the undersize from the secondary screens, is the finished product of the coarse-crushing plant and is elevated by belts to the mill bins. The belts beneath the shorthead crusher are arranged so that it is possible to operate this machine in closed circuit, when it is found desirable to do so. The foreman in charge of this section endeavours to deliver a product to the ball-mills that is all minus ½ in. An assay sample is taken by a bucket sampler which makes a 0·5% cut.

The mill bin erected for the dry-crushing plant has been retained, this being a timber structure with a capacity of 900 tons of ore. There is also a reserve bin for supplying ore over the week-end.

Milling and Classification.—In order to liberate the gold-bearing minerals from the gangue fine grinding is necessary, the pulp going to the flotation plant at present containing 95% of minus 200 mesh. It is also advisable to remove the free gold from the grinding circuit as soon as it is liberated, as otherwise the gold is ground too fine to be easily saved on strakes and there is a danger of it being locked up behind mill liners and in similar places. For this reason it is not advisable to close-circuit a mill, unless strakes form part of the circuit.

Grinding is done in three stages—the first by ball-mills in open circuit, the second by tube-mills in closed circuit, with straight-line classifiers and strakes, and the third by tube-mills in closed circuit, with bowl classifiers and strakes. Each ball-mill, tube-mill, straight-line classifier, and set of primary strakes forms a circuit of its own. It is not until the tertiary grinding circuit is reached that the pulps from the different



Steam locomotive hauled rakes of 20 trucks, "v"-shaped 2-ton side-tipping trucks.

(A) Chaffers breaker bin, 100-ton capacity.

(B) Ivanhoe, Horseshoe, and Lake View sub-level breaker bins, 130 tons capacity.

(C) Gates crushers (No. 7½) breaking to 5 in. 56-h.p. motor.

(D) Electro-magnets suspended.

(E) 20-in. inclined belt conveyors, 212-ft. and 178-ft. centres. Motors 16-h.p. and 25-h.p.

(F) Primary Sherwen screens, 1¼-in. aperture.

(G) Symons 4-ft. cone crushers, 485 r.p.m., breaking to 1 in. Maximum capacity 120 tons per hour each. 100-h.p. motors.

(H) 24-in. belt conveyor, 58-ft. centres. 10-h.p. motor.

(I) 24-in. belt conveyor, 92-ft. centres inclined. 20-h.p. motor.

(J) Secondary Sherwen screens, ⅞-in. aperture.

(K) 18-in. belt conveyor. Oversize. 92-ft. centres inclined. 12-h.p. motor.

(L) 4-ft. short head Symons cone crusher, 435 r.p.m. 150-h.p. motor.

(M) 24-in. belt conveyor. Undersize. 85-ft. centres inclined. 12-h.p. motor.

(N) 20-in. belt conveyor. 348-ft. centres. 25-h.p. motor.

(O) Chain bucket sampler. 0·5 per cent. cut.

To reserve bins and sample plant.

(P) 24-in. belt conveyor. 183-ft. centres inclined. 20-h.p. motor.

(Q) Merrick weightometer.

(R) 24-in. belt conveyor.
Mill fine ore reserve bins. 900 tons capacity.

(S) 18-in. belt conveyor. 70-ft. centres. 10-h.p. motor.

(T) Bucket elevator. 135 buckets, 16 in. by 8 in. 18-h.p. motor.

(U) 24-in. inclined belt conveyor.

(V) 18-in. belt conveyor.
Mill fine ore bins, 900 tons capacity.

(W) Shaking chute feeders, 120 strokes per minute.
To ball mills. (See Fig. 2.)

FIG. 1.—FLOW-SHEET OF CRUSHING AND GRINDING SECTION, CHAFFERS TREATMENT PLANT, LAKE VIEW AND STAR.

units are combined. This arrangement will be readily understood on reference to the flow-sheet (Fig. 2).

Ball-Milling (*Primary Grinding*).—There are five ball-mills, each 6 ft. in diameter and 5 ft. long. They are of Australian manufacture and were designed to fit on the foundations of the No. 8 Krupp mills formerly employed in the dry-crushing plant. By doing this the cost of new foundations was saved, while the old mill bin, mill buildings, and other accessories were utilized. Alteration from dry to wet crushing was brought about without any loss of tonnage. The first wet mill was erected on a new foundation, the others were then replaced one at a time. Actually a gradually increasing tonnage was obtained during the change over, as the capacity of the wet mills is greater than that of the dry.

For driving the ball-mills Tex-ropes are used, these having been given the preference over reduction gears, as no flexible coupling was required as well as no lubrication of the gear box. (It is hardly necessary to mention that any contamination of the flotation circuit with lubricating oil through spillage is detrimental to flotation.) A second alternative drive would have been the use of a slow-speed motor and helical gear. This would be more expensive than the Tex-rope and would also have required the use of a flexible coupling. The only disadvantage of the Tex-ropes is the increased area of floor space required.

The mills are driven at 25 r.p.m. by 100-h.p. motors through fourteen $1\frac{1}{4}$ by $\frac{3}{4}$ in. Tex-ropes. Their design (Fig. 5) has proved very satisfactory, the shells being of mild steel plate and the ends are cast steel, while discharge is at trunnion level. Scoop feeders are fitted and are supplied with ore from the mill bin by adjustable shaking chutes. A trommel perforated with $\frac{3}{8}$-in holes is attached to the discharge trunnion, this being necessary to protect the Wilfley pump that elevates the discharge to the strakes, as otherwise the plus $\frac{3}{8}$-in. material would choke the runner. The oversize from the trommel is elevated by a small bucket elevator back to the scoop box. Mill liners are of manganese steel of the shiplap type, a set weighing 7 tons and being $4\frac{1}{2}$ in. thick at the thickest part. They will crush approximately 100,000 tons of ore before being discarded. The ball load weighs 8·5 tons, additions of new balls being 5 in. in diameter. They are of forged steel and are manufactured in Western Australia from steel scrap in an electric furnace. The consumption is 0·92 lb. per ton crushed and they cost £23 a ton delivered at the mine. The normal feed to a mill is 300 tons in 24 hours and the grading of the discharge is shown in Table I.

TABLE I.

+ 20 mesh	37%
+ 60 mesh	35%
+ 100 mesh	11%
+ 150 mesh	1%
− 150 mesh	16%

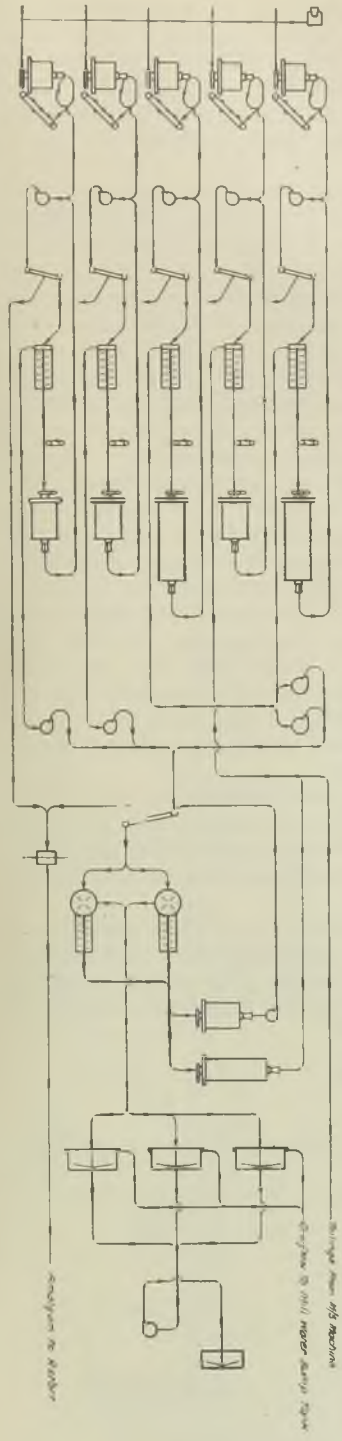
Tube-Milling (*Secondary Grinding*).—The discharge from each ball-mill is elevated by a Wilfley pump to corduroy strakes and, after passing over them, it falls into a rake classifier (6 ft. by 25 ft. and making 16 strokes per minute), which separates the sand for tube-milling. The discharge of the tube-mill goes to the Wilfley pump and is re-elevated for classification.

When the plant was designed it was laid out for the installation of long tube-mills, 5 ft. 6 in. in diameter and 22 ft. long, in which imported flint stones were to be the grinding media. After three mills of this size had been installed there was an increase in the price of flints due to exchange, while at the same time there was a decrease in the price of 2-in. steel balls of Australian manufacture, which made it more economical to use the latter. The remaining mills were therefore ordered of the same design, but only 11 ft. 6 in. long, so as to carry the same load of balls as they had previously carried of flints. The alteration has proved so beneficial, both as regards cost of grinding and tonnage, that one of the original mills has already been cut in half to adapt it for balls and the remaining two will also be reduced in length as soon as the stocks of flint stones are exhausted. Both kinds of tube-mill are similar in construction to the ball-mills and are driven in a similar way. The motors installed are of 150 h.p. and the Tex-ropes are of the same size as on the ball mills, but there are 16 of them instead of 14. Scoop feeders of 4-ft. radius are used

TABLE 2.

Grade.	*Feed.*	*Discharge.*
+ 20	20%	
+ 60	36%	14%
+ 100	29%	36%
+ 150	5%	7%
− 150	10%	43%

and the discharge grating is 30 in. in diameter. The average grade of feed and discharge are shown in Table 2, while Table 3 gives a



① Reagent solution feeder. Bucket type. Sodium Aerofloat 0·004 lb. per ton.

③ Ball mills, 6 ft. dia. by 5 ft., 25 r.p.m. 100-h.p. motor.
⑤ Trommel screens, $\frac{3}{8}$-in. dia. holes.
⑤ Oversize return elevators.

⑤ 3-in. Wilfley pumps.

Strakes, two sets of four, 6 ft. by 3 ft., per mill. Slope 1 in 8. Concentrate to amalgam barrel.

⑤ Duplex classifiers, 6 ft. by 25 ft., 16 strokes p.m. 4-h.p. motor.

⑤ Dry reagent feeders, belt type. Thiocarbanalide 0·05 lb. per ton.

④ Tube mills, 11 ft. by 5 ft. 6 in. dia., 26 r.p.m. 15 tons 2-in. steel balls. 150-h.p. motors.

② Tube mills, 22 ft. by 5 ft. 6 in. dia., 29 r.p.m. 13 tons flint. 150-h.p. motors.

② 6-in. Wilfley pumps (one operating).

② 3-in. Wilfley pumps.

③ Secondary strakes, 10 ft. by 3 ft. each. Slope 1 in 10. Concentrate to amalgam barrel.
① Amalgam barrel, amalgam to retort Fig. 4.

② Bowl classifiers, 14-ft. dia. bowl, 1 rev. in 25 sec. Rake compartment 6-ft. wide, 16 strokes p.m. Dilution 4·5 to 1.

① Tube mill, 11 ft. by 5 ft. 6 in. dia., 26 r.p.m. 15 tons 2-in. steel balls.

① 3-in Wilfley pump.
① Tube mill (spare), 20 ft. by 4 ft. 6 in. dia.

③ 50-ft. dia. thickeners.

① 4-in. Wilfley pump.

① 20-ft. dia. surge tank (flotation feed). (See Fig. 3.)

FIG. 2.—FLOW-SHEET OF CRUSHING AND GRINDING SECTION, CHAFFERS TREATMENT PLANT, LAKE VIEW AND STAR.

comparison of the two types of mill in use and shows the cost of producing a ton of minus 200 mesh material.

An interesting experiment has been made by replacing the load of flints in one of the long mills with a similar load of steel balls. Although the load only occupies a small part of the volume of the mill, it is indicated by gradings that the grinding capacity is as great as in the short mills, but the power consumption is greater.

Tertiary Grinding (Tube-Milling).—Before going to the bowl classifiers (which separate the sand for tertiary grinding) the pulp is passed over a second set of corduroy strakes. These strakes act as scavengers and are only required when ore containing an abnormal amount of free gold is being crushed. There are two bowl classifiers, each having 14-ft. bowls and 6-ft. rake compartments. About 700 tons of sand a day are separated for regrinding.

For tertiary grinding there is one tube-mill. It is similar to the short mills in the secondary circuit except that it has smooth, manganese-steel liners, 4 in. thick, the life of which has not yet been determined. The pulp entering the tertiary circuit contains 20% of plus 200 material and this is reduced to 5%.

Pulp elevation throughout the entire plant is done by Wilfley pumps. They are usually driven by Tex-ropes on account of the greater speed range and better protection of the motors than can be obtained when they are direct coupled.

Corduroy Strakes.—In the secondary grinding circuit there are four corduroy strakes to each tube-mill. They are 6 ft. long and 3 ft. wide and have a fall of 1 in 8. (This fall is required to prevent banking up of the pulp, which contains a lot of coarse material.) In the tertiary circuit there are ten strakes, each 10 ft. long and 3 ft. wide, with a fall of 1 in 10, the lesser fall being possible as the pulp contains no coarse material.

The tables on which the cloth is spread are made of "Fibrolite," $\frac{3}{4}$ in. thick. "Fibrolite" is a building-board made in Western Australia from cement and asbestos and it is fastened down with countersunk wood screws and has the advantage over timber that it does not wear or warp.

Every eight hours the strake cloths are removed and washed by hand, about 600 lb. of concentrate being recovered from the washings in twenty-four hours. This is transferred to an amalgam barrel and rolled for three hours with mercury, the barrel being cleaned up in the usual manner. After the separation of amalgam the ground concentrate, being still high in value, is pumped to the concentrate flotation thickener and ultimately reaches the roasters and cyanide plant. When worn out the strake cloths are burnt and the ashes added to the cyanide clean-up. Six months' wear is usually obtained from the cloths before discarding them.

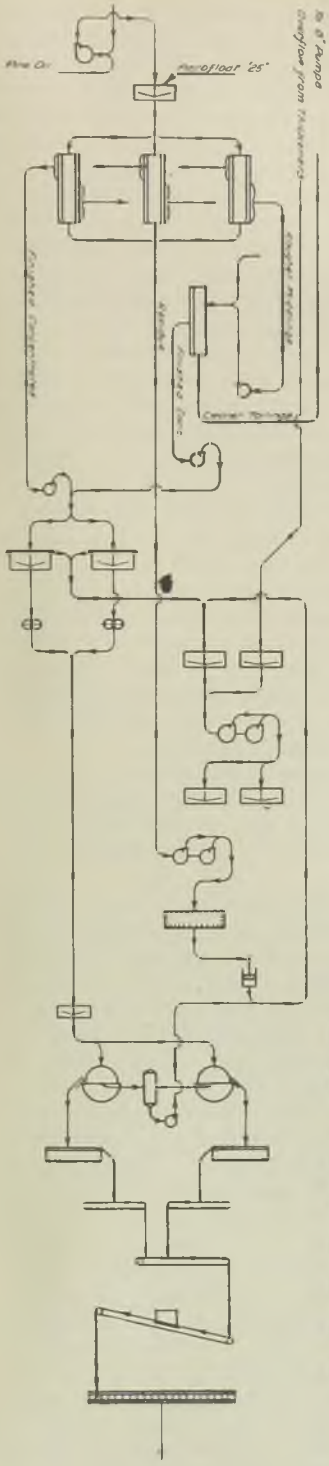
The strake plant accounts for 24% of the amount of gold recovered, but it varies considerably from day to day with the nature of the ore, at times as much as 35% having been obtained.

Concentration Plant.—In addition to the flotation machines the concentration department contains the usual accessory machinery, including thickeners, filters, and driers (Fig. 3).

Table 3.

		Long Mill.	*Short Mill.*
Size of Mill		5 ft. 6 in. by 22 ft.	5 ft. 6 in. by 11 ft. 6 in.
Type of Lining		Wave Type	El Oro
Material of Lining		Hard Iron	Manganese Steel
Life of Lining		8 months	Over 12 months
Grinding Media		Danish Flints	2-in. Steel Balls
Grinding Media, tons		13	13
Per Cent. Moisture in Feed		32	32
Tonnage Fed to Mill, per day		662	810
Tons — 200 mesh produced		159	209
Power Consumed		162 h.p.	175 h.p.
Per ton — 200-mesh	lb. grinding media consumed	6·87	1·28
	Cost of grinding media, pence	6·04	3·99
	Cost of power, pence [1]	12·80	10·50
	Cost of power and grinding media, pence	18·84	14·49

[1] Power has been taken at 0·7d. per unit. The life of the liners in the short mills has not yet been determined and has not been taken into account in the comparative cost.



No. 5 Pine oil to pump, 0·04 lb. per ton. Aerofloat " 25," 0·003 lb. per ton to tank.

③ Denver Sub-A Fahrenwald flotation machines (rougher), 24-in. impeller, 290 r.p.m. Ten cells, five 16-h.p. motors. Feed density, 30% solids.

Addition of sodium silicate, 0·15 lb. per ton.

① Mineral Separation flotation machine (cleaner), 24-in. impeller, 275 r.p.m. Ten cells, five 10-h.p. motors.

① 3-in. Wilfley pump.

① 3-in. Wilfley pump.
① 2-in. Wilfley pump.

② Concentrate thickeners, 27 ft. dia. (one operating).

② Diaphragm pumps (one operating).

② Mill water sump tanks (22 ft. dia. by 8 ft.).

② 6-in. centrifugal water pumps (one operating).

② Mill water head tanks (22 ft. dia. by 8 ft.).

② 4-in. Wilfley pumps (one operating).

Tailings dam.

① Plunger pump (three throw). Return water from dam.

① Concentrate surge tank.

② Oliver filters, 8 ft. dia. by 5 ft. 6 in. Moisture 12% (one operating) with vacuum receiver and extraction pump.

② Mechanical hearth dryers. Moisture 7% (one operating). 10-h.p. motor, 4 strokes per min.
② 14-in. conveyor belts (one operating).

① 14-in. conveyor belt.

① 14-in. inclined conveyor belt.

① Merrick weightometer (raw concentrate).

① Overhead push conveyor, 24 in. wide (20 strokes per minute).

Feed to three roasters. (See Fig. 4.)

FIG. 3.—FLOW-SHEET OF CONCENTRATION SECTION, CHAFFERS TREATMENT PLANT, LAKE VIEW AND STAR.

Thickening.—There are three thickener vats, each 50 by 8 ft., which are used to thicken the flotation feed to 30% of solids, the overflow going to the mill tanks. A useful feature of the mill tanks is the fitting of agitation gear, which is used for the occasional removal of accumulated silt, stoppage for cleaning out by hand being thus avoided.

Flotation.—The object desired in the plant here described is somewhat different from that required in base-metal flotation. In the latter a clean concentrate is required and it is frequently necessary to depress some minerals, either all together or until a later stage of the process, an end brought about by careful control of the addition of reagents and of conditioning. At Lake View the main objective is to float all the mineral, the grade of the concentrate being not very important as it is treated on the spot by a comparatively cheap process. For these reasons all the conditioning reagents are added to the mills so as to get the benefit of them as early as possible—*i.e.*, there is no danger of over-conditioning.

The flow-sheet of the plant is a very simple one, consisting as it does of two stages only—roughing and cleaning. Roughing is done by three Fahrenwald Sub-A machines No. 24. Each machine has eight cells and will take a feed of 500 tons a day. Two grades of concentrate are made in this machine, the first cell and sometimes the second being taken as finished concentrate and going direct to the cyanide plant, the remaining six cells going to the cleaner. The tailing is pumped to the tailings area.

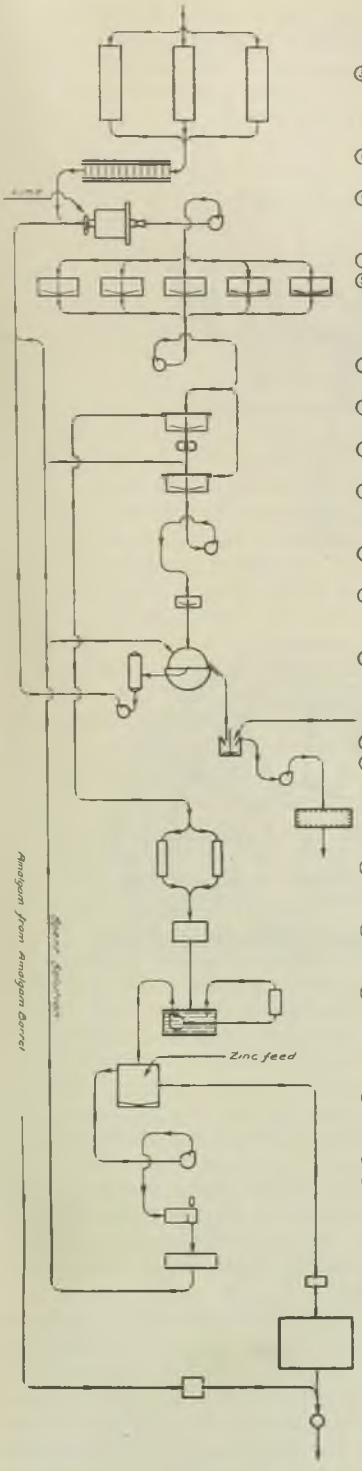
For cleaning there is a Minerals Separation 24-in. machine. All of the concentrate which it produces goes to the cyanide plant and the cleaner tail is returned to the bowl classifiers. No accumulation of mineral takes place in the tertiary grinding circuit, although the cleaner tail is constantly returned to it. The value of cleaner tail seldom exceeds 8s.

As the quantity of pyrite in the ore seldom exceeds 5% the amount of froth in the rougher is small in bulk and fragile. At the start difficulty was experienced in separating it when using a standard Fahrenwald machine. This has now been overcome by crowding the froth to the centre by means of a conical crowding hood. The hood (Fig. 6) consists of a conical shell of galvanized iron, 4 ft. square at the base and fitting tightly inside the cell. At the top there is a circular opening (2 ft. in diameter) for the escape of the froth, while just beneath this opening a galvanized-iron apron is attached for draining the froth to either side of the machine. The grids provided with the standard machine are dispensed with, as are the froth paddles. The function of the cone is to increase the depth of froth and thus strengthen it, while the froth is removed more quickly, so that there is less chance of a particle of mineral sinking back once it has risen to the surface. The crowding of the machines has both increased the capacity of them and made control easier.

A recent test made in the rougher machine showed that 45% of the gold value was saved in the first cell, the second cell saving 20%, the remaining six cells 16%, and the residue containing 9%. The last cell accounted for only 1·3% in the form of a concentrate worth only 12s. per ton. At the present time two extra cells are being added to each of the roughers and it is expected that after allowance has been made for loss in cleaning the flotation recovery will be increased by from 1% to 2%. Operation of the cleaner machine is also assisted by the use of hoods, where they are of use in producing a clean concentrate.

The bulked value of concentrate sent to the cyanide plant varies between three and four hundred shillings per ton and amounts to between 6% and 7% of the weight of ore milled.

Flotation Reagents.—A large variety of flotation reagents have been experimented with, those in use at the present time being shown in Table 4. This list is of interest both on account of the small quantities of reagents used and also the absence of xanthates. It has been found that the froths produced with xanthates are too dry to handle easily, thiocarbanalide being an equally-good conditioning reagent that produces a froth no tougher. Thiocarbanalide could be equally well used in the ball-mills, except that the passage through the mill is too rapid for it to dissolve, a soluble reagent being therefore preferable. There is no conditioning, except that which takes place in the grinding circuits. Sodium silicate in the form of a 50% solution is used as a gangue depressing agent at the feed to the cleaner machine and this makes the pumping of the concentrate very much easier by reducing the bulk. The total cost for all reagents is about two pence per ton in Australian currency.



③ Duplex roasters, 52 rabbles each.

① Push conveyor, 4 ft. wide, 20 strokes per min.

① Calcine mill, 4 ft. dia. by 4 ft., with scoop feeder. 25½ revs. per min. Addition of lime to mill.

① 2-in Wilfley pump.

⑤ Agitators, 26 ft. dia. by 8 ft. 6 in. 18 hours, 0·15% KCN.

① 2-in Wilfley pump.

① First decanter, 25 ft. dia. by 8 ft.

① Diaphragm pump.

① Second decanter, 25 ft. dia. by 8 ft.

① 2-in. Wilfley pump.

① Surge tank, 13 ft. dia. by 6 ft.

① Oliver filter, 14 ft. dia. by 11 ft. 6 in., with vacuum receiver and extraction pump.

Salt water from mine.

① Vortex mixer.

① 2-in. Wilfley pump.

Residue dam (water to waste).

② Dehne filter presses for clarifying gold-bearing solutions, 40-in. frames.

① Gold solution storage tank, 20 ft. dia. by 6 ft.

① Crowe vacuum tank and submerged 3-in. centrifugal pump.

① Merrill precipitation tank.

① 3-in. centrifugal pump.

① Lea " v "-notch solution recorder, 1,000 tons per day.

① Spent solution tank.

① Clean-up press.

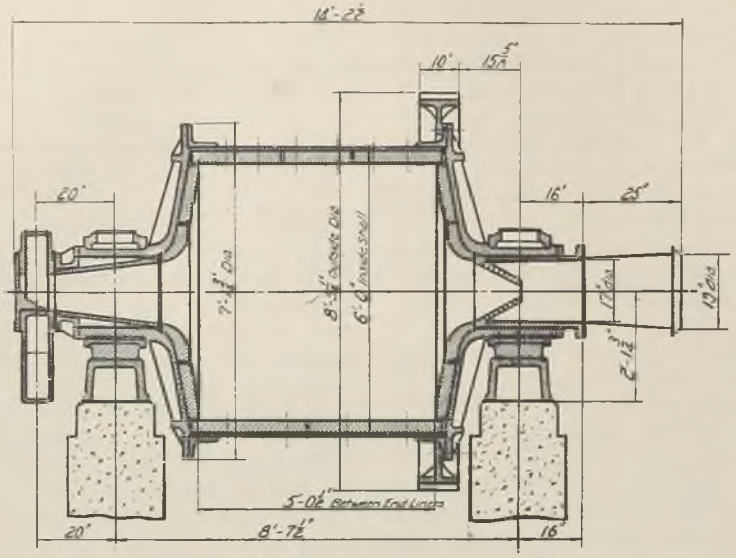
Calcining and smelting furnaces.

Amalgam retort.

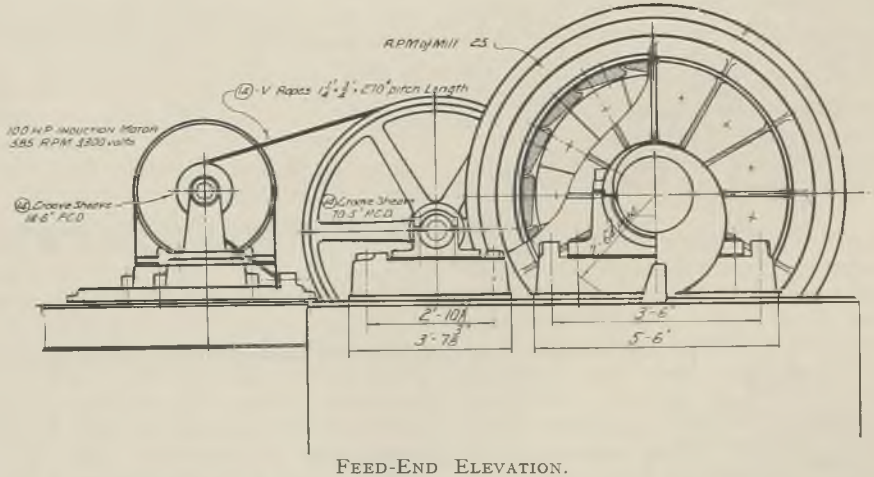
① Bullion furnace, No. 60 crucible.

Gold Bullion.

FIG. 4.—FLOW-SHEET OF ROASTING AND CYANIDING SECTION, CHAFFERS TREATMENT PLANT, LAKE VIEW AND STAR.



Section on Centre Line.



Feed-End Elevation.

Fig. 5.—Wet Ball-Mill (6 ft. diam. by 5 ft.), Chaffers Treatment Plant, Lake View and Star.

Filtering and Drying.—The finished concentrate is pumped to an elevated thickener vat, 20 by 8 ft., and the underflow is lifted by a diaphragm pump to a concentrate storage vat fitted with agitation gear. This vat is the only storage for concentrate in the plant, as it is found more convenient to store the concentrate in the form of pulp than to store the dry concentrate in a bin, the latter packing badly and being very difficult to feed.

Table 4.

Reagent.	*Where Used.*	*lb. per ton.*
Sodium Aerofloat	Ball-Mills	0·04
Thiocarbanalide	Tube-Mills	0·05
Aerofloat 25	Flotation Surge Tank	0·005
Pine Oil No. 5	Thickener Underflow.	0·04
Sodium Silicate	Cleaner Feed	0·15

There are two Oliver filters, 5 ft. 6 in. in diameter with 8-ft. face, for filtering concentrate, although one only is usually in use. The concentrate filters readily and a duty of 1,500 lb. per sq. ft. of filter surface per 24 hours is obtained. For this capacity the cake is about ¾ in. thick. The filters discharge their cake to two hearth driers of

the mechanical rake type, the hearth area of each being 480 sq. ft. About 40 tons of Salmon Gum firewood is used in a month, this wood having a calorific value of 5,000 B.Th.U. per lb. The moisture is reduced from 12% to 7%. Further drying is not desirable, as it causes dusting in the roasters.

Roasting and Cyanidation.—The concentrate is elevated to the roasters by an inclined belt, which passes over a Merrick weightometer that enables a reliable record to be kept of the tonnage and gold entering the cyanide plant. Roasting (Fig. 4) is done by three Duplex Edwards furnaces having 52 rabbles each. The furnaces were originally erected for the roasting of ore, but they give satisfactory results with concentrate, the capacity of the latter being 30 tons per day each. The fireboxes on the roasters have been retained, but are only used when starting up to bring the furnaces to roasting temperature. The concentrate contains 35% of sulphur and once that is well alight it will continue roasting without the use of external fuel. So easily does the concentrate burn that it is possible to close down a furnace for 24 hours and then bring it back to roasting temperature without the use of firewood. Rabbles and tynes are of cast iron and water cooling is not required.

When the change was made from the roasting of ore to the roasting of concentrate it was found that the flues and chimney originally installed were not large enough to draw off the larger volume of gas produced. Extra capacity was obtained by installing an auxiliary flue part of the way down the furnaces. By this means the velocity of the gas at the feed end is reduced and dusting is prevented without reducing the capacity of the furnace. The auxiliary flue, which is of steel, is connected to the crown of the furnace at the 13th rabble from the feed end, the gases from it going to a separate chimney.

The successful roasting of the concentrate for cyanidation depends on slow oxidation with ample admission of air. Normally the furnaces are operated with all the inspection doors open except about six at the feed end. Under normal working conditions the sulphur is well alight by the 8th rabble from the feed end, the highest temperature being attained at the 14th rabble, where the blue flame ceases. From there on cooling of the charge starts and all visible redness has ceased at the 4th rabble from the discharge end.

Cyanidation.—There are no serious

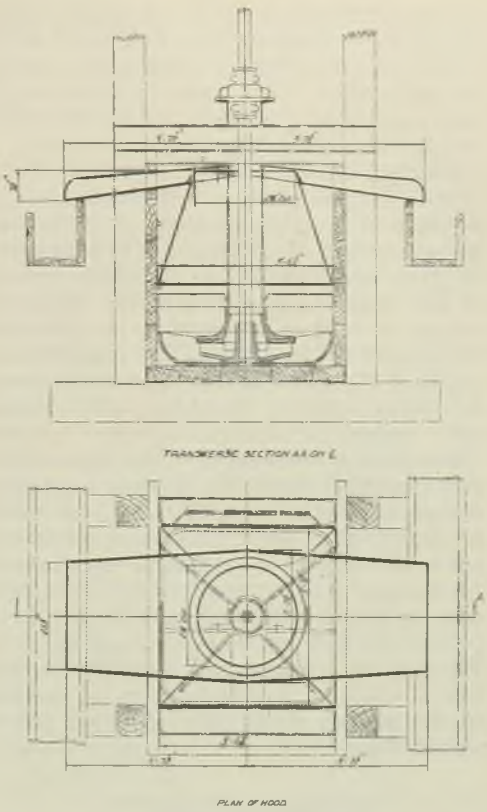


Fig. 6.—Froth-Crowding Hood for Flotation Machine, Lake View and Star.

difficulties in the cyaniding of the concentrate, but suitable plant (Fig. 4) is required to deal with material of such high value, especially with regard to dissolved gold losses.

After being cooled slightly on a push conveyor the concentrate is mixed with spent solution by feeding it to the scoop of a small ball-mill, lime also being added at this point. The cyanide pulp is made up to two parts of solution to one of concentrate and is pumped to five agitators 26 ft. in diameter by 8 ft. 6 in. deep. Agitation is effected both by power-driven paddles and by compressed air, the "charge" system being used in preference to "continuous" agitation, as it enables poor roasts to be isolated and given preferential treatment, the time of agitation being 18 hours.

Separation of the gold solution from the cyanide residue is effected by decantation, followed by filtration. There are two thickeners 20 by 8 ft., which are operated counter-currently. The discharge from the

second thickener goes to an Oliver filter 11 ft. 6 in. in diameter by 14 ft. long, where it receives a final wash of both spent solution and fresh water. The roasted concentrate is very porous and the filter is not in continuous use, as it has excess capacity.

PRECIPITATION AND SMELTING.—Gold solution for precipitation is obtained from the overflow of the first decanter; it is clarified in two Dehne filter presses. Precipitation is by the Merrill-Crowe process. This consists of two stages—extraction of the dissolved oxygen by vacuum, followed by precipitation of the gold by zinc dust. The precipitation vat is of the vacuum leaf type, there being 24 leaves, each 6 by 4 ft., with double calico covers.

Zinc dust is obtained from the Electrolytic Zinc company's works at Risden, Tasmania. It is manufactured from electrolytic zinc and is coarser than imported "blue powder," but it will all pass through a 325 mesh sieve. An analysis of it, as compared with dust from other sources, is shown in Table 5. As a precipitant it is just as effective as the finer brands, the consumption being 0·1 lb. per ton of solution. Lead nitrate equal to 10% of the weight of the zinc is added before clarification.

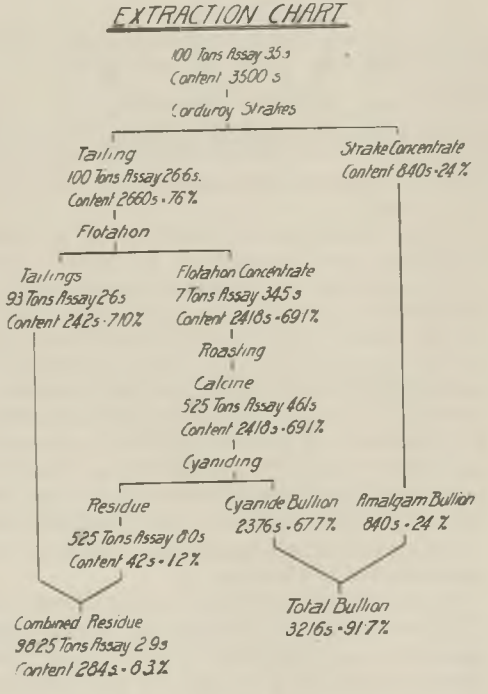


FIG. 7.

TABLE 5.

Origin.	Metallic Zinc.	Lead.	Cadmium.
	%	%	%
Electrolytic Zinc, Tasmania . .	98·3	0·021	0·009
Continental Blue Powder . . .	92·1	2·100	1·690
American Blue Powder	93·9	0·085	0·171

The cyanide plant clean-up is made twice a month, when the precipitate is sluiced out of the Merrill tank and filter pressed. No acid treatment is given and the precipitate passes direct to cast-iron muffles, where it is roasted. An additional life has been given to the muffles by fitting them with renewable, chrome-steel bottoms containing 27% of chromium.

The roasted precipitate is fluxed with borax and sand and is smelted in tilting bottle retorts, of which there are two. Oil is used for melting and each furnace is fitted with one high-pressure burner, placed in front, underneath the retort, hose connexions for air and oil allowing it to be removed during pouring. For the production of 14,000 oz. of bullion a month 130 gallons of fuel oil are used, oil being considerably cheaper and cleaner than the coke which was previously used. The average life of the retorts is twenty-five pours and they contain 120 lb. of calcined precipitate to a charge, the average time for melting a charge being two hours. The precipitate yields 70% by weight of bullion. No refining is done at the mine, as the bullion is 760 parts fine.

EXTRACTION AND COSTS.—The extraction obtained at different stages of the process is shown in Fig. 7, which deals with the treatment of 100 tons of ore of an assay value of 35s. The present cost of treatment in Australian currency is 6s. 4d. per ton, this including the cost of operating a small portion of the dry-crushing plant, which is still in use for the treatment of clean-up material from the old mill sites. When the treatment of this is completed the cost will be reduced to under 6s. per ton. This cost compares with 16s. a ton, which obtained when 15,000 tons of ore a month were treated in the dry-crushing plant. In comparing the cost of treatment with those obtaining in other places the very high cost for water should not be forgotten. Water costs 5s. 1d. per 1,000 gallons and the cost per ton treated is 1s. 4d. Power costs 0·68d. per unit and the total consumption of power is 27 units per ton milled.

SULPHUR IN CHILE

By S. V. GRIFFITH, A.I.M.M.

(*Concluded from the September issue, p. 144.*)

Data Concerning Companies, Production, Costs, etc.

(*a*) *Tacora and Chupiquiña Sulphur Region.*

General.—The sulphur deposits of this region are located in Mount Tacora, 6,200 m. above sea-level, and Mount Chupiquiña, 5,712 m. above sea-level. These two mountains are connected by a low saddle-back, some 10 to 15 Km. west of the Arica-La Paz Railway and some 173 Km. from Arica, on the coast. Previously, three companies operated these deposits: (*a*) Messrs. Canessa, Laneri, and Co., who owned sulphur claims on the north-western slopes and in the crater of Mount Tacora and had their refining establishment located at Ancara; (*b*) Messrs. Espada and Donoso, who owned claims on the western slopes and in the crater of Mount Tacora, with their refining plant situated at Villa Industrial; and (*c*) Messrs. Muecke-Gildemiester, who owned the Chupiquiña deposit and had their refining plant situated at Chislluma. (Figs. 9, 10, and 11.) However, to enable them to control the market and to keep up prices, these three firms formed a "ring" and agreed that only two companies should operate, the third being paid a yearly subsidy to discontinue operations. After this system had been in force a short time the Muecke-Gildemiester group sold their property to Messrs. Canessa, Laneri, and Co. and up to the end of 1930 the sulphur region of Tacora and Chupiquiña, the most important in Chile, was controlled by the two firms of Canessa, Laneri, and Co. and Espada and Donoso. During the latter part of 1930 these two firms sold their interests to a national company with British capital, called the Compañia Azufrera y Minera del Pacifico, S.A. The operations of each firm are now described separately.

(*a*) *Messrs. Canessa, Laneri, and Co.*

Mining Operations.—Mining methods were those described earlier in this article, with an average output of "caliche" of some 500 tons per month. On Mount Chupiquiña the "caliche" was mined from the sides and back of a small adit, which had been driven into the hillside. A very small output averaging about 50 tons per month was obtained from this source.

Transport.—On Mount Tacora the sorted "caliche" was filled into sacks, holding approximately 46 Kg. each, and was transported to the refining plant at Ancara by "llamas." This method of transport was very expensive, as the cost per ton of "caliche" transported was $45·00 Ch. or 22s. 6d.

On Mount Chupiquiña the "caliche" was trammed to the loading station of a Pohlig aerial ropeway, gravity operated, installed during the Muecke-Gildemiester régime. This ropeway was 4½ Km. long, having a capacity of 10 tons per hour, and connected the deposit with road-head at Calzon Chata. From Calzon Chata the "caliche" was transported to Ancara by "llamas." Transport costs were:

By ropeway, $6·50 Ch. or 3s. 3d. per ton of 1,000 Kg.

By "llamas," $21·00 Ch. or 10s. 6d. per ton.

The total cost of transport, therefore, from Mount Chupiquiña to Ancara was $27·50 Ch. or 13s. 9d. per ton.

No "caliche" was transported to the refining plant at Chislluma, as this plant was more or less abandoned during the régime of Canessa, Laneri, and Co., although a certain amount of sulphur-clinker, averaging 50 to 55% S, was treated there for the production of "sublimed" sulphur in an old retorting battery.

Refining.—The system used is that earlier described as method (1*a*) for the production

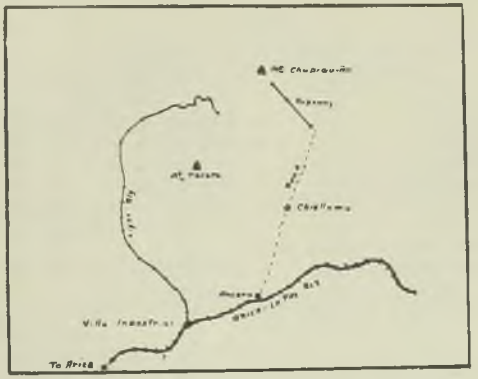


Fig. 9.—Sketch Showing the Tacora-Chupiquiña Region.

of lump sulphur only. The battery consisted of 10 retorts, treating some 500 tons (of 1,000 Kg.) of "caliche" per month for a production of 300 tons of refined or lump sulphur. Consumption of "yareta" was one ton per ton of sulphur produced.

Crushing and Ventilating.—The greater portion of the sulphur produced was crushed and ventilated in a "Guseo" installation. The monthly production was approximately 100 tons of fine-ground or "molido" sulphur and 100 tons of ventilated or "ventilado" sulphur. This plant was run by a "Sulzer" heavy-oil engine, two-impulse type, of 60 h.p., consuming 1,500 Kl. of oil per month, costing $207·50 Ch. or £5 3s. 9d. per ton.

Costs.—The average monthly costs are shown in Table 5.

TABLE 5.

Lump Sulphur or "Granulado."

Operations.	*Per Ton Sulphur Produced.*
Mining . . .	$58·00 Ch. or £1 9s. 0d.
Transport . . .	$86·50 Ch. or £2 3s. 3d.
Refining . . .	$43·00 Ch. or £1 1s. 6d.
Administration, etc. .	$34·00 Ch. or 17s. 0d.
Sacking, costs of sacks, etc.	$44·50 Ch. or £1 2s. 3d.
Total cost at plant, per ton, sacked . .	$266·00 Ch. or £6 13s. 0d.

Fine-Ground or "Molido" and Ventilated or "Ventilado" Sulphur.

To the above cost must be added the cost of crushing, administration, handling charges, freight, etc., to arrive at the cost per ton of the fine products. This cost equals $80 Ch. or £2 per ton, making the total cost at plant, per ton, sacked $346 00 Ch. or £8 13s. 0d.

(*b*) *Messrs. Espada and Donoso.*

Mining Operations.—Similar methods of mining were employed by this firm, the output being approximately 950 tons of low-grade "caliche" of 40% S per month.

Transport.—The workings on the lower slopes of Mount Tacora, where mining operations were in force, were connected with the refining plant at Villa Industrial by means of a light railway, 27 Km. long, of 0·75 m. gauge and having a 3% grade. The mined "caliche" was trammed to bins, which discharged directly into the railway wagons, each of which was capable of holding six tons, and then railed to the refining plant. A train usually consisted of an engine and six wagons and as only one trip per day could be made, owing to the stiff gradient and the large number of sharp curves in the line, the maximum amount of "caliche" railed daily was 36 tons. The fuel used was "yareta," 45 tons per month being consumed.

FIG. 10.—VILLA INDUSTRIAL, WITH MOUNT TACORA IN THE BACKGROUND.

Rolling stock consisted of two 125-h.p. steam locomotives and twelve 6-ton wagons, all of German manufacture.

Refining.—At this plant both methods (1*a*) and (1*b*) were used for the production of both lump and sublimed sulphur. The battery consisted of 28 retorts, four of which were utilized for lump sulphur and 24 for sublimed sulphur, treating 950 tons of "caliche" per month for a production of 300 tons of

refined sulphur (50% lump and 50% sublimed). "Yareta" consumption was three tons per ton of refined sulphur.

The condensing chambers were cleaned out once every seven to ten days, the sublimed sulphur resulting from the clean-up being first screened in an ordinary impact screen—80 mesh—and then filled into sacks of 69 Kg. capacity ready for shipment. Part of the lump sulphur produced at this plant was crushed in an ordinary Chilean mill for the production of fine-ground or "molido" sulphur, which averaged about 70 tons per month.

Costs.—The average monthly costs are shown in Table 6.

TABLE 6.

Lump Sulphur or "Granulado."

Operations.	*Per Ton Sulphur Produced.*	
Mining	$9·00 Ch. or	4s. 6d.
Transport	$16·50 Ch. or	8s. 3d.
Refining	$97·00 Ch. or £2	8s. 6d.
Administration, etc.	$25 50 Ch. or	12s. 9d.
Sacking, cost of sacks, etc.	$46·00 Ch. or £1	3s. 0d.
Total cost at plant, per ton, sacked	$194 00 Ch. or £4	17s. 0d.

Fine-ground or "Molido."—

To obtain the cost per ton of this product, crushing charges must be added to the above. These amount to $30 Ch. or 15s., which gives the cost at plant per ton sacked as $224·00 Ch. or £5 12s. 0d.

Sublimed or "Sublimado."

The cost of screening, which amounts to $42 Ch. or 21s. per ton, added to the cost per ton of lump sulphur gives the cost per ton of this product. This equals, at plant, per ton, sacked $236·00 Ch. or £5 18s. 0d.

Shipments.—The sulphur shipments for the year 1929 (up to and including the month of November only) from the port of Arica made by the firms of Canessa, Laneri, and Co. and Espada and Donoso are shown in Table 7.

FIG. 11.—CHISLLUMA.

(*b*) *Irruputunco Sulphur Region.*

GENERAL.—The Irruputunco sulphur deposit is located in Mount Irruputunco (5,168 m. above sea-level), on the Chilean–Bolivian border in the Tarapaca Province, some 27 Km. north of Ujina, a station on the Collahuasi branch of the Antofagasta-Bolivia railway and distant some 512 Km. from the port of Antofagasta on the coast. Ujina was the nearest and most convenient station for the deposit, with which it was connected by means of a fairly good motor road. This deposit is owned and operated by a syndicate composed of English business and mining men, but it was not sufficiently developed at the time of examination to call for much attention.

Mining Operations.—Some attempt had been made to work this deposit systematically by "benches," but owing to lack of continual and proper supervision this had been abandoned and the usual methods of mining, already described, were employed. It was

TABLE 7.

Class.	*Source.*	*Tonnage to Pampa Ports.*	*Tonnage to South.*	*Total.*
Fine-ground ("Molido")	Espada and Donoso	722	197	919
	Canessa and Laneri	961	20	981
		1,683	217	1,900
Lump Sulphur ("Granulado")	Espada and Donoso	719	118	837
	Canessa and Laneri	868	348	1,216
		1,587	466	2,053
Sublimed ("Sublimado") / Ventilated ("Ventilado")	Espada and Donoso	705	890	1,595
	Canessa and Laneri	90	1,462	1,552
		795	2,352	3,147
Grand Total		4,065	3,035	7,100

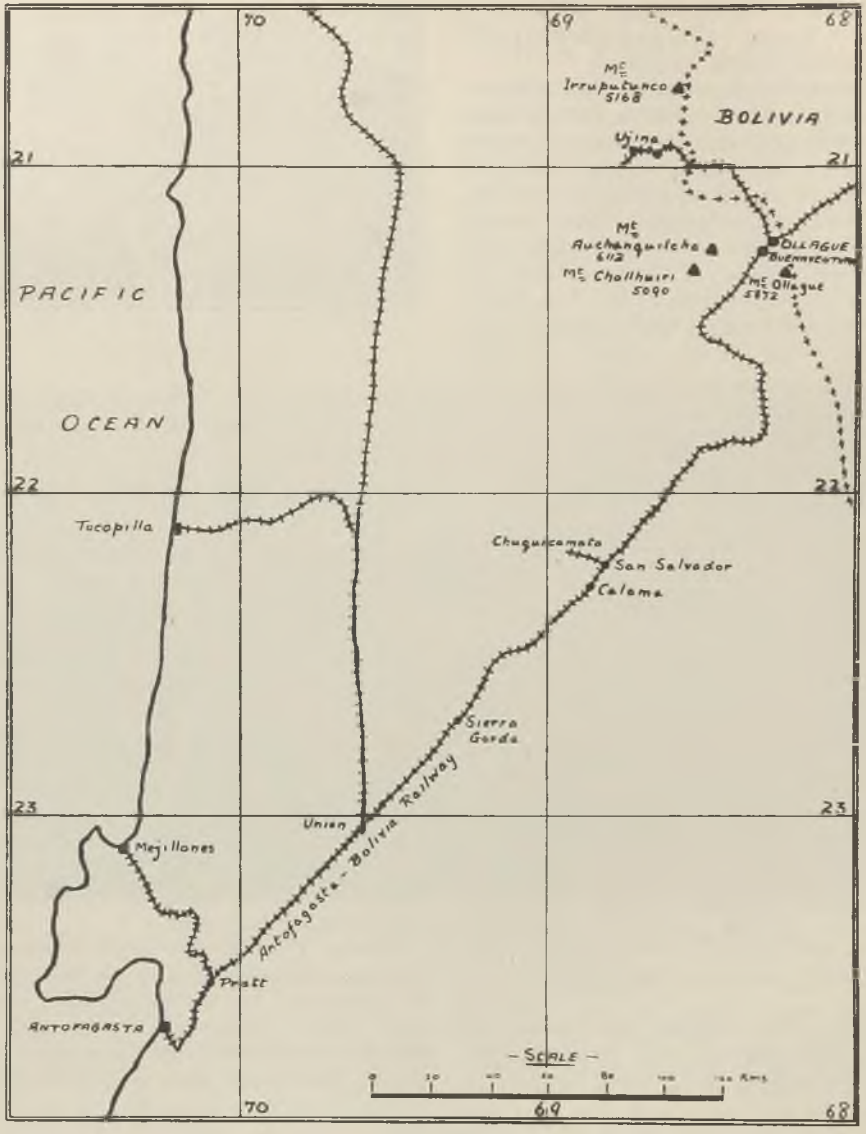


FIG. 12.—SKETCH MAP, SHOWING LOCATION OF THE IRRUPUTUNCO, OLLAGUE, AND AUCHANQUILCHA DEPOSITS.

worked spasmodically and at the time of examination 50 tons of "caliche" per month was being mined.

Transport.—The transport of the mined "caliche" from the workings to the refining plant—situated at the foot of the mountain—was by "llamas" and cost from $15·20 Ch. to $28·25 Ch. (7s. 7d. to 14s. 1½d.) per ton of 1,000 Kg., according to the situation of the workings from which the "caliche" was obtained.

Refining.—The "caliche" was refined in the usual form of retort for the production of sublimed sulphur, the battery consisting of three retorts. Production averaged about 25 tons per month, fuel consumption being one ton per ton of refined sulphur. Besides the refined sulphur obtained from retorting operations, a certain amount of sulphur was also obtained from the crater of Mount Irruputunco, where the sulphur is still in a molten condition. The owners hit upon

Fig. 13.—Crater of Mount Irruputunco, showing Condensing Chamber in Foreground.

a novel scheme for trapping part of the sulphur fumes given off by the molten sulphur for conversion into refined sulphur. A large condensing chamber, having a tall chimney at one end to supply the necessary draught, was built on the lip of the crater, with a flue 1 m. by 0·60 m. leading down into the crater, whence sulphur fumes were drawn into the condensing chamber and deposited as sublimed or "sublimado" sulphur. (Fig. 13.) This scheme has not been entirely successful, owing to the fact that the flue was continually being choked up by sulphur cooling and solidifying at the upper end.

Costs.—No details of costs are given, as owing to the intermittent nature of the operations these would have no real value. However, it was stated that sacked sulphur could be placed in Antofagasta at a cost of $265·00 Ch. or £6 12s. 6d. per ton.

(c) *Ollague and Auchanquilcha Sulphur Region.*

General.—The sulphur deposits of this region are located on the slopes surrounding the summits of Mount Ollague (5,872 m. above sea-level), Mount Auchanquilcha (6,112 m. above sea-level), and Mount Challhuiri (5,090 m. above sea-level), all in the neighbourhood of Ollague village, a station on the Antofagasta-Bolivia railway, having an elevation itself of 3,696 m. above sea-level and distant 442 Km. from Antofagasta. (Fig. 12.)

Mount Ollague, situated on the Chilean–Bolivian border, is 11 Km. S.E. of Ollague station, whereas Mounts Auchanquilcha and Challhuiri are 27 and 31 Km. west of Ollague station respectively. These deposits are owned and operated by Señor Juan B. Carrasco, who has his refining establishment located at Ollague village.

Mining Operations.—The same methods of mining were employed by this firm as those already described, the approximate monthly output of "caliche" being 500 tons (of 1,000 Kg.). Mining was by contract, the prices paid being as follows:—

Mount Challhuiri.—$6·00 Ch. or 3s. per ton, stacked at the working place.

Mount Auchanquilcha.—$30·00 Ch. or 15s. per ton, delivered to discharge terminal of ropeway.

Mount Ollague.—$30·00 Ch. or 15s. per ton, delivered to discharge terminal of lower ropeway.

Transport.—The mined "caliche" from the Challhuiri deposit was transported to the refining plant by lorry on contract, as a good road connected the two, the price paid being $25 Ch. or 12s. 6d. per ton.

From Mount Auchanquilcha the "caliche" was first lowered to road-head by means of a locally-constructed gravity ropeway, 2,500 m. long and having a capacity of five tons per hour. From road-head to the establishment transport was by lorry, the contract price being $20 Ch. or 10s. per ton.

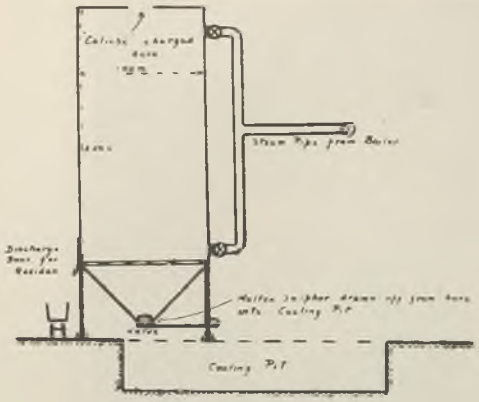


FIG. 14.—AUTOCLAVE.

TABLE 8.

Lump Sulphur or "Granulado."

Operations.	*Per Ton Sulphur Produced.*
Mining	$44·00 Ch. or £1 2s. 0d.
Transport	$38·00 Ch. or 19s. 0d.
Refining	$55·50 Ch. or £1 7s. 9d.
Administration, etc.	$48·50 Ch. or £1 4s. 3d.
Sacking, cost of sacks, etc.	$44·50 Ch. or £1 2s. 3d.
Total cost at Plant, per ton, sacked	$230·50 Ch. or £5 15s. 3d.

Ventilated or "Ventilado" Sulphur.

To the above cost must be added the cost of crushing, administration, handling charges, etc., to arrive at the cost per ton of the Ventilated product. This cost equals $28·00 Ch. or 14s. per ton, making the total cost at plant, per ton, sacked $258·50 Ch. or £6 9s. 3d.

On Mount Ollague there were two ropeways (locally made), 2,200 and 2,600 m. long respectively, each having a capacity of five tons per hour, which lowered the "caliche" to road-head. From this point lorry transport was used, the contract price being $20 Ch. or 10s. per ton.

Refining.—Previously the "retort" system of refining was employed, but this was eventually abandoned in favour of the steam refining system, which may be described as follows:—Steam at 60 lb. per sq. in. and having a temperature of 130° C. was brought into contact with the "caliche" in an "autoclave" or closed pressure vessel, patented by Señor J. B. Carrasco. (Fig. 14.) The steam penetrated the "caliche" from above and below and continued to heat it for an hour. A valve at the bottom was then opened and the molten sulphur allowed to run out into cooling tanks, each capable of holding eight tons, where it cooled and solidified. When all the molten sulphur had run out pressure was reduced to 5 lb. per sq. in. and the residue—consisting of ash, impurities, sulphur, etc.—was discharged through a side door and trammed to a dump, where it is being stacked for future treatment, as this residue contained 48% S. A new charge of "caliche" is then dropped into the "autoclave," the pressure raised to 60 lb. per sq. in., and the cycle of operations repeated. Steam for the "autoclave" system was generated in a 75-h.p. Cornish-type boiler, the fuel used being "yareta," of which one ton was used per five tons of refined sulphur produced. Three "autoclaves" were in operation, treating 1½ ton of "caliche" each per hour for a production of ½ ton refined sulphur each per hour.

The refined sulphur produced by this process was lump or "granulado," part of which was sold for black powder manufacture and part further treated for the production of ventilated or "ventilado" sulphur.

Crushing.—The lump sulphur from the cooling pits of the "autoclaves" was dug

TABLE 9.

	Tacora.	*Irruputunco.*	*Ollague.*
Mine Foremen	£10 to £13 10s. p.m.	£25 p.m.	£12 10s. p.m.
Mechanics	£15 p.m.	——	£25 p.m.
Miners	3s. 6d. to 3s. 9d. per day	5s. per day	8s. per day; also Contract
Refiners	4s. 6d. per day	7s. 6d. per day	16s. per day
Peones	3s. 6d. per day	5s. per day	5s. 6d. per day

The prices of the primary mining supplies also varied considerably in the different districts as follows:—

	Tacora.	*Irruputunco.*	*Oliague.*
Picks	£2 to £3 per dozen	£2 10s. per dozen	£1 10s. per dozen
Shovels	£2 10s. per dozen	£3 10s. per dozen	£2 2s. per dozen
Drill Steel	£50 to £87 10s. per ton	£40 per ton	£27 10s. per ton

out and transported by wheelbarrow to a "Guseo" installation for the production of ventilated sulphur, the average production being 120 tons per month.

The whole plant was run by a 50-h.p. crude-oil Diesel engine, consuming about 1,500 Kl. of oil per month.

Costs.—The average monthly costs are shown in Table 8.

Shipments, Selling Prices, etc.—The greater part of the sulphur produced by Señor J. B. Carrasco was sold locally. Lump sulphur was sold to the nitrate "oficinas" and to the Chile Exploration Co. at a price of £8 per ton, placed on truck at station. Ventilated sulphur was disposed of, through agents in Antofagasta, at a selling price of £11 per ton, on truck at station.

Summary of Costs, etc.—For the purposes of comparison, costs of production of the various firms and for the different grades, at establishment, are given below:—

	Lump.	*Fine-ground.*	*Ventilated or Sublimed.*
	£ s. d.	£ s. d.	£ s. d.
Canessa and Laneri	6 13 0	8 13 0	8 13 0
Espada and Donoso	4 17 0	5 12 0	5 18 0
J. B. Carrasco	5 15 3	—	6 9 3

Wages varied considerably in the different districts, as will be seen from Table 9.

It should be added that this article was written in 1931, when the Chilean peso was worth 6d. and when prices in Chile were normal. Since that time, however, owing to the crisis and to the depreciation of the peso, prices have altered considerably, for which reason the figures given should not be considered as applying to the present abnormal period.

DESERT PLACERS

By S. TRESKINSKY

The author, who acts as consulting mining geologist to the Persian Government, describes a type of desert placer deposit for which he has coined the term "proluvial."

In this article the term "proluvial" is used to describe such earth deposits as are formed by turbulent streams in mountainous and dry countries. Under the desert climatic conditions of Persia the destruction of rocky mountains, which are almost bare of vegetation, goes on very intensively. The torrents in the hills, which occur every year for a short period, create powerful streams called "sails." The sails carry all broken material accumulated in the clefts of the mountains and deposit it on the lower slopes bordering the plains. At the entrance of each cross-gorge its own talus is formed and in the area covered by the deposits the stream beds are constantly changing. As they are levelled in the course of a few years by rubble they no longer show a concave but a convex outline and a new bed is in course of formation by the sail beside the old one. The preparation of a new bed, which may go on for years, is usually completed by a sudden break at some other place. Thus the sail sometimes appears in unexpected places and attacks and covers up artificial work in places unprepared for the assault.

At a distance of several hundred metres from the steep mountain slopes the talus deposits are usually combining and fading into plains covered with rubble. The stream channels here are usually very shallow and covered with slimy sand. Turbid waters are usually flowing through them several hours after the chief pressure of the sail has ceased. Finally the central parts of depressions between two mountain chains are being filled year in year out by loess-like clays, which are deposited by rains and winds reaching them. All these deposits taken together might be called proluvial.

Genesis of Proluvial Placers.—The present geological period in Persia is extremely favourable for study of the formation of proluvial fields. The author bases his conclusions on his personal observations of the southern slopes of the Alborz mountain-ridges, east of Teheran, where huge sections of proluvium may be seen in the region of the road Teheran–Meshed and also in several areas of the Kevir-Dasht desert. The study of the placers of Kuh-Zar, south of Damghan, had his special attention.

The agents of transport of proluvial gold are, as previously mentioned, violent and intermittent streams. These streams, which lose themselves in the sands, do not seek a common channel and do not create a fluvial system. They have not a common base level, sea or lake. Each stream's "profile of equipose" is formed, therefore,

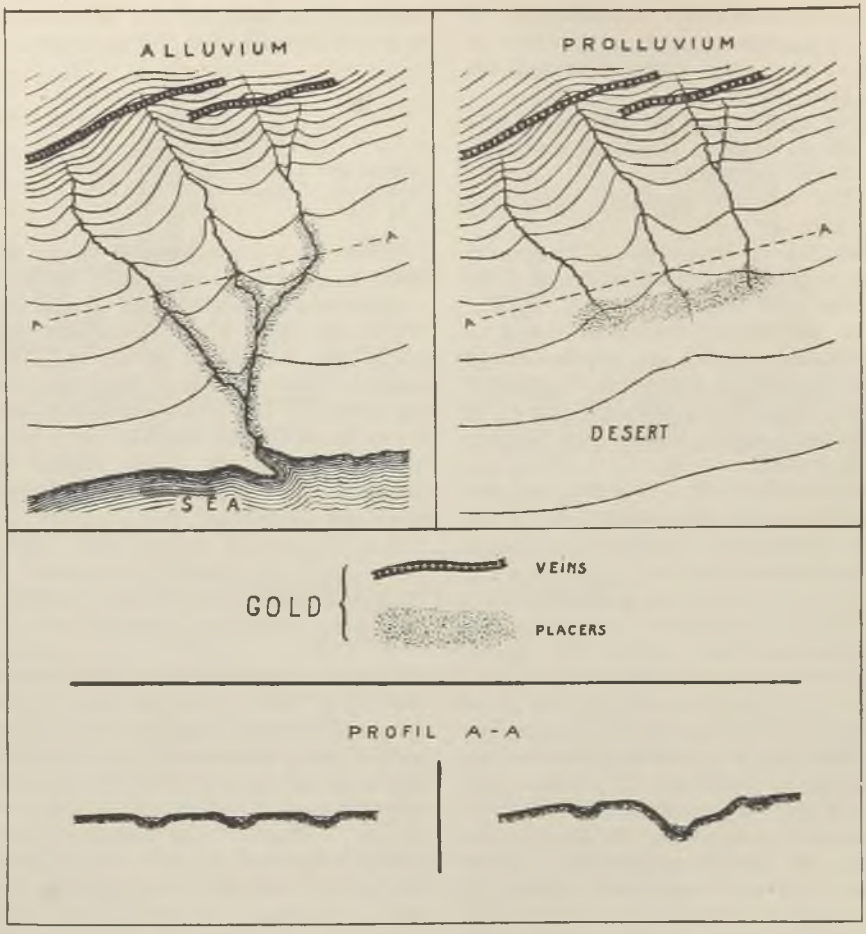


Fig. 1.—Sketch Plans and Sections to Illustrate the Distinction between Alluvium and "Proluvium."

independently from the other and such streams may terminate in different ways. In this way the distinction between proluvium and alluvium becomes obvious and is illustrated in Fig. 1.

Water currents joining into rills and rivulets tend to form a central fluvial system and placers formed by them extend into a common line from the hills to the sea. Short and independent systems of proluvial streams do not carry gold far away from the mountains and do not mix it into a common line. The proluvial deposits, as distinct from alluvial, are generally extended parallel to mountain chains and remain buried there a short distance away. Geological literature often speaks of a sedimentary gold deposit crossing a rivulet and concludes that the rivulet has changed its course, the direction of the deposit coinciding with the old course. It seems to the author that it is necessary in such cases to establish whether or not the deposit is proluvial, originating during a geological period when the area was a desert. To-day's rivulet may simply wash out and carry away the old proluvial deposit. The absence of common basis of erosion in proluvial deposits makes the altitude position independent of the age—*i.e.*, in proluvial deposits gold-bearing strata of one age may be found on different levels. Hence, age classification, easy for alluvium, is difficult to apply when speaking about proluvium.

In order to understand the distribution of gold in this type of deposit and the particular form of gold-bearing strata special attention must be paid to the

mode of formation. It is extremely difficult to observe directly the genesis of gold deposits in view of the insignificant quantity of gold grains contained in the sand and the author, in order to study the procedure, chose an indirect method, observing the formation of magnetic sands in exactly analogous conditions. A convenient subject was found in the Panj-Kuh mountains, near Damghan, where the destruction of porphyrites with magnetite inclusions is going on.

" Sails " may be divided into two phases—the first of chief pressure, when the torrential rains are supplying fresh quantities of water, and the second when, after the sudden stoppage of rain, there begins natural drainage of the inundated country and muddy waters are quietly flowing in their beds. In the first phase the flowing of large quantities of water takes place in such a precipitous manner that small unevennesses of the ground do not matter. At this phase the broken material (stone rubble) is subject to intensive pulverization by mutual friction and the gold nuclei are being freed. In the second phase the waters begin to flow slowly and small unevennesses of the ground determine changes of direction and the speed of the flow and in this period the broken material (stone rubble), washed into a net of innumerable rills, is being sorted out according to general laws. In accordance with these laws the major quantity of the gold is held up at the bends, the so-called " meanders " of the rills, and descends to the bottom. This process may be clearly seen in Panj-Kuh, where black spots of magnetite sand are sharply defined in the bends of the rills. The beds of these rills are not long-lived, as after a few years, perhaps after one year only, they are covered with additional rubble and pebbles. Generally long narrow and bent layers of gold-bearing sand are formed, sometimes twisted and hidden in the bulk of proluvial rubble. In such layers (in the Kuh-Zar) the gold content may vary between traces only in direct streams to several grams in the meanders.

The decisive moment in the formation of proluvial deposits is when the sail ceases. Horizontal pressure of the stream falls abruptly and the influence of weight becomes of first importance, as a result of which gold grains bury themselves in the sand and cement themselves in the muddy bed. Also during the small rainfalls after the sail periods the grains penetrate into the sand with the turbid waters, which help the gold grains remaining on the surface to penetrate into depth. Some weeks after the sail the black spots of magnetite sands, in Panj-Kuh, disappear completely from the surface, but by breaking up the sand they may be found to the depth of several centimetres. The same must also be the case with gold grains and the quick burying into the bulk of deposit is the reason why they are not carried far and, if the liberation of gold grains from the stone took place at the primary veins only, the width of proluvial deposits would scarcely attain a few half-scores of metres. The breadth of the Kuh-Zar goldfield is 3 to 4 kilometres, which can be explained by the presence of several parallel rows of veins and by the fact that the liberation of gold from the pebble takes place not only at the veins, but also considerably lower, in places where this pebble disintegrates.

Gold grains which are buried in the thickness of proluvial deposits move gradually deeper. In rill deposits they soon reach the muddy bottom, while in the thickness of stone rubble deposits the downward movement of gold grains may take years, as the waters helping this sifting of gold grains appear only periodically. The major part of the year these stone rubble deposits are absolutely dry. The descent of the grains goes on until they meet waterproof levels, such as clay, a layer of compactly cemented material, flint conglomerate, or bedrock. A layer of cementation found in an artificial subterranean channel (" kanat ") in the Kuh-Zar mountains showed large-size grains reaching 10 mgrs. in size. They had been caught in a process of chemical cementation, an action which may produce larger grains, even nuggets. Cementation may also promote the accumulation of reducing matter, even at the expense of increasing porosity, for organic matter such as turf and plant roots reduces gold from solution, pyrite being the chief inorganic reducer.

Survey of Proluvial Placers.—From what has been said about the genesis of these deposits a number of general rules emerge. In the proluvium the following features should be examined for their gold content: (*a*) Rill deposits and (*b*) cementation zones. It is easy to distinguish the former from the general bulk of proluvium by the following rule: In the rill deposits the material bears marks of sorting, whereas

in the mass of proluvium large-size stones are mixed with clay and sand. A survey by perpendicular sounding is generally useless, as the gold in rill deposits is distributed extremely unevenly. Perpendicular sounding may pass a few metres away from a meander rich with gold, discovering only a slight trace.

In the author's opinion the correct method of survey is a trial extraction of a series of rill layers from different points of the field. By doing so one must pass at least two to three curves of the layer. In order to discover the track of a layer it is advisable to dig deep transverse trenches. From the section of the layer it is easy to see whether the trench has crossed a rill layer in the straight current or in the meander. In the straight line this profile usually looks symmetric, whereas in the meander it assumes the form of a right triangle. As regards the cementation zone above the bedrock and above any impervious horizon, such may be tested by simple sounding. It may, of course, prove difficult to find gold in a new area, but once it has been discovered in any of the layers it can be traced back to the first layer.

In recent deposits—*i.e.*, where the relief of the country has been preserved—there is a possibility of observing direct connexion between placers and primary veins. In such cases the survey should consider both. Observation of primary veins gives indications of the placers and *vice versa*. In order to co-ordinate observations in a mountainous desert area it is advisable to compile a map of gullies. As they go out of the mountain-ridges the gullies pass more or less into oblique valleys (Fig. 2), in which the survey of sedimentary deposits must be concentrated. In comparing these valleys those most likely to contain gold are those having the maximum contact with veins at their outcrop, or those with the largest water-collecting basin. Gullies having the greatest contact with veins are those which have been formed by the destruction of the veins themselves—*i.e.*, these coincide with them. In the case of gullies crossing the veins the contact with them will be the more the smaller their angle of intersection. The Germab valley, in the Kuh-Zar, is an example of this, the feeders turning in the direction of primary veins. In this valley are situated the greater number of old mines.

Fig. 2.—The Kuh-Zar Placer Deposits.

The rule regarding the influence of the size of the water-collecting basin scarcely requires a proof, being confirmed by the location of the bulk of old Kuh-Zar mines in the Germab and Chinaran valleys, which possess the most extended net of flows in the area.

The relation of gold ore to contraction crevices, which are the deepest in the eruptive massif, is recognized theoretically. The direction of contraction crevices is as a rule perpendicular to the pressure operating at the time of cooling of the massif. This pressure is shown in its turn by the orientation of minerals in magmatic rocks,

as, for example, leaves of mica in granite. In consequence the placer-finding rule may also be set out as follows : The gullies most likely to bear gold are those which turn in their upper courses in the direction of mineral orientation in the eruptive massif. This rule is upheld by the author's observations in the Kuh-Zar. When the eruptive massif does not appear on the surface, however, the mineral orientation may be found by an indirect method and consequently the gullies must be examined.

Geological observations in Persia prove that the pressure at the time of cooling of the igneous massifs coincides with the tangential pressure prevailing during this period. For instance, the line of orientation of minerals in the granite of Kuh-Zar represents an arc concentric with that arc which is formed by the tertiary folds north of this massif. This means that when one does not succeed in discovering the eruptive itself the observation of the folds synchronizing with these eruptives makes the task easier. The problem must be tackled on the grand scale. The general idea of the tectonic structure of the locality must be clear to the geologist and local exceptions to the general rule, resulting from a later period foldings or dislocations, must not be overvalued, evident as they may be.

The structure of the valleys also has an important meaning. Observations on the formation of magnetite deposits in Panj-Kuh have shown that the quiet currents of innumerable rivulets in broad and flat valleys favour assortment more than the turbulent ones in narrow valleys. Therefore in beginning the search for gold it is advisable to give preference to valleys of type I before those of type II, as shown in Fig. 2. This picture represents a general view of the Kuh-Zar placers, which confirm this rule.

Study of the Gold.—It is generally advisable to submit to microscopic analysis the gold grains received from different places and levels during the survey. The analysis will show whether the grain has been mechanically transported or whether it has been formed on the spot by precipitation from solution. Observation of the colouring, mixture of silver, etc., gives valuable data for the classification of the different parts of the deposit, in regard to the unity of the origin. Marking all these indications on a map 1 : 1,000, it will be easier for the geologist to discover the method of formation of the deposit and the lines of transport, even if the old relief has been much changed since the time of its formation.

Sometimes the analysis of the grain may serve a better purpose. For instance, a quantity of grains from the Kuh-Zar placers bear in them the stamp of pyrite crystals of particular form, which is typical for one series of the Kuh-Zar veins only. This shows a direct connexion between the gold placers and these veins.

Conclusion.—By employing the principles set out in this article in examining the ancient gold placers of Kuh-Zar the author was able to find the veins themselves, which contained in the zone of oxidation up to 20 grams per ton. The author has endeavoured to attract the attention of geologists connected with the study of the gold ore to a little-investigated type of sedimentary gold deposits—*i.e.*, the proluvial. It appears to him that in many cases, in spite of all distinctions, proluvial placers are figuring in mining literature under the name of alluvial. A desert climate especially favours the destruction of rocks and consequently the formation of gold placers, which means that the bulk of placers are probably proluvial in origin.

LETTER TO THE EDITOR

"Sekenke Gold Mine, Tanganyika Territory"

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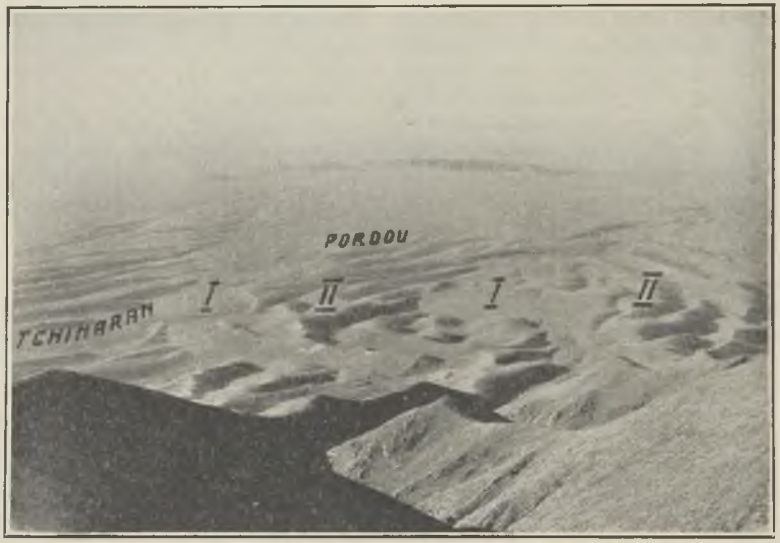

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"duricrust," "silcrete," and "natural cement" suite of surface rocks that cover so much of the East African plateaux. A similar rock seen on the Tanganyika central railway near Saranda was mistaken for trachyte by an eminent German geologist. Rhyolite (or dacite) does occur on the Sekenke property, but is very old, probably pre-mineralization in date, and may perhaps be correlated with the Ventersdorp of South Africa or may be older still.

The Sekenke lode (the Dernberg) was originally described as being situated at the contact of coarse- and fine-grained diorites. The fine-grained rock, however, proves to be felsitic and grades in places into granophyre ; the latter rock occurs also as dykes elsewhere on the property. Although the present new shaft is being sunk in unfaulted diorite and felsite I failed to find evidence on which to determine their relative ages.

D. R. GRANTHAM.

Georgetown, British Guiana.
August 27.

NEWS LETTERS

BRISBANE

August 29.

Mount Isa.—The registered office of Mount Isa Mines, Ltd., has been moved from Sydney to Brisbane, where Mr. J. P. Blaikie Webster has taken an office. The board of the Queensland company is now composed of Mr. Webster (chairman), Mr. Julius Kruttschnitt (general manager), Lord Castle Stewart, Colonel Evans, and Mr. A. M. Hemsley. During July development and production work at the mine proceeded as usual, underground operations being still confined to the Black Star, Black Rock, and Rio Grande sections. In the following table are given details of the mine production for July, with comparative figures for June :—

	June.	*July.*
Ore mined, tons	71,582	61,331
Ore milled, tons	71,035	63,406
Assaying—Lead, per cent.	9·6	9·2
Silver, oz.	4·4	4·4
Lead Concentrates produced—		
Flotation, tons	10,654	9,407
Assaying—Lead, per cent.	42·3	39·4
Silver, oz.	17·8	16·1
Jig, tons	1,507	1,845
Assaying—Lead, per cent.	47·8	43·8
Silver, oz.	21·1	17·2
Silver-lead bullion produced, tons	4,850	4,170

Mount Morgan.—Heavy rains during July prevented the Mount Morgan company achieving its objective of producing up to the plant's full capacity of 3,000 tons a week or indeed of increasing at all the output of the mine, as was expected. It is anticipated, however, that work and production will be carried on throughout the present month up to the standard provided for. The collapsed section of the main shaft has been "picked up" and the preparation of the site for the new crusher that is to be installed has been pushed forward. One result of the rains is that the dams are now full and a good supply of water is assured for several months. Over 350 men are employed, the ore produced in July being 11,490 tons and the value of the output in copper and gold £16,026. Mount Morgan is an interesting example of the application of improved methods of treatment to comparatively low-grade ores such as were a few years ago regarded as unprofitable and the operations of the new company are being watched with much interest by those concerned in the gold-mining industry. When the old company closed down in 1927 there was left in the mine about 8,000,000 tons of ore, all comparatively low grade, and the big task of mining and treating this ore profitably, with the help of modern appliances and methods, is what has been taken in hand by the present company. About the same quantity of ore as that left in the mine was treated by the previous company, which paid about £8,000,000 in dividends in its earlier days, although no distributions were made for several years prior to the stoppage of operations.

Mount Coolon Goldfield.—On the Mount Coolon goldfield, Queensland, Mount Coolon Gold Mines, Ltd., continued its activities on the usual scale last month. Ordinary work is being kept up and the mill is continuously running at its full capacity. The quantity of ore treated last month was 5,186 tons, which gave a return of 2,826 oz. of fine gold, worth £12,002, and 1,134 oz. of silver. For some time past Mount Coolon has been the highest producer among the Queensland goldfields. Last month, however, it was run close by Mount Morgan in gold yield, while the latter mine had a considerably better output in value of gold and copper combined.

Tin Mining in Queensland.—The recent substantial advance in tin prices has already led to a marked renewal of activities in the tin-mining centres of the State. The improve-

ment is most noticeable in the Herberton district, the largest producer of the metal. In a number of mines which had been closed down because working them had become unprofitable operations have now been resumed and prospecting for new finds has been stimulated. Several special prospecting parties which lately returned from the southern end of the district located not only tin but gold, silver-lead, and copper deposits. In the Kangaroo Hills tinfield, further south, near Townsville, the improvement in tin values had an immediate effect in increasing its output of the metal and last month's return was the highest since that of May, 1929. Stanthorpe, also the parent tinfield of the State, situated near the southern New South Wales border, is reaping some benefit from the rising market. While the present yield of alluvial tin on this field is, of course, small compared with what it was, say, in the seventies, it is an improvement over the returns for many months past.

New Mining Companies.—South New Moon, N.L., is being formed in Melbourne, with a capital of £50,000, to work the famous New Moon mine at Bendigo, Victoria. Operations on this property were begun in 1871 and up to 1931 about 400,000 tons of ore was crushed for a yield of 300,000 oz. of fine gold. Dividends aggregating £500,000 on a capital of £28,000 were paid. Ore averaging 11 dwt. a ton has in the past two or three years been obtained by tributers. Forsayth Gold Mines, N.L., has been formed in Brisbane, with a nominal capital of £200,000, to operate in the vicinity of Forsayth, on the Etheridge goldfield, North Queensland. There are to be issued 70,000 10s. shares to the Australian Mining Trust, Ltd., as part consideration for the transfer to the new company of 197 acres granted by the State Government as a concession for prospecting purposes.

Western Australian Gold.—In connexion with Australia's recovery from the long period of depression from which the World has been suffering, the gold-mining revival in Western Australia has been one of the bright spots in a dark period. The gold yield of the State has gradually risen in value from £1,530,429 in 1929 (the lowest on record for one year) to £2,546,176 in 1932, taking gold at the standard value of £4 5s. per ounce. The peak period was 1903, when the production was valued at £8,335,579.

Aerial Survey Expedition.—Prospecting for the discovery of further auriferous wealth in Western Australia should be greatly helped by the work of the best-equipped aerial survey expedition ever organized in Great Britain. This is to survey an area of 12,000 square miles, largely desert, to assist the Western Mining Corporation's geologists to locate new gold formations. This corporation, which was registered in Melbourne in March last with a nominal capital of £500,000, has been granted reservations of large areas of auriferous country, to be prospected by means of aerial photography and geophysical methods. These reservations extend from Southern Cross to the Kimberleys.

JOHANNESBURG

August 30.

Ore-Shoot Theory.—The importance of the ore-shoot theory with respect to the gold-bearing bankets of the Witwatersrand, particularly on the Far East Rand and Far West Rand, has now become generally recognized. Having been established as a result of the investigations of the Geological Survey which were carried out a few years ago by Dr. E. T. Mellor and subsequently demonstrated in a more definite way in the workings of the Sub Nigel and other Far East Rand mines, its practical application in this area has become a part of standard development methods. It can scarcely be doubted that a much wider investigation will show that the shoot system is a characteristic feature of the auriferous banket beds the farther one departs from the more uniform gold distribution in the Central and Main Witwatersrand area. In the light of this sufficiently-established theory it appears likely that the comparatively neglected banket occurrences beyond Heidelberg, as well as those in the Potchefstroom, Klerksdorp, and Vaal River fields, will be found to warrant more intensive inquiry.

New Mining Area.—The case of the Far East Rand Areas, Ltd., which company is testing the theory that there is a second Far East Rand basin, has its duplicate on the West Rand, where North Rand Mining Areas, Ltd., is exploring a "northern basin" some eight miles north of Krugersdorp. This northern basin is not merely a faulted portion of the main sequence of rocks comprising the Witwatersrand System but is the northern limb of the great anticlinal fold giving rise to the West Rand basin itself. North Rand Mining Areas, Ltd., holds, in

addition to its own mineral rights over land in the vicinity, options to purchase mineral rights over 11,200 morgen. The farms on which mineral rights are held under option are as follows: Kromdraai 71, Rietfontein 69, Sterkfontein 70, Danielsrust 19, and Weltevreden 40. The capital is £75,000 in 300,000 shares of 5s. each.

New Mining Companies.—The numerous small gold-mining companies registered during July are the feature of the list advertised in the Government Gazette by the Registrar of Companies. In all 83 companies, with nominal capitals totalling £308,506, were registered. This number creates a record for the year and exceeds the previous highest number in any one month of the year by one. The largest total nominal capital of £1,411,151 in April, however, is still to be exceeded. It is also gazetted that 12 companies, with capitals totalling £306,253, were placed in voluntary liquidation during the month.

Northern Transvaal Copper.—The latest information from the property of the Northern Transvaal (Messina) Copper Exploration, Ltd., intimates that the drilling operations taken in hand at the beginning of July are making satisfactory progress. At the site selected for No. 1 bore-hole the drill has reached a depth of 102 ft. After passing through the overlying sand and overburden, which had to be cased up, the drill entered the red granite in which the copper lodes occur at a depth of about 30 ft. from the surface. Several bore-hole sites were originally selected by the engineers of the Elbof Geophysical Survey Company.

Coal Problems.—Presenting his inaugural presidential address at the monthly meeting of the Chemical, Metallurgical, and Mining Society of South Africa, at Johannesburg recently, Dr. P. N. Lategan said: The outlook for the coal industry in South Africa would be a black one indeed if it were not for the researches of the fuel chemist. In countries like South Africa, where coal is cheap and abundant and natural oil non-existent, the day cannot be far distant when expensive imported oil will be replaced by locally-produced coal oil. Dr. Lategan claimed that he himself so far back as 1928 had proved that South African coal was amenable to hydrogenation.

Balla Balla Peak.—Having regard to the view taken in authoritative circles of the potential importance of the discovery at Balla Balla Peak it will not be out of place to relate the following: About four months ago a prospector, Mr. J. W. Pretorius, of the Essexvale district, explored the range of hills near Balla Balla Peak, which is the highest of the range. The peak is on the Bulawao side of Balla Balla, about seven miles off the main road to Beit Bridge. The length of the reef which has been discovered, so far as it has now been exposed, is 50 ft. and the width is 18 ft., while the ore pans 8 dwt. to the ton. Owing to the rocky nature of the locality further development work has been hampered, there being huge boulders on the extensions of the outcrop. The reef has been examined by a well-known geologist and two mining engineers, who are of opinion that the property possesses great possibilities.

Chrome in Zululand.—Some time ago, Mr. Alan Stuart made a report on the chrome occurrence of the Isitilo mines and it is understood that steps are being taken to form a private company or syndicate to take over the lease of the mine on a tributing basis for a period of six years. The ore occurs in serpentine and has been proved over considerable distances in two distinct forms and zones. It is estimated that there are available not less than half a million tons. It has been decided to market the ore in the form of a concentrate, samples of which were submitted to users of the ore in the various European countries. Replies having been favourable, a pilot plant was begun, and is now nearing completion, with a capacity of about 100 long tons per month.

Record Run for Copper Furnace.—Having been in continuous operation for 413 days, the No. 1 reverberatory furnace at N'kana mine had its fire drawn at the end of July. It is reported that this furnace operated quite satisfactorily during the whole period of this record run and that the results obtained exceeded all expectations. The material treated during the 413 days' run exceeded 141,500 long tons.

South-West Africa.—Samples showing visible gold have been obtained from the Rehoboth district, but it has not yet been possible to state definitely the magnitude of the gold-mining possibilities there. This area is new ground and a great deal of experimental work has still to be carried out before its value can be ascertained. Some 600 claims have been pegged. A further gold area has been discovered near Rooibank, in the vicinity of Walvis Bay. Claims have been pegged, but reports in respect of the find are difficult to obtain. Dr. de Kock, Inspector of Mines for South-West Africa,

has proceeded to the district to investigate the matter.

Gold Fever.—As a result of the present attractive price of gold, backed up by the statement of the Minister of Finance to the effect that South Africa would never revert to the old gold standard, much has been done to further the reopening of old mines and the investigation of abandoned properties. The Vesta mine, on the Black Reef, some ten miles south of Johannesburg, is coming into the limelight again and one hears of goldfields in the Hex River district, near Balfour and Greylingstad. In the Orange Free State it is reported that there is considerable activity in the Odendaal district. Komati goldfield properties are also being revived. Here there was at one time, before and shortly after the Boer War, a number of properties that were returning gold, particularly from what was known as the Steynsdorp district. Similar stories come from Southern Rhodesia, many mines whose names are well known to mining people of earlier days becoming active again. On the West Rand work has been commenced on Mr. J. H. Humphrey's claims to the east of the early workings of the old Teutonia mine. These old workings have been lying fallow since 1895 and in most cases have silted up with sand and rubble washed in by storm water during the past 35 to 40 years. Rich values are expected from this area, which in the early days was known as "the jeweller's shop of the Rand."

VANCOUVER

September 8.

Bridge River.—There has been a succession of discoveries at the Bralorne mine, the last of which was made in continuing the cross-cut on the 8th level from the King vein workings. A favourable arrangement has been made between the Bralorne company and Taylor (Bridge River) Gold Mines, Ltd., owning adjoining property to the north, whereby development of the latter ground is to be attacked from the Bralorne workings. Colonel H. H. Yuill has been retained as consulting engineer for the Taylor company and is understood to have expressed the view that there is a good chance for finding a large body of the augite-diorite formation on the Taylor ground at depth, in which it may be anticipated that similar veins to those of the Bralorne system may be encountered. The 8th level cross-cut from the Bralorne workings is to be continued for the specific purpose of penetrating the Taylor holdings.

Cariboo.—The recent announcement of the discovery of a 50-ft. ore-body in the lowest workings yet carried out on the Cariboo Gold Quartz property has given rise to much additional interest in the progress of development in this area. Views have been expressed that the property of Cariboo Gold Quartz, Ltd., represents a particularly favourable section of the whole area and it is not improbable that some operations in other sections that are in progress at the present time will not be resumed next year. Premier Gold Mines, Ltd., have suspended prospecting work at some of their camps and are concentrating their attention on their Antler Mountain property. Britannia Mines, Ltd., are carrying out a diversified programme of scouting and it is understood that the opinions of their examining engineers are not entirely in accord in regard to the value of the extensive holdings of the company in this area. W. R. Wilson and Sons have acquired properties on Proserpine Mountain, where the Newmont Corporation of New York have relinquished certain holdings to concentrate upon their cross-cut development work on Island Mountain. This work is said to have been productive of some encouraging results and is being continued. On Burns Mountain the cross-cut tunnel has been carried for over 800 ft., but has not encountered certain veins that were expected to be cut.

Boundary. — Encouraging developments have occurred in the Beaverdell camp, where, in addition to the opening up of a high-grade ore-shoot on the Beaver-Silver ground, the Sally mine is faced with good prospects as a result of work carried out at a low horizon. This work was done at the request of the Sally Mines company by the Wellington mine, which adjoins the Sally holdings and where facilities were available for deep level development. The tunnel that has been driven has penetrated the Sally ground and has opened up a good ore-shoot on a vertical depth of about 450 ft. below the existing Sally workings. In the Fairview camp it is reported that some high-grade ore has been obtained in upper workings on the Morning Star property, but no shipments from this camp have yet been reported.

Nelson.—In the Sheep Creek camp it is reported that plans are under consideration for the driving of another low-level tunnel to develop ore which has been proved to continue below the No. 5 level of the Reno

mine in winze workings. The Motherlode mine is being cleaned out by Reno Gold Mines with a view to further development and for the purpose of obtaining mill feed available from the old workings. No conclusive results have yet been obtained in the deep level work on the Gold Belt property, in so far as locating the main "C" vein is concerned. Having this object in view, the tunnel was driven at a depth of 600 ft. below the outcrop and it is understood that an intermediate tunnel is now being driven to locate the downward continuation of this vein. All the above-named properties lie on the north side of the Sheep Creek valley. On the south side the Queen, Kootenay Belle, and Vancouver groups are being operated. These properties are located on the same belts of quartzite that pass in a north and south direction through the whole camp area. The Queen property was one of the first to be operated—over 30 years ago—and covers the largest ore-body yet opened up in the camp. The Queen workings have been under water for many years, but the mine is now being pumped out by C. E. Witter, who holds a long term option on the property. A new flume has been constructed for supplying water under a head of about 450 ft. from Wolf Creek. The Queen property owns water rights on both Wolf and Sheep Creeks and, with a natural mill site at the junction of these two creeks, occupies a more or less strategic position in the camp. Adjoining the Queen are the Kootenay Belle and Vancouver groups. The Kootenay Belle is being operated by Diesel engine power with the production of periodic carload shipments of ore from narrow high-grade veins in which shoots of ore occur. The Vancouver group adjoins the Kootenay Belle on the south and the Queen on the west and covers a width of the quartzite formation allowing for a distance of about 2,000 ft. on the strike of three principal veins. One of these veins has been operated by leasers with the production of exceptionally high-grade shipping ore. The group has been acquired by the Midnight Mining Syndicate, representing Kamloops interests, and development work is in progress. The No. 2 tunnel, from which most of the work was done in past years, is being continued with the object of opening up further ore-shoots towards the east. The Alexandra vein, which has been worked on the Queen property, also passes through the Midnight ground, where it is said to have been exposed on surface over a width of 7 ft. with a value of about $14·00 per ton. To the north of the Sheep Creek camp the Clubine-Comstock group is being operated and shipments have been made during recent months to a value of about $8,000. The ore is of the silver-lead type and occurs in a vein in a fractured volcanic formation. At the Goodenough property, in the Ymir camp, it is understood that diamond drilling is to be commenced with a view to locating the vein which as yet has not been encountered in the No. 3 tunnel workings. This tunnel has been driven for a considerable distance already in anticipation of encountering the downward continuation of a good shoot of ore that was opened up in the level above.

Kamloops.—The Windpass mine, at Chu Chua, in the North Thompson valley, which has been closed down for several years, has been reopened by the owners, Messrs. Trites, Wilson, and Woods, of Vancouver. Under the present advantageous conditions connected with the market price of gold the owners have decided to incur the cost of mill construction in the hope that developments, which may be carried out during the course of ore extraction may serve to establish further reserves. A crew of about 100 men is employed upon the construction work. A tram line has been built to a mill site, where power equipment has already been installed, and it is understood that active milling operations will be commenced in the near future.

Hope.—The Nickel property owned by B.C. Nickel Mines, Ltd., at the head of Emory Creek, has been acquired by interests which are actively engaged in making preparations for a major scheme of development. A road is being built to the property for the transport of machinery. Wide bodies of pyrrhotite, with an average nickel content of about 2·7%, occur and have been prospected by open cuts and diamond drilling.

TORONTO

September 18.

Gold Production.—Ontario's gold production for the month of August had a value of $3,716,395, being the second highest monthly total for the year to date and $79,641 in excess of July's total of $3,636,754. The amount of ore milled during the month was 480,923 tons, the average recovery being $7·72 per ton. The Porcupine camp led all other areas in production, with $1,886,546 from 291,391 tons. The total

production in Ontario for the eight months ended with August was $29,517,884 from 3,687,630 tons of ore, exclusive of premium. This compares with $30,839,592 from 3,618,157 tons for the corresponding period of last year.

Sudbury.—Preparations are being made by Falconbridge Nickel Mines, Ltd., for the removal of the office staff and engineering and draughting force into a new building now nearly finished, which will combine the functions of office building and warehouse. The cost of the new structure, which increased scope of operations has rendered necessary, will bring the firm's total expenditure for construction and development in the Sudbury district for the past four years to more than $1,500,000. The main ore-body on the property of the Lee Gold mine, in the Swayze area, has been traced for 700 ft. on surface, with the No. 1 vein showing widths up to 14 ft., average values being $12 per ton in gold across 10 ft. Diamond drilling is being started immediately and if results prove satisfactory a mining plant will be taken in as soon as winter roads are in shape. Kenty Gold Mines has put down two shafts to a depth of 500 ft. on its property in the Swayze area and preliminary underground work is proceeding. Driving being carried on from No. 1 shaft is opening up a quartz vein with considerable free gold in evidence. A station is being cut for underground work from No. 2 shaft. The No. 2 vein at the Halcrow-Swayze mine has been penetrated for 15 ft. without finding the opposite wall. This vein was intersected by the cross-cut on the 200 ft. level and was found to be well mineralized. At the east end, about 1,000 ft. from the main shaft, the showing has been extended to 230 ft., with values in excess of $10 over widths of from 6 to 10 ft. The company is proceeding with the installation of a 200-h.p. hydro-electric power plant on the Kinogami River three miles from the present workings. Shaft sinking is being carried on at the property of McMillan Gold Mines, Ltd.

Porcupine.—Production of Dome Mines for August amounted to $367,321, exclusive of premium, as compared with $359,520 for July and $317,788 for August, 1932. Total production for the first eight months of the current year, exclusive of premium, was $3,105,160, as against $2,836,822 for the same period last year. This year's monthly average to date is $388,145 and, if this is maintained for the remaining four months of the year, production for the year will total $4,657,740, as compared with $4,040,317 for 1932. A new depth record for the Porcupine area has been established by McIntyre-Porcupine Mines, by the cutting of a station at 4,700 ft. The new inside winze, through which this depth was attained, started at 3,875 ft. and has as its objective a depth of 7,000 ft. below surface. It is planned to install a larger hoist in this winze in order to speed up operations. Porphyry is showing on one side of the winze and Keewatin formation on the other and the winze is thought to be near the bottom of the Pearl Lake porphyry mass. Good results are being obtained on other parts of the property and mill-heads are being maintained at capacity of 2,000 tons per day. Paymaster Consolidated Mines, Ltd., has completed financial arrangements which will enable it to resume operations on the West Dome Lake end of its property, adjoining Dome Mines.

Kirkland Lake.—Good progress is being made by Lakeland Gold Mines, Ltd., in its programme of underground development. A vein which was entered at a distance of 150 ft. in the cross-cut on the 575-ft. level had a width of 10 ft. 10 in. showing a good formation. Samples taken over a width of 62 in. on the north wall of the cross-cut returned an assay value of $6·60, or $9·90 at the current price of gold. The cross-cut on the 825-ft. level has been started and work is being speeded up to intersect the ore zone on this horizon. It is estimated that the ore opened in the levels, with that on the dump, would be enough to feed the proposed 100-ton mill for a year at least. The site for this mill has already been cleared and work is being started on the foundations. Hoisting facilities at the main shaft have been increased and operations are being carried on on a 24-hour basis, with three shifts. Additional electrical equipment has been ordered with a view to increasing air capacity for underground development. A test shipment of ore which was made to Ottawa indicated values of $8·61 in gold per ton at the current price. Sinking operations have been commenced by Barry-Hollinger Gold Mines and the winze is down 160 ft. from the 1,875-ft. horizon. It is the intention to carry the winze down to 2,375 ft. and to establish new levels at 2,125 and 2,375 ft. Continuation of favourable mineral conditions in the sections which will be opened by the new levels has been indicated by diamond drilling and it is expected that

sufficient ore will be developed to make possible the re-opening of the mill shortly after the completion of sinking operations. Construction work is being rushed by Macassa Mines with a view to having the property in production within the next few weeks. Ore reserves between the 2,000- and 2,475-ft. levels are estimated at about 150,000 tons of an average grade of $15 per ton. Stoping operations are now proceeding and a large tonnage of ore will be ready for the mill when it is completed. There are some sections in which the ore runs upwards of $25 per ton and officials are confident of maintaining millheads at a profitable level. Work on the 42nd level of the property of Teck-Hughes Mines has opened up ore conditions which compare favourably with those on the 41st level. The south shaft extension has been carried as far as the 45th level and from this point a cross-cut will be run to intersect the ore which is believed to lie within 300 ft. Shaft sinking has been started by Canadian Kirkland Gold Mines on its property in the western section of the Kirkland Lake camp. No 2 shaft, which is now at 150 ft., will be continued to 250 ft., where a station will be cut and lateral work proceeded with. Ashley Gold Mines is extending the vein system on its underground workings and the total ore.

North-Western Quebec.—Production of bullion by Siscoe Gold Mines during August had a value of $94,700 exclusive of premium, compared with $98,634 for July. Production for the eight months ended with August totalled $720,813 exclusive of exchange premium, as against $678,309 for the corresponding eight months of last year. Production is being maintained at a good average with the enlarged mill. The new central shaft at the Granada Gold Mines property is down 1,656 ft., with 3,000 ft. the next objective. Sufficient ore reserves to feed the present mill for five years are reported. Development work at the Malartic Gold Mines property has revealed a large tonnage of ore averaging about $3 per ton. A small pilot mill will be installed. Shaft-sinking is being carried on by Canadian Pandora Gold Mines on its property in the Cadillac district and a depth of 350 ft. has been reached. Stations will be established at the 375- and 500-ft. levels, the latter being the objective, and underground development will be undertaken. The construction of a new mill at the Greene Stabell mines is now practically completed and production is expected to start before the end of this month. There is sufficient ore on hand to supply the mill for some time. Two showings of free gold have been located on the property of Northern Quebec Gold Mines and a tunnel will be driven into the hillside to explore the vein system at a depth of about 100 ft. A high-grade gold pocket, which yielded ore valued at $30,000, was encountered on No. 5 shaft of Lamaque Gold Mines, controlled by Teck-Hughes, in Bourlamaque township. Encouraging results have also been obtained from work on the first level of No. 3 shaft. After values ranging between $11·80 and $24·80 were obtained on surface on the Malrovic property a shaft was put down on the vein and commercial values were obtained to a depth of 85 ft., at which point the vein dipped out. A programme is being carried on to extend present exposures. Shaft sinking has been started by Vicour Gold Mines, which has completed 6,000 ft. of diamond drilling on its property in Louvicourt township.

Manitoba.—Highly encouraging results have been obtained from extensive explorations carried on at the property of God's Lake Gold Mines, in the God's Lake district, where average values of $20 per ton in gold were revealed across an average width of 60 in. and over a length of about 1,000 ft. Continuity of the ore for at least 3,700 ft. was indicated, with veins and favourable structure and gold deposition at intervals over a length of several miles. The first of five deep holes to be sunk on the property has reached 275 ft., the vein at that depth having a width of 4·24 ft. and the average grade of ore being $8·20. The programme for the coming winter will include shaft sinking to a depth of 500 ft. and about 6,000 ft. of underground lateral development. Tenders have been called for for the shipment of between 500 and 700 tons of equipment and supplies to the property during the winter. Smelter Gold Mines, Ltd., has commenced an extensive campaign of diamond drilling on its property. Purchase of an adjoining property to the east of the company's present holdings gives them an additional length of 4,500 ft.

PERSONAL

H. H. W. Boyes is coming home from Nigeria.
Frank Dixey has returned to Nyasaland.
L. L. Ellis is returning to the Transvaal.
W. J. Evans is home from the Gold Coast.
J. M. Forbes has resigned as general manager of Siscoe Gold Mines.
J. E. Halford is returning from West Africa.

E. L. Hay has left for the Gold Coast.
W. T. Hudson has left for India.
A. J. Marin is returning to Kenya.
L. A. Mayo has returned to Northern Rhodesia.
H. C. Robson has left for India.
F. Schreiber has left Berlin for Singapore.
Duncan Smith has left Brussels for New York, where his address will be c/o Guaranty Trust Co., 140, Broadway.
C. O. Stee has been appointed general manager of Siscoe Gold Mines.
D. A. Sutherland has returned from the Near East.
M. T. Taylor has left for Australia.
F. L. Thomas has left for Canada.
D. A. Thompson has returned from West Africa.
G. W. Thomson has returned to New Zealand.
W. J. Wilson has returned to Nigeria.

Frank van Horn died on August 1, aged 61. He was professor of geology and mineralogy in the Case School of Applied Science.

Herbert Lapworth, who died last month, aged 58, was a former secretary of the Geological Society of London and an authority on geology as applied to civil engineering.

Charles Kennedy Cochran-Patrick, who was killed in an air disaster in South Africa on September 26 at the age of 37, was a pioneer of aerial surveying, having done much with his associates in the Aircraft Operating Company to perfect a system for obtaining geological and topographical information.

Alfred Grenville Burrows died in Toronto on September 2 at the age of 55. A native of Ontario, he graduated from Queen's University, Kingston, where he was for some time demonstrator in mineralogy. He had been in the service of the Province for more than 30 years and at the time of his death was Provincial Geologist.

John Edward Marr, who died on October 2, aged 76, was Emeritus Professor of Geology at Cambridge. In 1886 he was appointed lecturer at the University and remained so until he was elected Woodwardian Professor in 1917. He was a Fellow of the Royal Society, of which he served on the Council for two years and received a Royal medal in 1930, and a former President of the Geological Society of London, of which for many years he was Vice-President. He received the Lyell Medal in 1900 and the Wollaston Medal in 1914 and was Foreign Secretary from 1925 to 1928.

TRADE PARAGRAPHS

Hoffmann Manufacturing Co., Ltd., of Chelmsford, issue their new abridged catalogue relating to various kinds of ball and roller bearings. This gives dimensions and useful data.

Metropolitan-Vickers Electrical Co., Ltd., of Trafford Park, Manchester, in the September issue of their *Gazette* publish an article describing new developments in winding engine protection and practice.

Braithwaite Welding and Construction Co., Ltd., of Clock House, Arundel Street, Strand, W.C. 2, state that their recent formation has as its object the combination of high-class welding facilities and extensive technical and practical experience of bridge and other structures or fabricated work.

Mond Nickel Co., Ltd., of Thames House, Millbank, London, S.W. 1, in their *Nickel Bulletin* for August and September have an article describing the use of nickel cast-iron in vertical air-compressors manufactured by Reavell and Co., Ltd.

International Combustion, Ltd., of Aldwych House, Aldwych, London, W.C. 2, announce that all the shares previously held in their company by the International Combustion Engineering Corporation, of New York, have been acquired by English interests. The company is, therefore, now solely under British control.

Eversheds and Vignoles, Ltd., of Acton Lane Works, Chiswick, London, W. 4, have issued a 48-page booklet on how to avoid electrical breakdowns. This booklet, which is of pocket size, is illustrated by diagrams and contains chapters on carrying out tests on motors and generators and the use of "Megger" insulation testers.

Sir Isaac Pitman and Sons, Ltd., of Parker Street, Kingsway, London, W.C. 2, have published parts 25 and 26 of their *Engineering Educator*. The subject of steam condensing plant is concluded in part 25 and this is followed by the opening chapters on gas engines and producers. Part 26 concludes this section and also contains the introduction to the chapters which will be devoted to the construction, operation, and maintenance of Diesel engines.

Demag A.G., of Duisburg, Germany, have issued a book entitled "Demag Products," which is copiously illustrated, covers 200 pages, and fully describes the wide variety of their operations. The work opens with a description of the organization, tracing it briefly from its beginning in 1819. First place is given to their manufactures for the mining, quarrying, and tunnelling industries. These include rock-drills and coal-cutters, excavators and loading shovels, conveyors, compressed-air underground locomotives, mining wagons, winding engines and headgear, reciprocating and turbo compressors and blowers, steam plant, and oil and gas engines. Blast furnace plants, steelworks plant, rolling-mill equipment, shipyard and harbour installations, and plant for the chemical and allied industries, including cement, are the principal headings under which the firm's other products are listed.

Ingersoll-Rand Co., Ltd., of 165, Queen Victoria Street, London, E.C. 4, have issued a number of pamphlets setting forth the advantages of their Jackbits and drill rods. The Jackbit is a detachable bit with a special form of shallow reverse buttress type thread of carefully determined angle which keeps the bit tight and yet makes it easily detach-

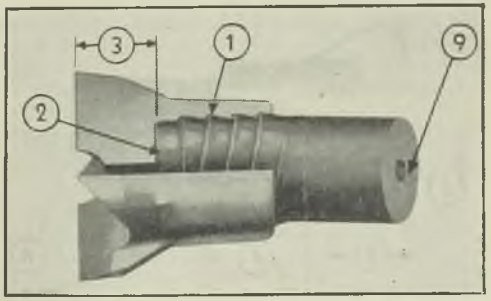


Fig. 1

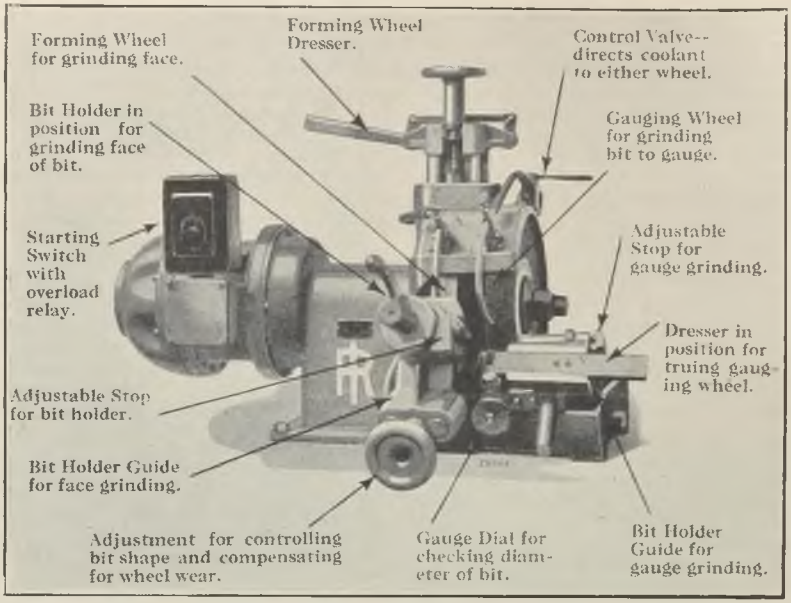


FIG. 2.—INGERSOLL-RAND JACKBIT GRINDER.

able (1). The threads do not become loose with wear. The maximum hammer blow is transmitted to the cutting edge through the full area of the end of the drill rod (2) and it is claimed that none of the blow is transmitted through the threads. Contact between the bit and the rod is close to the cutting edge (3). These features may be seen by reference to Fig. 1. Jackbits are made of special steel and properly heat-treated to give toughness with hardness and high drilling efficiency and are cadmium plated to prevent rust. Having a bright finish, they are less liable to be lost. Features of the drill rod are—its manufacture from a high-grade steel of proper carbon content and its smooth uniform hole, whereby fatigue cracks and corrosive action are prevented (9). Another pamphlet refers to the Jackbit grinder. The use of this machine enables the same detachable bit to be used three times over. The practice is to use the new Jackbit until worn dull and then to sharpen the dull bit to the next smaller gauge ($\frac{1}{8}$ in. less) and use until dull again and then resharpen to the next smaller gauge. The principal parts of the machine are shown in Fig. 2. The standard grinding machine is arranged for electric motor drive and is supplied with a grinding wheel suitable for bits up to $2\frac{1}{2}$ in. diameter. By fitting a wheel with a wider face it is possible to sharpen bits up to 3 in. diameter.

SHIPPING, ENGINEERING, AND MACHINERY EXHIBITION

The twelfth Shipping, Engineering, and Machinery Exhibition was held at Olympia from September 7 to September 23. While the exhibitors were for the most part showing products of interest to marine engineers there were, nevertheless, a number of oil engines and some other exhibits appealing to mining men.

Petters, Ltd., of Westland Works, Yeovil, were showing a variety of Diesel engines of both marine and industrial types. These included a 180-b.h.p. Atomic Diesel engine (of the type described in the MAGAZINE for March, 1930) and a 40-b.h.p. high-speed compression-ignition marine Diesel engine (of the type described in the MAGAZINE for February, 1932). Smaller engines of 15, 9, and 5 h.p. for auxiliary duties were also exhibited.

Davy, Paxman, and Co., Ltd., of Colchester, had as the principal exhibit a six-cylinder totally-enclosed vertical heavy-duty oil engine which develops 300 b.h.p. at 600 r.p.m. and was shown in operation direct coupled to a 200-kw. d.c. generator. This forms one of a range of vertical oil engines from 50 to 1,200 b.h.p. and is controlled by a single lever and arranged for air, electric, or petrol starting.

Mond Nickel Co., Ltd., of Thames House, Millbank, S.W. 1, had a number of exhibits displayed to exemplify the wide range of uses to which nickel alloys are being put in various engineering fields. Nickel-cast iron liners for Diesel engines and a piston made of the same alloy were shown and there were also nickel-bronze gears, heat-resisting castings, and nickel-aluminium cylinder heads suitable for aero engines.

W. H. Allen Sons and Co., Ltd., of Bedford, were exhibiting a number of examples of their heavy-oil engines, including a six-cylinder 550-b.h.p. unit and a six-cylinder 252-b.h.p. generator set, the other sets being for marine purposes. The engines are of the vertical solid-injection type, operating on the four-stroke cycle, and are constructed in units of 2, 3, 4, 5, 6, 7, or 8 cylinders running at speeds ranging from 275 r.p.m. to 1,200 r.p.m. and in sizes from 30 to 1,200 b.h.p.

Ruston and Hornsby, Ltd., of Lincoln, were joint occupants of a stand with Ruston-Lister Marine, Ltd., on which were marine Diesel engine units. As an example was a Ruston 150-b.h.p. engine direct

coupled to an electric generator giving 100 kw. This is a five-cylinder unit running at 600 r.p.m. and, although intended for marine propulsion, is similar to industrial units of the same class.

Murex Welding Processes, Ltd., of Forest Road, Walthamstow, London, E. 17, were displaying a comprehensive range of welding plant, electrodes, and products and in particular their application to ship construction and repair. Several new types of electrodes for arc welding were demonstrated. They were also showing a hand bend-testing machine in operation. The object of this is to provide a simple, inexpensive, and rapid method of carrying out a bend test as a measure of the ductility of welded metal and welded joints.

Wild-Barfield Electric Furnaces, Ltd., of Elecfurn Works, North Road, Holloway, London, N. 7, were demonstrating forced-air circulators as applied to industrial heating furnaces. By means of a fan the air is caused to circulate more rapidly round the furnace wall, thus increasing the rate of heating. A new furnace was also shown described as "heavy-hairpin," so called because the heating elements are built up in the furnace wall of hairpin-shaped members. Many of the furnaces shown were equipped with automatic control so that the required temperature when reached is maintained.

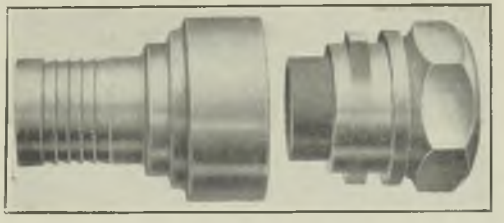
Norris, Henty, and Gardners, Ltd., of Patricroft, Manchester, were showing a range of high-speed airless-injection engines and a heavy-oil engine operating on the two-stroke cycle. The high-speed engines although designed for marine work are suitable for general power-generation purposes. They are of the solid-injection type and made in three, four, five, six, or eight cylinder sizes. The eight-cylinder model exhibited develops 136 b.h.p. at 800 r.p.m. Another model with six cylinders develops 102 b.h.p. at 800 r.p.m. on continuous duty, but can be run up to 1,200 b.h.p., the power at 1,000 being 127 b.h.p. A four-cylinder unit develops 38 b.h.p. at 1,000 r.p.m.

National Gas and Oil Engine Co., Ltd., of Ashton-under-Lyme, were showing two engines of interest to power users generally. The first was a 335-b.h.p. six-cylinder heavy-oil engine at 428 r.p.m. This is one of a range of vertical oil engines made in sizes from 280 to 446 b.h.p. in 5, 6, 7, and 8 cylinders. Another range running at 500 r.p.m. gives from 317 to 506 b.h.p. and a third range from 525 to 840 b.h.p. at 300 r.p.m. The engine operates on the four-stroke cycle and is of the totally-enclosed type. The fuel consumption for a 630 b.h.p. is given as 0·38 lb. per b.h.p. hour. The other exhibit of interest was a six-cylinder 120-b.h.p. oil engine running at 800 r.p.m. This was adapted as a marine unit. It is also one of a range of engines, the series being two-cylinder 40 b.h.p., three-cylinder 60 b.h.p., and four-cylinder 80 b.h.p. at the same speeds.

J. and H. Maclaren, Ltd., of Leeds, were exhibiting examples of their range of high-speed Diesels, which cover engines from 8 to 340 b.h.p. Units shown included a 20–25 b.h.p. four-cylinder at 1,000–1,250 r.p.m. and a 50–60 b.h.p. six-cylinder at the same speed. Other ranges of which examples were shown are the 15–17½ b.h.p. per cylinder units in combinations of 2, 3, 4, 6, and 8 cylinders for speeds of 800–1,000 r.p.m. and the 40 b.h.p. per cylinder units. A feature was made of a starting mechanism, known as the Inertia starter, for hand or pedal operation, by means of which a flywheel is caused to revolve at 3,000 r.p.m. through a chain of gears and this is connected through a clutch and worm to the crankshaft of the engine.

Department of Scientific and Industrial Research, of 16, Old Queen Street, London, S.W. 1, were occupants of a large stand on which were examples of work done by various constituent bodies of this Government organization. The National Physical Laboratory were showing, through their engineering department, a combined bending and torsion fatigue-testing machine and a spring plate fatigue-testing machine. The Fuel Research Station by means of a model were demonstrating the "grid" short flame powdered fuel burner for use with cylindrical boilers. The Chemical Research Laboratory were showing the results of sea-water corrosion on iron and steel bars. The British Non-Ferrous Metals Research Association had examples of new alloys of lead, copper, etc., to which attention has already been directed in the MAGAZINE. The National Federation of Iron and Steel Manufacturers' Industrial Research Council, in addition to demonstrating recent researches on coke, were drawing attention to results of research into blast-furnace reactions.

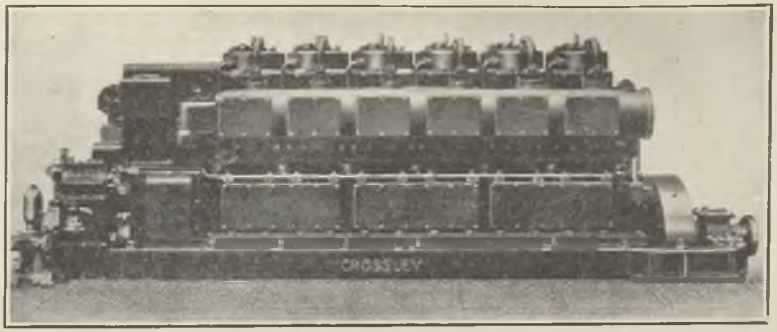
Belliss and Morcom, Ltd., of Birmingham, were showing their six-cylinder 200-b.h.p. totally-enclosed airless-injection type Diesel engine, direct coupled to a generator and adapted as a marine unit. The industrial type of this machine has already been described in the MAGAZINE. Another exhibit was of a two-crank combined steam engine coupled to a generator built for a continuous output of 50 kw.



FITTING A. FITTING B.

at 600 r.p.m. A 300-kw. steam turbine designed for running at 6,000 r.p.m. was also shown. Of particular interest are these manufacturers' quick-fit pneumatic hose couplings, which are made from steel bar in a variety of shapes and sizes for connecting lengths of hose or for connecting hose to drills or to air-compressors. The essential feature of this coupling is the rubber lining to the fitting B (see figure), which grips the walls of fitting A under the pressure of the air passing through the union. A half turn of fitting B against fitting A secures complete locking of the joint. The combination shown in the illustration is for connecting hose to a wall cock.

Crossley Bros., Ltd., of Openshaw, Manchester, and the **Premier Gas Engine Co., Ltd.,** of Sandiacre, Notts, were showing a number of horizontal and vertical oil engines. Among these was an eight-cylinder horizontal vis-a-vis Diesel engine coupled to a d.c. generator. The unit is designed for electric propulsion of ships, but is interesting as being similar to those installed at the Lake View and Star mine, described in the MAGAZINE for December, 1930, and referred to by Mr. Degenhardt in his



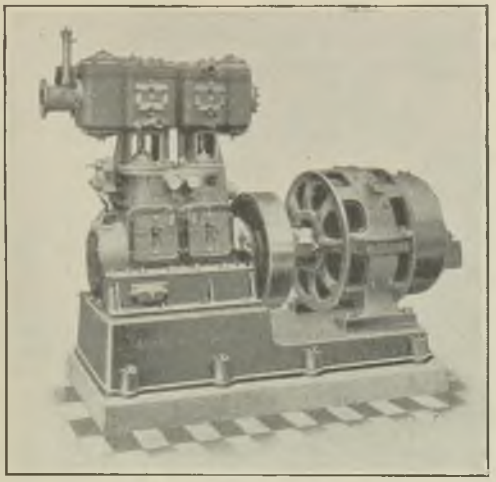
CROSSLEY SCAVENGE PUMP DIESEL ENGINE.

article in May last. The unit exhibited develops 600 b.h.p. at 300 r.p.m., or, if supercharged, from 750 to 800 b.h.p. An important exhibit on this stand was a new vertical Diesel engine, which is a six-cylinder unit developing 150 b.h.p. at 450 r.p.m. The engine is fitted with a scavenge pump for cleaning the spent gases from the cylinders and thereby leaving a full charge of clean air, which gives a high power output and an efficient control of the temperature. The engine is of the airless-injection cold-starting type and operates on the two-stroke cycle. Another smaller scavenge-pump Diesel was shown as a two-cylinder model of 50 b.h.p. at the same speed. The larger engine is shown in the accompanying illustration, which, although a marine installation, gives a good idea of the size of the unit.

Sir W. G. Armstrong Whitworth and Co. (Engineers), Ltd., of Newcastle-on-Tyne, were making a special feature of Diesel-electric traction. For this purpose they had a 15-ton shunting locomotive running on a length of standard-gauge track. The unit consists of an Armstrong-Saurer six-cylinder Diesel engine coupled to a generator set, the power being transmitted to the driving wheels by an electric motor, which is fed with current from the generator. Thus there is no mechanical transmission—clutch or gearbox. This results in easy acceleration and greater flexibility, as was demonstrated by a series of trial runs in the exhibition. Between the generator and the motor is a special type of switch, by means of which the driver controls the movement of the engine—this has a reverse lever and one handle only. This locomotive is able to haul from 280 to 300 tons on a level track at five miles an hour. For Diesel-electric traction in general the makers claim that shunting duties can be carried out with locomotives having considerably less horse power but greater initial starting effort than steam locos of comparable weight. The firm were also showing a portable air-compressor suitable for supplying air to rock-drills.

Reavell and Co., Ltd., of Ipswich, had a number of air-compressors of both reciprocating and rotary types. Special attention may be devoted to their vertical stationary compressors, two of which were on show, one having a delivered capacity of 500 cu. ft. of free air per minute at 100 lb. pressure and another of 1,000 cu. ft. These compressors are double-acting two-stage and in virtue of their short stroke and relatively high rotational speed are suitable for direct drive by an electric motor or internal combustion engine. They are also built for steam drive and in such a case are made with simple or compound steam cylinders arranged in tandem with the air cylinders and suitable for steam pressures up to 160 lb. per sq. in. The two-stage compressor is of two-crank construction, having one low-pressure cylinder and one high-pressure, both double-acting and arranged side by side, and it is capable of work up to a pressure of 120 lb. per sq. in. An independent inter-cooler of the multi-tubular counter-current

ARMSTRONG WHITWORTH DIESEL-ELECTRIC LOCOMOTIVE.



type is provided to cool the air from the low-pressure cylinder to a suitable temperature before it enters the high-pressure cylinder. Similar vertical double-acting air-compressors are also made as single-stage machines, where pressures up to 40 lb. per sq. in. are required. The following figures give the power consumption for a number of two-stage and single-stage compressors :—Two-stage at 100 lb. per sq. in. pressure delivering 500 cu. ft. per minute requires 110 b.h.p., 1,000 cu. ft. per minute requires 215 b.h.p., and 5,000 requires 1,060 b.h.p. The corresponding figures for single-stage with compression to 40 lb. per sq. in. are :—550 cu. ft. per minute, 78 b.h.p. ; 1,100 cu. ft. per minute, 156 b.h.p., and 5,520 cu. ft. per minute, 770 b.h.p. The two-stage compressor direct coupled to an electric motor is shown in the illustration.

METAL MARKETS

Copper.—Standard copper prices drifted downwards during September, the explanation being that interest in the metal, particularly on this side of the Atlantic, was very subdued. Owing to general economic uncertainties the summer holiday quietude was maintained longer this year than usual. The outlook remains somewhat obscure, as, although the statistical position of the metal in the United States is unofficially reported to be still improving, the fate of the great Roosevelt experiment is still in the balance. However, there are faint signs of better trade in Europe and if this tendency persists the copper industry may benefit in due course.

Average price of Cash Standard Copper : September, 1933, £35 3s. 7d. ; August, 1933, £36 2s. 3d. ; September, 1932, £35 0s. 7d. ; August, 1932, £31 9s. 1d.

Tin.—During the first part of September prices receded owing to general apathy and the continued abstinence of America as a buyer, but towards the close a better tendency supervened on the expectation of good statistics for the month. As a matter of fact world supplies in sight were reduced by another 4,000 tons during September. Unless the International Tin Committee decides to increase the rate of authorized output, it looks as if market supplies will become increasingly stringent. The future of the market must necessarily also hinge very largely on American developments, as to which we should not care to prophesy.

Average price of Cash Standard Tin : September, 1933, £216 19s. 3d. ; August, 1933, £215 5s. 10d. ; September, 1932, £152 16s. 3d. ; August, 1932, £142 2s. 4d.

Lead.—The undertone of this market was barely steady last month. Demand from users was restricted and holders, although maintaining firm control of the situation, made no effort to push up prices when a little inquiry developed. This policy was probably a sensible one, for the statistical position of the metal remains far from brilliant owing to the large surplus stocks that still exist. There has been a better demand in the United States at times and the stocks in that country are still decreasing, although whether the metal is all going into consumption is not clear.

Average price of soft foreign lead : September, 1933, £12 1s. 7d. ; August, 1933, £12 6s. 4d. ; September, 1932, £13 4s. 8d. ; August, 1932, £11 9s. 4d.

Spelter.—Rather colourless conditions prevailed on this market during September also and prices reflected a slightly easy tendency. Towards the close of the month mild excitement was caused by the report that the International Zinc Cartel had been denounced by a group of Belgian members, but it transpired that this was merely a formality preliminary to the discussion of certain questions connected with the fines fund. The cartel has now been renewed till the end of the year.

Average mean price of spelter : September, 1933, £16 18s. 6d. ; August, 1933, £16 19s. ; September, 1932, £15 10s. 8d. ; August, 1932, £13 14s. 4d.

Iron and Steel.—The British pig-iron market maintained a good tone throughout September and, although Cleveland foundry pig-iron prices underwent no change, demand was insistent and the blowing-in of additional blast furnaces was believed to be imminent. Hematite was a rather firmer market, East Coast Mixed Numbers being generally quoted at 60s. per ton at the close of September. The new trade treaties seem to be benefiting British ironmasters to some extent from the export point of view. A distinct improvement is reported by British rolling mills, whose position is likely to become better still when the incipient revival in the shipbuilding industry gets into full swing. The Continental steel market remained dull during the month.

Iron Ore.—Some fairly good business has been done at times, but generally speaking demand is still for odd cargoes. Best Bilbao rubio is rather firmer owing to exchange considerations, the current price being about 15s. 6d. to 16s. per ton c.i.f. Good North African ores are about 13s. 6d. to 14s. c.i.f.

Antimony.—During most of September there was very little demand for antimony, but sellers upheld prices at around £23 to £23 10s. c.i.f. for foreign regulus. English regulus was unchanged at £37 10s. to £40, ex warehouse, throughout the month.

Arsenic.—Business is only moderate, Mexican being quoted at about £15 15s. to £16 per ton c.i.f. and Cornish white at £16 to £16 5s. f.o.r mines.

Bismuth.—Sales have been in fairly good volume

LONDON DAILY METAL PRICES.

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

	COPPER.				TIN.		ZINC (Spelter).	LEAD.		SILVER.		GOLD
	Standard.		Electro-lytic	Best Selected.				Soft Foreign.	English.			
	Cash.	3 Months.			Cash.	3 Months.				Cash.	Forward.	
Sept.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	d.	d.	s. d.
12	35 16 3	36 1 3	39 5 0	38 0 0	217 8 9	217 8 9	16 15 0	11 17 6	13 5 0	18 1/16	18 1/16	127 7
13	35 10 7½	35 14 4½	39 0 0	—	216 2 6	216 3 9	16 16 3	11 15 0	13 5 0	18⅛	18⅛	129 2
14	35 14 4½	35 16 10½	39 1 3	—	216 12 6	216 12 6	17 0 0	11 15 0	13 5 0	18 1/16	18 1/16	129 6
15	35 9 4½	35 13 1½	39 0 0	37 15 0	217 16 3	217 16 3	16 17 6	11 18 9	13 5 0	18⅜	18½	130 5
18	35 7 6	35 10 7½	38 12 6	—	217 13 9	217 13 9	16 18 9	11 18 9	13 5 0	18 1/16	18½	131 9
19	34 15 7½	34 19 4½	38 5 0	37 0 0	216 7 6	216 7 6	16 16 3	11 16 3	13 5 0	18⅜	18⅜	131 9
20	34 12 6	34 15 7½	37 15 0	—	216 11 3	216 11 3	16 16 3	11 16 3	13 5 0	18 7/16	18 7/16	133 9
21	34 10 7½	34 13 9	38 0 0	—	215 16 3	215 16 3	16 15 0	11 18 9	13 5 0	18½	18⅜	132 9
22	34 4 4½	34 8 1½	37 10 0	36 10 0	214 16 3	214 16 3	16 13 9	11 17 6	13 5 0	18½	18⅜	133 7
25	34 2 6	34 5 7½	37 12 6	—	215 16 3	215 8 9	16 12 6	11 18 9	13 5 0	18 1/16	18 1/16	132 9
26	34 2 6	34 6 3	37 12 6	36 10 0	215 11 3	215 8 9	16 11 3	12 0 0	13 5 0	18½	18⅝	133 2
27	34 9 4½	34 13 1½	38 0 0	—	216 13 9	216 11 3	16 13 9	11 17 6	13 5 0	18 1/16	18 1/16	133 0
28	34 12 6	34 16 3	38 0 0	—	216 16 3	216 11 3	16 12 6	11 18 9	13 5 0	18 1/16	18½	132 4
29	34 18 9	35 0 7½	38 10 0	37 0 0	219 13 9	219 8 9	16 15 0	12 0 0	13 10 0	18 1/16	18½	133 0
Oct.												
2	35 10 7½	35 14 4½	39 0 0	—	222 13 9	222 12 6	16 17 6	12 1 3	13 10 0	18⅜	18 1/16	133 5
3	35 4 4½	35 8 1½	38 15 0	37 5 0	221 3 9	221 2 6	16 13 9	11 18 9	13 10 0	18 1/16	18 1/16	134 8
4	34 18 9	35 3 1½	38 7 6	—	221 17 6	221 16 3	16 12 6	11 18 9	13 10 0	18 1/16	18 1/16	134 6
5	35 0 7½	35 5 7½	38 12 6	—	224 16 3	224 16 3	16 13 9	12 1 3	13 10 0	18½	18⅝	133 8½
6	34 19 4½	35 3 1½	38 10 0	37 0 0	224 11 3	224 11 3	16 15 0	12 2 6	13 10 0	18⅜	18⅝	133 11
9	34 11 10½	34 15 7½	38 0 0	—	224 8 9	224 3 9	16 15 0	11 17 6	13 5 0	18⅜	18 1/16	133 1

at the official price of 5s. 3d. per lb. for 5 cwt. lots and over.

Cadmium.—The market is quietly steady at about 1s. 2½d. to 1s. 3d. per lb.

Cobalt Metal.—Demand is improving slightly, but is still rather quiet. The official price is unchanged at 5s. per lb. for cwt. lots.

Cobalt Oxides.—Only a restricted demand for cobalt oxides is in evidence from the ceramic trades, but prices are steady at 4s. 6d. to 4s. 8d. per lb. for black and 4s. 9d. to 4s. 11d. for grey.

Chromium.—Metal remains at 2s. 8d. per lb. delivered.

Tantalum.—Inquiry is small, but prices are steady at about £15 per lb.

Platinum.—A seasonal expansion in business became apparent in September, but the market cannot be said to be active. Refined metal remains at £7 12s. 6d. to £7 15s. per oz.

Palladium.—With buying on a small scale the price is fractionally easier at about £3 10s. to £4 5s. per oz.

Osmium.—There is no change in this market, a quiet business being done at around £12 to £13 per oz.

Iridium.—Trade is of a limited character, but quotations are upheld at £9 to £10 per oz. for sponge and powder.

Tellurium.—About 15s. to 16s. per lb. is still quoted for fair-sized parcels of ingots.

Selenium.—Prices are easier, about 7s. 8d. to 7s. 9d. per lb. sterling now being quoted for black powder, ex warehouse Liverpool.

Manganese Ore.—Rather more demand has been in evidence recently, especialy for good second-grade ores. Business, however, is mostly for individual parcels and not for period contracts. Prices are quotably unchanged at 9½d. per unit c.i.f. for best Indian and 8½d. to 9d. c.i.f. for washed Caucasian ore.

Aluminium.—Whilst some improvement in business is reported, the fundamental position has changed hardly at all. Prices here are unaltered at £100 for ingots and bars and £102 for rolling billets, both less 2% delivered.

Sulphate of Copper.—English material is now quoted at £16 5s. to £16 15s. per ton, less 5%.

Nickel.—Demand continues to make quite a good showing and prices are upheld at £225 to £230 per ton, according to quantity.

Chrome Ore.—Whilst some improvement in consumption is apparent, the movement as yet is slight. Meanwhile prices are unaltered at 80s. to 85s. per ton c.i.f. for first quality 48% Rhodesian and 100s. to 105s. c.i.f. for 55 to 57% New Caledonian.

Quicksilver.—A rather firmer tone has developed following an expansion in consumption and spot metal is now quoted at about £9 10s. to £9 15s. per bottle.

Tungsten Ore.—Although the proposed export monopoly in China does not seem to have materialized, the market is much firmer. Producers have been reticent and, with buyers showing more interest, quotations have risen rapidly to their present level of around 23s. per unit c.i.f. for forward shipment.

Molybdenum Ore.—The market is steady at the unaltered price of 40s. to 42s. 6d. per unit c.i.f. for 80 to 85% concentrates.

Graphite.—A fair demand is experienced at times, but prices are without change at £19 to £21 duty paid for 85 to 90% raw Madagascar flake and £15 to £17 c.i.f. for 90% Ceylon lumps.

Silver.—Price movements during September were narrow, spot bars being 18 1/16d. on September 1, 18⅜d. on September 15, and 18 7/16d. on September 30. During the first half of the month the market was quiet, but Chinese buying offset the scattered selling of speculators. Later Senator Pittman, of the United States, proposed a scheme whereby domestic producers should sell their output at enhanced prices to the American mints for minting into silver dollars. For a time this tended to improve sentiment, but, although prices were higher on the month, the tone of the market cannot be said to be particularly buoyant.

STATISTICS

PRODUCTION OF GOLD IN THE TRANSVAAL.

	Rand.	Elsewhere.	Total.
	Oz.	Oz.	Oz.
September, 1932	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
June	868,834	49,799	918,633
July	872,695	50,976	923,671
August	882,587	52,127	934,714
September	851,985	49,814	901,799

TRANSVAAL GOLD OUTPUTS.

	August.*		September.†	
	Treated Tons.	Yield Oz.	Treated Tons.	Yield Oz.
Brakpan	121,500	£230,012	117,000	£232,360
City Deep	110,000	22,383	109,000	22,017
Cons. Main Reef	83,000	23,567	82,000	22,990
Crown Mines	300,000	88,528	294,000	86,761
Daggafontein	57,200	£128,644	58,000	£133,075
D'rb'n Roodepoort Deep	53,300	14,678	52,000	13,896
East Geduld	76,000	25,652	77,000	25,835
East Rand P.M.	171,500	40,904	168,000	39,210
Geduld	93,000	27,657	91,000	26,878
Geldenhuis Deep	82,400	15,321	80,000	14,438
Glynn's Lydenburg	7,750	3,046	7,500	2,832
Government G.M. Areas	216,000	£546,764	208,000	£537,692
Kleinfontein	53,600	9,769	48,600	£60,984
Langlaagte Estate	83,000	£128,737	79,000	£117,399
Luipaard's Vlei	37,100	8,384	36,500	8,245
Modderfontein New	180,000	51,417	176,000	49,612
Modderfontein B	80,000	17,701	80,000	17,609
Modderfontein Deep	46,800	19,237	44,900	17,302
Modderfontein East	81,000	21,471	78,000	20,631
New State Areas	94,000	£252,036	91,000	£254,825
Nourse	72,000	17,827	71,500	17,573
Randfontein	275,000	£446,358	270,000	£439,195
Robinson Deep	101,000	27,295	100,000	£170,533
Rose Deep	65,000	12,615	63,000	11,674
Simmer and Jack	90,200	21,065	87,000	£132,532
Springs	84,500	£227,275	84,500	£233,681
Sub Nigel	42,300	36,772	41,000	£230,064
Transvaal G.M. Estates	20,700	5,495	19,700	5,232
Van Ryn	53,000	£64,362	53,000	£62,015
Van Ryn Deep	80,000	£128,375	77,000	£125,318
West Rand Consolidated	98,000	£152,646	95,000	£155,547
West Springs	87,000	£102,902	88,000	£102,699
Witw'tersr'nd (Knights)	76,000	£79,590	75,000	£77,635
Witwatersrand Deep	50,000	14,086	50,500	£66,378

* Gold at 125s. per oz. † Gold at 129s. 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.	£
June, 1932	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	2,922,200	36 1	19 9	16 4	2,381,971
May	3,144,000	35 8	19 5	16 3	2,556,066
June	3,093,500	35 4	19 6	15 10	2,453,205
July	3,182,600	35 5	19 3	16 2	2,568,899
August	3,221,850	35 9	19 4	16 5	2,651,880

NATIVES EMPLOYED IN THE TRANSVAAL MINES.

	Gold Mines.	Coal Mines.	Diamond Mines.	Total.
September 30, 1932	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
June 30	229,751	12,059	—	241,810
July 31	230,306	12,269	—	242,575
August 31	231,341	11,947	—	243,288
September 30	230,774	11,832	—	242,606

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	45,032	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	53,358
June	45,208	44,118	48,441	54,442
July	45,810	44,765	47,331	54,561
August	46,152	43,292	49,254	56,147
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.

	August.		September.	
	Tons.	Oz.	Tons.	Oz.
Cam and Motor	25,800	9,272	25,400	9,128
Globe and Phœnix	6,084	5,437	6,086	5,433
Lonely Reef	13,500	1,860	14,000	1,861
Rezende	6,500	2,156	6,500	2,154
Sherwood Star	7,000	1,887	6,800	1,805
Wanderer Consolidated	15,900	3,489	15,500	3,268

WEST AFRICAN GOLD OUTPUTS.

	August.		September.	
	Tons.	Oz.	Tons.	Oz.
Ariston Gold Mines	8,863	£26,907	9,055	£26,087
Ashanti Goldfields	13,647	14,832	13,711	14,902
Taquah and Abosso	11,168	3,785	10,576	3,554

AUSTRALIAN GOLD OUTPUTS BY STATES.

	Western Australia.	Victoria.	Queensland.
	Oz.	Oz.	Oz.
September, 1932	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	—	4,005
February	47,281	—	4,365
March	47,105	—	4,758
April	52,909	—	12,460
May	53,300	—	7,135
June	53,451	27,593*	7,699
July	54,455	—	—
August	56,147	—	—
September	58,670	—	—

* Six months to June 30. † Period Jan.–Nov., 1932.

AUSTRALASIAN GOLD OUTPUTS.

	August.		September.	
	Tons.	Value £	Tons.	Value £
Associated G.M. (W.A.)	5,362	5,784	5,103	4,306
Blackwater (N.Z.)	4,108	1,858*	4,020	1,710*
Boulder Persev'ce (W.A.)	7,337	7,553p	7,289	8,201p
Grt. Boulder Pro. (W.A.)	6,475	5,326*	—	—
Lake View & Star (W.A.)	43,016	84,930	—	—
Sons of Gwalia (W.A.)	12,016	15,933	11,958	14,924
South Kalgurli (W.A.)	9,531	12,710	—	—
Waihi (N.Z.)	17,693	5,959* / 32,043†	—	—
Wiluna	40,426	10,706*	—	—

* Oz. gold. † Oz. silver. p Profit.

GOLD OUTPUTS, KOLAR DISTRICT, INDIA.

	August.		September.	
	Tons Ore.	Total Oz.	Tons Ore.	Total Oz.
Champion Reef	9,470	5,503	9,160	4,855
Mysore	14,900	7,688	14,672	7,582
Nundydroog	18,797	10,019†	18,052	10,262*
Ooregum	12,502	4,593	12,500	4,506

* 1,538 oz. from 932 tons Balaghat ore.
† 1,314 oz. from 924 tons Balaghat ore.

MISCELLANEOUS GOLD, SILVER, AND PLATINUM OUTPUTS.

	August.		September.	
	Tons.	Value £	Tons.	Value £
Bulolo Gold	—	8,045*	—	7,335*
Chosen Corp. (Korea)	13,250	16,508	12,200	18,435
Frontino Gold (C'lbia)	4,830	20,023	4,510	18,296
Fresnillo	83,532	65,148*d*	—	—
New Goldfields of Venezuela	14,563	3,490*	—	—
Oriental Cons. (Korea)	—	91,419*d*	—	58,180*d*
St. John del Rey (Brazil)	—	40,500	—	37,000
Santa Gertrudis (Mexico)	14,330	15,010*d*†	—	—
Viborita	—	—	—	—
West Mexican Mines	2,220	20,500*d*	—	—

* Oz. *d* Dollars. † Loss.

PRODUCTION OF TIN IN FEDERATED MALAY STATES.

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

January, 1933	2,312	July, 1933	2,446
February	2,154	August	1,816
March	1,506	September	1,335
April	2,589	October	—
May	1,917	November	—
June	1,092	December	—

OUTPUTS OF MALAYAN TIN COMPANIES.

In Long Tons of Concentrate.

	July.	Aug.	Sept.
Ayer Hitam	—	—	—
Batu Caves	49	—	—
Changkat	28	28	36
Gopeng	—	—	60½*
Hongkong Tin	—	—	74*
Idris Hydraulic	21⅛	8⅜	—
Ipoh	23⅜	37¼	15
Kampar Malaya	—	—	—
Kampong Lanjut	—	—	—
Kamunting	137	83½	75
Kent (F.M.S.)	—	—	—
Killinghall	—	—	76½*
Kinta	—	—	28½*
Kinta Kellas	—	—	—
Kramat Tin	50	40	40
Kuala Kampar	13	33	46
Kundang	—	—	—
Lahat	9⅝	12½	10⅜
Lower Perak	—	—	—
Malaya Consolidated	—	—	136
Malayan Tin	71½	62½	27½
Malim Nawar	5	26	23
Pahang	78	78	78
Penawat	32	43	32
Pengkalen	—	—	55½*
Petaling	—	89	—
Rahman	—	—	—
Rambutan	—	—	—
Rantau	33	—	—
Rawang	35	30	60
Rawang Concessions	27	30	30
Renong	40⅜	—	—
Selayang	—	—	—
Southern Kampar	130	—	—
Southern Malayan	59⅜	71½	71½
Southern Perak	57½	—	—
Southern Tronoh	15	—	—
Sungei Besi	—	—	—
Sungei Kinta	—	—	—
Sungei Way	59½	—	—
Taiping	16	—	—
Tanjong	—	—	—
Tekka	—	18½	39*
Tekka Taiping	—	—	54½*
Temoh	26	22	13¾
Tronoh	33	—	—
Ulu Klang	—	—	—

* 3 months to September 30.

OUTPUTS OF NIGERIAN TIN MINING COMPANIES.

In Long Tons of Concentrate.

	July.	Aug.	Sept.
Anglo-Nigerian	16	16	16
Associated Tin Mines	101½	100	100
Baba River	2	6	8
Batura Monguna	—	—	—
Bisichi	20	18	—
Daffo	—	—	—
Ex-Lands	24	21	23
Filani	—	—	—
Jantar	10	10	—
Jos	7½	7	—
Juga Valley	5½	5½	5½
Kaduna Syndicate	10	10	—
Kaduna Prospectors	6	7	—
Kassa	5	4	4
London Tin	70	73	76
Lower Bisichi	3	—	—
Naraguta Extended	—	—	—
Nigerian Consolidated	—	5	5
Offin River	—	—	—
Ribon Valley	10	7	6
Tin Fields	—	—	—
United Tin Areas	9	7	6
Yarde Kerri	—	—	—

OUTPUTS OF OTHER TIN MINING COMPANIES.

In Long Tons of Concentrate.

	July.	Aug.	Sept.
Anglo-Burma (Burma)	37⅜	42	—
Aramayo Mines (Bolivia)	90	110	—
Bangrin (Siam)	56½	87⅜	—
Beralt	26*	27*	—
Consolidated Tin Mines (Burma)	98	118	100
East Pool (Cornwall)	46	46	—
Fabulosa (Bolivia)	27	25	—
Geevor	66	61	59½
Kagera (Uganda)	25	28	—
Kamra	25⅜	26	17½
Malaysiam Tin	14½	14½	14½
Mawchi	226½*	240½*	264⅜
Patino	—	—	—
Pattani	67	68	66½
San Finx (Spain)	—	—	—
Siamese Tin (Siam)	130	219	—
South Crofty	53½	54⅜	53½
Tavoy Tin (Burma)	51	65	86
Tongkah Harbour (Siam)	35	39	32
Toyo (Japan)	65½	68	62
Zaaiplaats	—	—	—

* Tin and Wolfram.

COPPER, LEAD, AND ZINC OUTPUTS.

		Aug.	Sept.
Britannia Lead	Tons refined lead	4,703	—
	Oz. refined silver	297,729	—
Broken Hill South	Tons lead conc.	5,168†	—
	Tons zinc conc.	5,308†	—
Burma Corporation	Tons refined lead	5,880	5,880
	Oz. refined silver	510,000	495,400
Electrolytic Zinc	Tons zinc	—	—
Indian Copper	Tons copper	400	370
	Tons yellow metal	450	474
Messina	Tons copper	612	688
Mount Isa	Tons lead bullion	4,930	—
Mount Lyell	Tons concentrates	3,011*	3,496†‡
North Broken Hill	Tons lead conc.	6,400	6,060
	Tons zinc conc.	5,710	5,430
Rhodesia Broken Hill	Tons Zinc	1,650	1,620
	Tons V_2O_5 conc.	—	—
Roan Antelope	Tons blister copper	—	—
Sulphide Corporation	Tons lead conc.	1,756†	—
	Tons zinc conc.	2,547†	—
Trepca	Tons lead conc.	5,244	5,246
	Tons zinc conc.	7,621	7,585
Zinc Corporation	Tons lead conc.	5,193‡	—
	Tons zinc conc.	4,589‡	—

* To Aug. 9. † To Sept. 9. ‡ To Sept. 16. ‡‡ To Sept. 6.

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

		July.	Aug.
Iron Ore	Tons	229,023	227,527
Manganese Ore	Tons	8,759	15,181
Iron and Steel	Tons	63,434	79,710
Copper and Iron Pyrites	Tons	28,778	29,203
Copper Ore, Matte, and Prec.	Tons	5,729	63
Copper Metal	Tons	13,000	13,694
Tin Concentrate	Tons	2,376	2,929
Tin Metal	Tons	175	235
Lead Pig and Sheet	Tons	23,995	22,695
Zinc (Spelter)	Tons	8,185	7,280
Zinc Sheets, etc.	Tons	2,147	2,048
Zinc Oxide	Tons	54	59
Zinc Ore and Conc.	Tons	—	16,706
Aluminium	Cwt.	50,962	12,961
Mercury	Lb.	112,850	116,150
White Lead	Cwt.	7,375	5,851
Barytes, ground	Cwt.	31,718	26,525
Asbestos	Tons	2,384	2,250
Boron Minerals	Tons	819	846
Borax	Cwt.	10,690	8,440
Basic Slag	Tons	—	—
Superphosphates	Tons	180	—
Phosphate of Lime	Tons	34,432	35,009
Mica	Tons	99	142
Tungsten Ores	Tons	568	306
Sulphur	Tons	8,028	1,708
Nitrate of Soda	Cwt.	20	1,622
Potash Salts	Cwt.	122,405	454,116
Petroleum : Crude	Gallons	42,667,317	27,268,277
Lamp Oil	Gallons	17,032,268	12,509,352
Motor Spirit	Gallons	111,278,469	95,169,032
Lubricating Oil	Gallons	9,143,396	6,493,551
Gas Oil	Gallons	9,054,758	11,268,254
Fuel Oil	Gallons	37,857,365	42,226,108
Asphalt and Bitumen	Tons	11,221	8,818
Paraffin Wax	Cwt.	82,261	127,518

OUTPUTS REPORTED BY OIL-PRODUCING COMPANIES.

In Tons.

	July.	August.	Sept.
Anglo-Ecuadorian	18,168	18,208	17,099
Anglo-Persian	—	—	—
Apex Trinidad	42,870	44,120	41,280
Attock	1,106	1,113	1,035
British Burmah	4,819	4,513	—
British Controlled	27,773	27,191	25,841
Kern Mex.	835	856	551
Kern River (Cal.)	2,926	2,248	2,232
Kern Romana	126	222	168
Kern Trinidad	3,447	3,571	3,468
Lobitos	22,170	22,208	21,518
Phœnix	62,275	60,484	57,144
St. Helen's Petroleum	4,090	4,756	4,020
Steaua Romana	94,298	104,393	—
Tampico	2,292	2,312	—
Tocuyo	1,023	1,108	968
Trinidad Leaseholds	33,050	33,700	32,550

QUOTATIONS OF OIL COMPANIES' SHARES.

Denomination of Shares £1 unless otherwise noted.

	Sept. 9, 1933.	Oct. 10, 1933.
	£ s. d.	£ s. d.
Anglo-Ecuadorian	16 0	15 9
Anglo-Egyptian B	1 10 0	1 12 6
Anglo-Persian 1st Pref.	1 11 0	1 11 0
,, ,, Ord.	2 6 9	2 10 0
Apex Trinidad (5s.)	1 7 0	1 8 6
Attock	11 9	12 6
British Burmah (8s.)	4 9	4 6
British Controlled ($5)	5 3	5 9
Burmah Oil	4 5 6	4 6 9
Kern River Cal. (10s.)	5 9	5 3
Lobitos, Peru	2 8 9	2 9 3
Mexican Eagle, Ord. (4 pesos)	12 0	11 6
,, ,, 8% Pref. (4 pesos)	12 0	11 0
Phœnix, Roumanian	12 6	12 6
Royal Dutch (100 fl.)	22 10 0	22 7 6
Shell Transport, Ord.	2 15 0	—
,, ,, 5% Pref. (£10)	11 15 0	12 0 0
Steaua Romana	11 0	13 0
Trinidad Leaseholds	2 19 3	3 8 9
United British of Trinidad (6s. 8d.)	5 6	5 3
V.O.C. Holding	2 2 6	1 17 6

PRICES OF CHEMICALS. Oct. 10.

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	15	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	5
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.		2	8
,, ,, crystallized, 40°	per lb.			9½
Carbon Disulphide	per ton	30	0	0
Citric Acid	per lb.			9½
Copper Sulphate	per ton	16	5	0
Creosote Oil (f.o.b. in Bulk)	per gal.			4½
Cresylic Acid, 99-100%	,,		1	3½
Hydrofluoric Acid, 59/60%	per lb.			6
Iodine Resub. B.P. (28 lb. lots)	,,		9	3
Iron, Nitrate 80° Tw.	per ton	6	0	0
,, Sulphate	,,	1	15	0
Lead, Acetate, white	,,	34	0	0
,, Nitrate (ton lots)	,,	27	10	0
,, Oxide, Litharge	,,	28	0	0
,, White	,,	36	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	15	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	10	0
,, Chlorate	per lb.			4½
,, Chloride, 80%	per ton	9	10	0
,, Ethyl Xanthate	per 100 kilos	7	8	0
,, Hydrate (Caustic) 88/90%	per ton	39	10	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)	,,	7	15	0
,, Phosphate, comml.	,,	12	0	0
,, Prussiate	per lb.			4¾
,, Silicate	per ton	9	10	0
,, ,, (liquid, 140° Tw.)	,,	8	10	0
,, Sulphate (Glauber's Salt)	,,	2	15	0
,, ,, (Salt-Cake)	,,	3	3	6
,, Sulphide, Conc., 60/65%	,,	10	15	0
,, Sulphite, pure	per cwt.		14	0
Sulphur, Flowers	per ton	9	7	6
,, Roll	,,	9	7	6
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	49	0	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)	,,	30	0	0
,, Sulphate	,,	9	0	0

SHARE QUOTATIONS

Shares are £1 par value except where otherwise noted.

GOLD AND SILVER:	Sept. 11, 1933.	Oct. 9, 1933
	£ s. d.	£ s. d.
SOUTH AFRICA:		
Brakpan	5 17 6	5 17 6
City Deep	1 11 9	1 15 0
Consolidated Main Reef	2 7 6	2 5 6
Crown Mines (10s.)	9 6 3	9 2 6
Daggafontein	4 15 0	4 12 6
Durban Roodepoort Deep (10s.)	2 2 6	1 19 3
East Geduld	6 12 6	6 13 9
East Rand Proprietary (10s.)	1 16 0	1 15 0
Geduld	6 13 9	6 15 0
Geldbenhuis Deep	1 8 0	1 7 6
Glynn's Lydenburg	1 15 0	1 15 0
Government Gold Mining Areas (5s.)	2 13 9	2 13 9
Grootvlei	4 0 0	3 16 3
Langlaagte Estate	1 8 0	1 7 6
Luipaard's Vlei (2s.)	12 6	12 6
Modderfontein, New (10s.)	3 6 3	3 5 0
Modderfontein B (5s.)	1 1 0	1 0 9
Modderfontein Deep (5s.)	19 3	1 0 3
Modderfontein East	3 2 6	2 18 9
New Kleinfontein	1 18 9	1 10 9
New State Areas	3 2 6	3 0 0
Nourse	2 2 6	1 19 3
Randfontein	2 16 6	2 15 3
Robinson Deep A (1s.)	13 9	13 9
" " B (7s. 6d.)	1 13 9	1 11 9
Rose Deep	1 3 0	1 1 3
Simmer and Jack (2s. 6d.)	11 3	11 0
Springs	5 11 3	5 7 6
Sub Nigel (10s.)	8 17 6	9 1 3
Van Ryn	1 8 9	1 7 6
Van Ryn Deep	2 0 0	1 19 3
Village Deep (9s. 6d.)	1 9	1 6
West Rand Consolidated (10s.)	1 4 9	1 3 6
West Springs	1 18 9	1 15 0
Witwatersrand (Knights)	1 6 3	1 6 3
Witwatersrand Deep	1 9 3	1 7 6
RHODESIA:		
Cam and Motor	2 13 9	2 11 6
Globe and Phœnix (5s.)	1 0 0	1 1 6
Lonely Reef	11 3	13 9
Luiri Gold (5s.)	9	9
Rezende (17s. 6d.)	1 10 0	1 8 9
Sherwood Starr (5s.)	12 9	12 6
Wanderer	17 6	17 6
GOLD COAST:		
Ariston (2s. 6d.)	8 3	8 3
Ashanti (4s.)	2 5 9	2 6 3
Taquah and Abosso (4s.)	13 9	13 9
AUSTRALASIA:		
Associated Gold (4s.), W.A.	4 9	4 3
Boulder Perseverance	3 6	3 0
Gold Mines of Australia	12 0	10 6
Golden Horseshoe (3s.), W.A.	4 9	4 3
Great Boulder Propriet'y (2s.), W.A.	10 6	10 0
Lake View and Star (4s.), W.A.	1 6 6	1 6 0
Sons of Gwalia (10s.), W.A.	1 16 9	1 15 6
South Kalgurli (10s.), W.A.	1 12 6	1 12 6
Waihi (5s.), N.Z.	1 1 0	1 1 6
Wiluna Gold, W.A.	2 15 6	2 10 6
INDIA:		
Champion Reef (10s.)	1 9 3	1 5 6
Mysore (10s.)	17 9	15 9
Nundydroog (10s.)	2 19 6	2 18 0
Ooregum (10s.)	9 9	7 9
AMERICA:		
Camp Bird (2s.), Colorado	9	1 4
Exploration (10s.)	3 6	3 6
Frontino and Bolivia, Colombia	1 14 3	1 14 3
Mexican Corporation (10s.), Mexico	9 3	9 6
New Goldfields of Venezuela (5s.)	7 6	8 0
St. John del Rey, Brazil	1 5 0	1 4 6
Santa Gertrudis, Mexico	5 3	5 9
Viborita (5s.), Colombia	4 6	4 3
MISCELLANEOUS:		
Chosen, Korea	18 9	18 9
New Guinea	6 0	5 6
COPPER:		
Bwana M'Kubwa (5s.), Rhodesia	5 3	5 0
Esperanza	6 3	6 3
Indian (2s.)	2 3	2 6
Loangwa (5s.), Rhodesia	3 0	2 6
Mason and Barry	1 2 0	1 0 0
Messina (5s.), Transvaal	11 3	11 0
Mount Lyell, Tasmania	17 6	19 0
Namaqua (£2), Cape Province	3 6	3 6
Rhodesia-Katanga	12 3	12 0
Rio Tinto (£5), Spain	20 15 0	19 10 0
Roan Antelope (5s.), Rhodesia	1 8 6	1 7 9
Tanganyika Concessions	15 9	15 0
Tharsis (£2), Spain	3 16 3	3 16 3

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

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.

MINING METHODS AT SHERRITT GORDON

The methods of mining and milling that it was proposed to adopt on the Sherritt Gordon Copper-Zinc mine, in Northern Manitoba, were set out by the staff of the property in a paper appearing in the *Canadian Mining and Metallurgical Bulletin* for August, 1930, which was reproduced in the Mining Digest of the MAGAZINE for September, 1930. In the issue of the same paper for September, 1933, E. L. Brown describes the mining methods actually employed on the mine and gives details as to costs.

The No. 3, or main working, shaft, details of which were given in the paper already referred to, was sunk in the foot-wall of the West ore-body at an angle of 51°. The first station was cut at a depth of 200 ft. on the incline, with succeeding stations at regular intervals of 150 ft. The additional 50 ft. above the first level was allowed as a surface pillar.

LATERAL DEVELOPMENT (Ore Dipping 45° to Vertical).—The third, or 500-ft. level, was driven along the foot-wall contact of the ore, about one-third of the face being kept in the ore. Near the end of the ore-body (the last 700 ft.) the drive was driven 7 by 8 ft. and was single tracked. In the centre of the ore-body it was driven 7 by 15 ft. and was double tracked. The track was 24-in. gauge and was laid with 35-lb. rail. Switches from the hanging-wall track to the foot-wall track were put in at intervals of about 350 ft. Air and water lines were carried along the back of the drive on the hanging-wall side. An open drainage ditch was also carried along on the hanging-wall side. Box-holes were put in on the foot-wall side of the haulage drive at 30-ft. intervals. Rises 5 by 5 ft. were driven in the ore at 120-ft. intervals. These rises started from a box-hole and followed the foot-wall of the ore up to second level. After connexion had been made with the second-level drive they were driven up to first level. Similarly, after connexion had been made with the first-level drive the rise was driven up either to surface or to the sub-level at the bottom of the surface pillar. All the muck broken in driving these rises passed down to the third level, where it was drawn off through the box-holes.

First-, second-, and the sub-level drives at the bottom of the surface pillar were driven in the foot-wall, parallel to the ore. The drives were driven 4 by 6½ ft. and were kept, as nearly as possible, from 10 to 15 ft. from the ore. These drives were connected by short cross-cuts with the rises driven up from the third level. The cross-cuts were driven so that they broke into the side of the rise near the hanging-wall. This left the foot-wall of the rise unbroken and the muck from above did not lodge in the cross cuts.

STOPING (Ore Dipping 45° to Vertical).—The first step in the stoping method was to cut out a stope floor connecting all the box-holes above the third level. This was done by slashing around the box-holes, funnelling them out until they connected with each other. Slashing was continued until both foot-wall and hanging-wall were exposed. In places where the ore was too narrow to permit of slashing, short inclined rises were driven to connect the box-holes. Fig. 1 shows a stope floor cut out ready for stoping. This work was contracted at from $0·40 to $0·70 per ton, the price varying with the width of the ore. The contract price covered all labour and explosives.

The next step was to start a bench at the top of one of the rises at the second level. This was done by slashing around the top of the rise until both walls were exposed and a bench about 8 ft. wide was cut out on each side of the rise. The ore broken in slashing fell down the rise and was drawn off through the box-holes on the third level. The bench on one side of the rise was then drilled-off with pluggers, the holes being spaced at the corners of 2-ft. squares. The ore on the hanging-wall side of the rise, if any, was drilled off in the same way. The bench was then blasted, the broken ore falling down the rise into the box-holes on the third level. The close spacing of the holes broke the ore small enough so that it gave very little trouble by hanging-up in the rise. This bench was carried down in this manner until it broke through to the stope floor above the third level. The holes in the benches were drilled about 10 ft. deep, so that each blast took the bench down about that distance. One of these first benches is shown in Fig. 1. A ladderway was carried down along the foot-wall, together with the air and water lines. Heavy ladders were used, the sides being 3 by 4 in. fir and the rungs being made of 1-in. iron pipe. The top ladder was chained to two steels drilled into the foot-wall and wedged and succeeding ladders were hooked together with *S*-shaped hooks made of ½-in. round iron. After the first bench had been carried through to the stope floor above the third level a second bench was started at the second level and carried down in the same manner.

These successive benches were drilled off with holes spaced about 3 ft. apart, as once the first bench had been carried through there was no longer any danger of big muck hanging up. When slashing to start the benches at the second level, a ledge or path was cut into the foot-wall for a width of 3 to 4 ft. This ledge was used as a manway along the top of the stope and the ladderways down to the benches were started from it. Short cross-cuts were driven through to the second-level drive as desired, thus shortening the distance travelled along this ledge or goat-path, as it was called locally. Benches were taken down in succession, retreating from the rise. Either side was worked as desired, but it was found from experience that it was not efficient to work benches on both sides of an opening

at the same time. When both sides were worked at once the ladderways and pipe-lines were often broken by rocks from the opposite benches during blasting.

The face of the stope was carried back for a distance of 50 to 55 ft. from the centre line of the rise. As the rises were at intervals of 120 ft., when the face of the stope retreating from an adjoining rise had been carried back a similar distance, a rib pillar from 10 to 20 ft. thick was left between the two stopes. The thickness of the pillar depended upon the width of the ore at that particular point; in some cases the pillar was stoped out and the hanging-wall left unsupported. In the event of a lean or narrow section of the ore-body being encountered, before the stope face had retreated back to the regular pillar location, the narrow or lean section was left as a pillar and the regular pillar was stoped out. In this way the percentage of good ore tied up in pillars was very small.

After the faces of the stope between the second and third levels had retreated from 30 to 40 ft. back from the centre-line of the rise a bench was started at the top of the rise at the first level. This bench was carried down along the rise until it broke through into the open stope below the second level. The muck broken into the rise fell down through the open stope into the box-holes on the third level. This stope was carried back in the same manner as the stope below. Similarly, when the stope faces between the first and second levels were sufficiently far back from the centre-line of the rise, a third stope was started between the first level and the sub-level at the bottom of the surface pillar. The ore broken in this stope also fell down through the open stopes into the box-holes on the third level.

Where the width of the ore was over 9 ft. three men were used on a bench; where it was less than 9 ft. two men were used. The stopes were worked two shifts per day, the same as all the other mine operations. The morning shift was from 8 a.m. to 4 p.m. and the evening shift from 7 p.m. to 3 a.m. This allowed sufficient time between shifts for the smoke from blasting to clear away. For the slashing done in starting benches, etc., Waugh 7 and 7L drifters were used. For the drilling on the benches, which was all underhand, Waugh 7, 7L, and 107L pluggers were used. The stope-men took their own sharp steel from the stations into the stopes. The dull steel was collected in the stopes by the nippers and taken up to the steel shop. The stope-men got their powder from the nearest underground cache, where each group of contractors had its own locked box. The powder was distributed to these local caches by the powder-man once a day. The fuses were all treated with Celakap, when capped, in order to get away from missed holes on the benches.

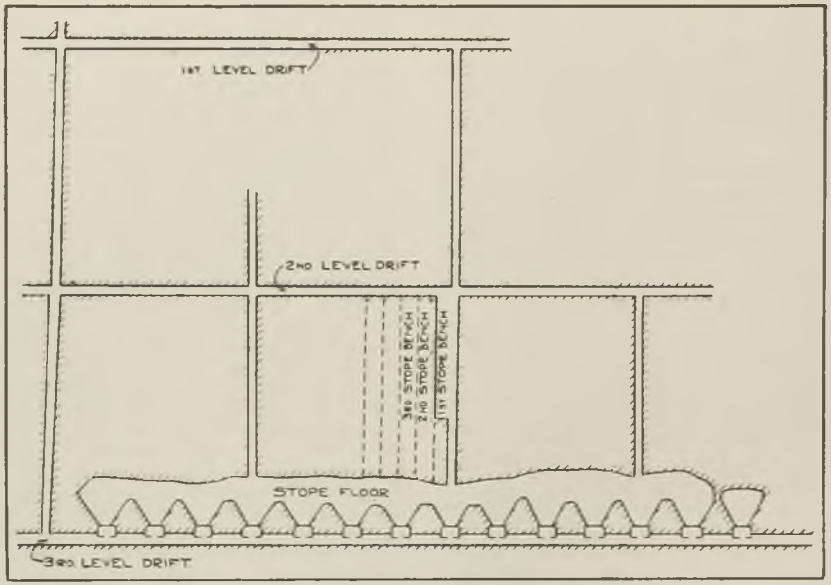


FIG. 1.—SECTION IN PLANE OF SHEAR ZONE, SHOWING PART OF ORE-BODY WITH STOPE FLOOR CUT AND STOPING STAIRED AT ONE RISE.

A safety belt and 50 ft. of ½-in. manilla rope was issued to every man in the stopes. The men had to sign for the belts but were not charged with them, except when they lost or destroyed them. The men were required to wear the belts when working on the benches and any man caught working without a safety belt was liable to be dismissed. After every blast the walls were sealed tight and then never gave any further trouble. The men were always working beside a solid pillar of ore, so that, even if the hanging-wall had slabbed-off over an unsupported span, they would not have been caught. In one or two places the foot-wall showed a tendency to slab-off, so, as it was not wanted that the ore should be diluted with this barren foot-wall rock, the slabs were pinned to the solid foot-wall by anchoring 1¼-in. iron bars in holes drilled through the loose slabs into the solid foot-wall. The stoping system was found to be perfectly safe as long as the safety regulations

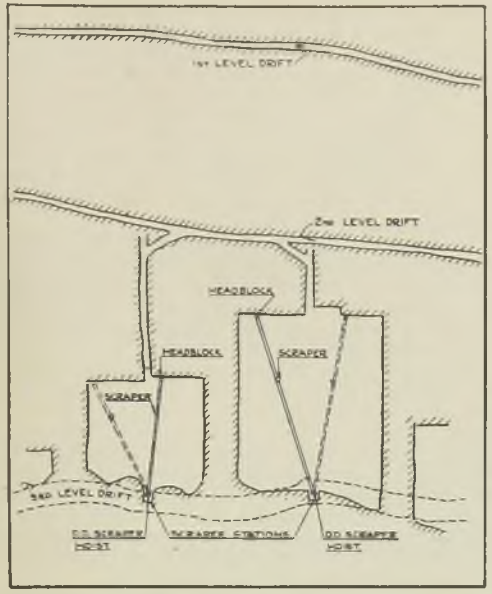


FIG. 2. — STOPES IN FLAT-FLYING ORE-BODY, SHOWING SCRAPING METHOD.

which had been laid down were adhered to. In fifteen months of operations in these stopes there was only one fatal accident and that was a man falling into an open stope entirely through his own carelessness. Practically the only other accidents in these stopes were foot injuries due to men dropping pluggers on their feet.

The system was thoroughly tried out with widths of ore varying from less than 3 to over 50 ft., and with dips varying from 45 to over 70°. The average stope width during 1931 was 12·5 ft.; during 1932 it was 12·1 ft. Very complete extraction of the ore was obtained, as any ore left on either foot-wall or hanging-wall while one bench was being carried down was easily cleaned off when the next bench was carried down. Dilution was kept at an absolute minimum, as the men could always see just what had to be taken out. With this system of stoping there is no money tied up in broken ore and the cost per ton of developing the ore for stoping is very small.

LATERAL DEVELOPMENT (Ore Dipping Less than 45°).—The third, or 500-ft., level drive was driven in the same manner as for the steeper ore. Box-holes were put in on the foot-wall side of the drive at 30-ft. intervals as before, with the exception that every fourth box-hole was omitted. The reason for this was that the flatness of the hanging-wall necessitated the provision of regular rib pillars for support. Hence the ore-body in this flat area was divided into 90- to 100-ft. stopes with 20- to 30-ft. rib pillars in between. As every fourth box-hole would have been located in a pillar they were omitted. Rises 5 by 5 ft. were driven in the ore, following the foot-wall, as before, at 120-ft. intervals, starting from the centre box-hole of each group of three. As these rises were too flat for the broken ore to run down to the box-hole it was necessary to wash the muck down with water after every blast. Scraping in these rises was tried, but found to be more expensive than washing down with water. As this flat-dipping area is located under Camp lake we did not plan on doing any stoping above the first level, hence the rises were not driven above this level. Connexion was made with the service drives as before by means of short cross-cuts. The first and second level service drives were driven as before, with the difference that cars were used for tramming instead of wheel-barrows and the muck was trammed back to a rise that was steep enough for the muck to run down to the third level by gravity.

STOPING (Ore Dipping Less than 45°).—The stope floor was cut out in the same manner as in the steeper part of the ore-body, except that the regular pillars cut it up into 100-ft. sections. A small heading, about 7 by 7 ft., for use as a scraper station, was then driven into the hanging-wall at the foot of the rise. The heading was driven in for a depth of about 10 ft. A bench was then started each way from the foot of the rise and carried along horizontally for a distance of 45 to 50 ft. from the centre-line of the rise. The bench was carried the full thickness of the ore, except where the thickness exceeds 8 ft. Where this was the case the bench was carried about 6½ ft. high along the hanging-wall and the ore left on the foot-wall taken out by underhand stoping using pluggers. When the first bench was finished a second was started at the rise and carried along in the same manner. The rise was used as a man-way and air and water lines were brought down from the second level.

When the face of the stope got so far above the box-holes that the muck started to pile up on the foot-wall the scraping outfit was put in operation. A double-drum, air-driven scraping hoist was set up in the scraper station, the air line for the hoist being brought up through a drill-hole from the third level below. The head-block was anchored in the face of the stope and the muck scraped down

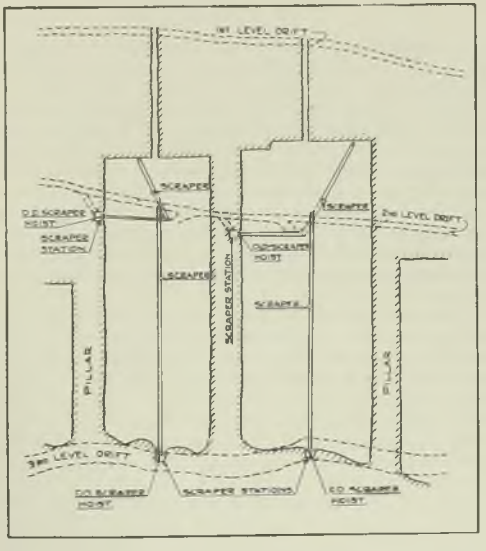


FIG. 3. — STOPES IN FLAT-LYING ORE-BODY, SHOWING METHOD PROPOSED FOR HANDLING MATERIAL OVER 2ND LEVEL.

into the box-holes. The head-block was anchored to a wedged eyebolt, which was readily moved. In this way the head-block could be moved along the face of the stope as required. The scraping layout is illustrated by Fig. 2.

Sullivan scraping hoists and head-blocks were used for this work, with ½ in. cable. The scrapers were made on the job. With the equipment we had we could scrape for 200 ft. on the incline. As none of these flat stopes got above the second level before the mine shut down we did not get a chance to try our plan for handling the muck from above the second level. Our plan was to cut out a second scraper station at the second level and to scrape the muck down to the third level box-holes in two stages. The second scraper station would have been cut out in one of the pillars and the muck scraped to the centre of the stope by using two extra blocks, as shown in Fig. 3.

Mucking and Tramming.—All the muck broken in the stopes from the third level to surface was drawn off through the box-holes on the third level. When getting out an average of 500 tons per shift the loading and tramming crew was made up as follows: One motorman, who also acted as trammer boss; one chute-blaster; and four loaders. Two extra muckers were carried on each shift to take the place of any loaders that were off and to keep the drives cleaned up. The cars used were 80-cu. ft. Granbys, built by the Manitoba Bridge Company. One storage battery locomotive did all the tramming. The locomotive was a five-ton Goodman, equipped with two batteries so that one was always on charge. The total length over which the muck was being drawn was about 2,000 ft. The standard type of platform chute has already been described.

The mine was divided into three sections for tramming purposes. The loaders worked in pairs and the regular practice was to have each pair of loaders in a different section. The motor would leave a train of five or six empty cars in one section and, while the loaders were filling these, would go to another section and pull out a full train to the tipple. In this way the motor was kept going almost steadily throughout the shift. The loaders spotted the empties under the chutes, then, after filling them, they coupled up the train ready for the motor to pull it out. The motor also had to haul the trains of Hudson cars from the face of the haulage drive.

The Granby cars, on passing the tipple, automatically dumped on to a slide which fed the muck into the crusher by gravity. The crusher ran continuously during each shift without any attention, except that the chute-blaster looked it over at intervals.

Hoisting.—One hoist-man and one cage-tender on each shift took care of all the hoisting. The hoist-man would operate either cage-hoist or skip-hoist according to the signal given by the cage-tender. All the usual supplies were taken down on the cage. Powder was taken down once per day, the two shifts' supply being taken down at 11.30 a.m. and distributed to the various caches underground. Steel was taken down and brought up once each shift. In addition to this cage work the cage-tender did all the skip loading.

The loading station at the 600-ft. level was equipped with loading pockets with a capacity of one skip-load. The flow of crushed ore into these pockets was controlled by guillotine gates operated by air lifts. The bottoms of the pockets opened by means of a toggle-gate arrangement operated from the same platform as the guillotine gates. The two four-ton skips operated in balance and travelled at a speed of 1,000 ft. per minute. With this layout it was possible to load, hoist, and dump from 200 to 240 tons per hour.

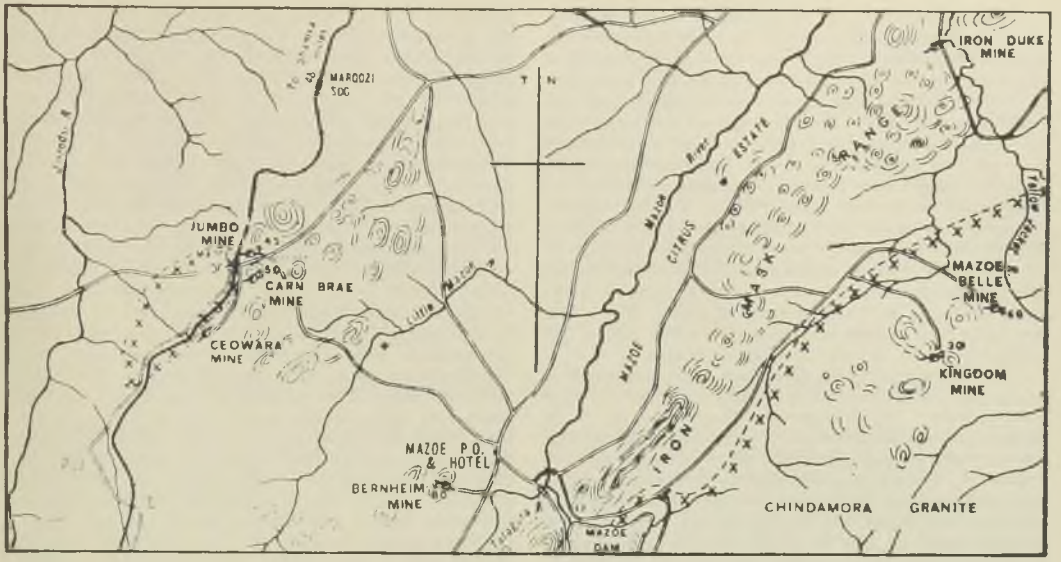
MAZOE DISTRICT, SOUTHERN RHODESIA

An article by R. Tyndale-Biscoe, of the Geological Survey of Southern Rhodesia, that appeared in the *Rhodesian Mining Journal* for April and May last contains some geological notes on gold-mining properties in the Mazoe district. The author says that the notes are not based on detailed surveys of the properties concerned, but on brief examinations made for special purposes, and the country around them has not been mapped in detail. Consequently they are in no way complete accounts of the ore-bodies and their geological setting. The accompanying sketch map shows the positions of the properties mentioned.

Bernheim and Rothschild Mines.—These are old properties upon which development work has been recently resumed. They are on a rather prominent hill to the south-west of Mazoe village, on the west side of the Tatagura River and facing the Iron Mask range. Mr. Lightfoot examined the workings early in December, 1932, and has recorded some interesting details concerning the ore-body and country rocks. These notes are based on his report. The country rock, of which the greater part of the hill is composed, is mainly an ancient porphyritic dolerite which is probably intrusive into slate. This slate forms bands in the mine and in one place is associated with a gritty band. Some of this material is seen under the microscope to be fragmental and probably represents a volcanic breccia or tuff. The strike is north 70° east (magnetic) the dip at one place where measured being north-westward at about 50°.

The ore-body is essentially a quartz fissure vein, but the fissure is not wholly filled with quartz, the filling including broken country rock with stringers of calcite. The reef contains some arsenical pyrites in depth. Where recently exposed in a winze put down from the adit level the fissure is 19 in. wide and contains two narrow quartz veins. The hanging-wall is more clearly defined than the foot-wall. The fissure dips steeply to the south-south-west, the strike being about west-north-west. It has therefore not been formed along the bedding planes of the sediments or their contacts with the porphyritic dolerite, but cuts across them.

Rothschild Parallel.—Other more or less parallel fissures occur in the vicinity, such as the two on the Rothschild claims some 500 ft. south of the Bernheim reef. What is known as the Rothschild Parallel, about 150 ft. south of the Rothschild Reef, is now under development and was also recently examined by Mr. Lightfoot. Unlike the Bernheim fissure, the Rothschild Parallel has a well-defined foot-wall, but indefinite hanging-wall, and the filling is extraordinarily irregular, consisting chiefly of broken country rock with only a small quantity of quartz



Sketch Map of Country around Mazoe.

and calcite. This is at the fifth and sixth levels and Mr. Lightfoot considers that the fissure should persist to a great depth. The extraction previously obtained from the ore stoped in the upper levels was 8 dwt. per ton and there seems no reason why this tenor should not be maintained in depth.

The two properties produced, according to the output returns, 14,528 oz. of gold from 45,148 tons of ore crushed from 1905 to 1910 and 6,695 oz. from 19,348 tons from 1917 to 1923, the average recovery during the first period being 7·4 dwt. and that of the second 8·2 dwt. per ton.

Ceowara Mine.—A small elliptical area of granite lies to the west of the Salisbury-Shamva railway line in the neighbourhood of Mazoe Siding. The eastern margin of this mass has been proved as a zone of gold deposition upon which several properties are located. The best-known of these is the Jumbo mine, which has produced a considerable amount of gold in the past and is producing again now after a long interval, but the bulk of the output of this belt now comes from the Ceowara and Carn Brae mines, situated south of the Jumbo and immediately east of the railway line.

The Ceowara mine is situated about a mile south-south-west of Mazoe Siding, on a belt of ferruginous quartzites with interbedded phyllites belonging to the Banded Ironstone formation, striking north-east to south-west, roughly parallel to the granite margin at this locality. On the south-east side this formation is in contact with a massive white siliceous rock of fine-grained texture, consisting chiefly of quartz and felspar and strongly resembling a felsite. Felsite is a convenient name to apply to it provisionally, but it might equally well be of sedimentary origin—that is, a felspathic quartzite or arkose. What it actually is may only be decided by detailed mapping of a large area of the country round for it has been so strongly metamorphosed that its original character cannot be determined merely by examination of the rock itself at one locality.

The workings of the mine are on two low ridges on a south-west to north-east alignment, separated by a small stream, which may be called the South Kop and North Kop respectively. The conditions differ somewhat in the two groups of workings.

On the North Kop a large deposit of low-grade ore is being worked by the open-cast method. The ore is highly ferruginous quartzite of a rather incoherent character, which makes it easy to work, the gold being disseminated irregularly through it so that there is no defined limit to the payable ore except at the north side of the quarry. Here the ore-body ends abruptly against a well-defined fault plane dipping northward at 55°. As this is probably a reversed fault, it is not likely that the ore-body will be found beyond it. The extension on the far side has probably been eroded away, having once been at a higher level. The effects of weathering, causing considerable migration of the iron oxides (limonite) in the rock, have largely obliterated the banding or bedding planes so that it is not easy to determine the dip of the ironstone. What little evidence there is suggests that the dip is south-easterly at a very low angle, perhaps 10°.

Adits driven into the face of the hill near the stream have exposed several small dykes of granite in a very weathered state cutting the banded ironstone, but little indication is afforded of the character of the ore-shoots. The irregular shape and ill-defined margins of the latter make it impossible to plan development work systematically. On the whole, it is found that the best values occur in the more ferruginous, dark red and brown parts of the rocks; those parts poor in iron, which are white in colour and frequently decomposed to a fine soft white sandstone, being in general unpayable. The inference is that the texture of the latter was less favourable to the passage of the gold-bearing solutions rising through the rocks from the granite mass beneath, than that of the former.

The conditions in the South Kop are more complex. Here there seems to be a remarkable concentration of payable gold values on the upper surface of a sheet of granite dipping north-westward

at a low angle. This is presumably an offshoot from the main granite mass. In addition, there are vertical ore-shoots which extend from the surface down to the granite sheet and there end abruptly. It is said that, where these vertical shoots join the ore-body at the granite surface, values are particularly high. An adit put into the western face of the hill on the incline has penetrated the granite sheet and exposed epidiorite below it. The surface of this epidiorite is dipping north-westward at about the same angle as the granite sheet, but is separated from it by four feet or so of shattered banded ironstone. The thickness of the granite sheet in the adit is approximately 25 ft. and its dip is north-westward at about 30°. The ore-body at its upper surface is about 8 ft. thick, but probably varies a great deal in thickness.

It appears at present, therefore, that the location of the pay shoots in the South Kop was controlled by two factors: (i) the granite sheet, and (ii) beds of suitable composition and texture in the formation above which account for the vertical shoots. However, there is a great deal to be learned about this occurrence. If the gold-bearing solutions rose through the rocks one would expect values to be concentrated at the lower surface of the granite sheet owing to its damming effect. The conditions suggest that the solutions moved laterally outward from the granite, above the sheet, and that the texture induced in the overlying rock by the contact metamorphism of the latter was favourable to the precipitation of the gold.

An extraction of nearly 5 dwt. per ton is being obtained at present, about 1,000 tons of ore being crushed per month. A chilian mill is at work on the North Kop and a five-stamp battery on the South Kop. The production of gold in 1931 was 367 oz. from 1,725 tons of ore; in 1932, 1,905 oz. were won from 7,920 tons of ore.

Carn Brea Mine.—This mine is situated on a prominent hill east of the railway and close to Mazoe Siding. The property has only been cursorily examined and little is known about it. It is evident, however, that the geological conditions are very different from those at the neighbouring Ceowara mine. In the first place, the reef is a well-defined fissure vein; in the second place, the country rock is "felsite," similar to that occuring in the south-east side of the Ceowara mine. The fissure varies in width from a few inches to about four feet and is occupied by quartz stringers, sometimes swelling out to considerable widths, and strongly-sheared country rock. It has a very constant dip of about 50° in a northerly direction and is evidently strong and persistent.

About 500 tons of ore a month are being crushed by a five-stamp battery and an extraction of about 11 dwt. per ton has been obtained during 1932, when 2,256 oz. were won from 4,010 tons of ore. Previous to that, during 1930 and 1931, 1,725 tons were crushed for a yield of 871 oz., representing a recovery of about 6·5 dwt. per ton.

Iron Duke Mine.—The high hills called the Iron Mask range which lie between the Mazoe valley and the granite country of the Chindamora Native Reserve are composed chiefly of fine-grained quartzites and quartz-schists, weathering white, and with these rocks are interbedded several layers of banded ironstone which, owing to their resistant character and steep dips, usually form the cores of steep-sided "razor back" ridges. The Iron Duke mine is situated on one of these layers of banded ironstone and the old workings for gold are on both sides of the Yellow Jacket River, which cuts through the range in a deep gorge. The principal working is an open-cut nearly 300 ft. long by 70 ft. wide and 60 ft. deep, the longer axis running in a nearly east to west direction. The north wall is composed of banded ironstone, the south of soft white decomposed quartzite, and it appears that the principal gold-bearing reef occupied a fissure at the contact, which dips north at a steep angle, and that there was also considerable impregnation of the wall rocks.

The mining returns show that, from 1914 to 1920, 32,240 tons of ore were crushed and that the yield from mill and tailings was 5,673 oz. of gold, indicating a recovery of 3·5 dwt. per ton. The proposition was therefore low-grade and this, no doubt, accounts for the fact that the mine was not worked to a greater depth. A vertical shaft was sunk on the south side of the open-cut, only a few feet from the face, to a depth of 160 ft. and a cross-cut was put in to the north, under the open-cut, for 160 ft. Gold values were not good in this cross-cut, but a large body of iron pyrites and vein quartz was intersected in the last 60 ft., the proportion of pyrite to quartz increasing northward. This body ends abruptly against a hanging-wall of hard epidiorite dipping north at about 70°. This is certainly a fault plane, probably earlier than the mineralization. Stoping has been carried out there for a width of some 30 ft. The foot-wall of the pyrite body is not well defined and there has been much impregnation of the foot-wall country rock by the pyrite. Drives have been put in east and west from the cross-cut, about 110 ft. from the shaft, for short distances on the vein quartz, which here is poor in pyrite, in the hopes, it is said, of proving a gold shoot. The values, however, were not encouraging.

The country rock in contact with, and impregnated by, the pyrite on the south (foot-wall) side of the body is not a magnetite-quartzite, as might have been expected from surface indications, but a greywacke. The pyrite has penetrated this rock in well-defined bands which might, on weathering, produce a strong resemblance to banded ironstone. It is quite possible, therefore, that much of the "banded ironstone" at the surface is really greywacke penetrated by bands of pyrite.

If the quartz-pyrite body were persisting to the surface one would expect to see some vein quartz exposed. Actually nothing is exposed and the inference is that the body is lenticular and does not reach the surface. It is likely that the fault seen at its north margin determined the pyrite ore-shoot, particularly as the pyrite content increases as this fault-plane is approached, and the fissure is probably persistent. Consequently, although the pyrite body exposed in the workings is lenticular and therefore limited in extent, other lenses may be expected to occur along the fissure, either in depth or on the strike.

Iron pyrites is now being mined at the property, 300 tons having been won in October, 1932, and 657 tons in January, 1933, the ore containing approximately 40% sulphur.

Mazoe Belle Mine.—There is apparently a belt of fissuring and injection of gold-bearing quartz veins in the Chindamora Reserve granite mass near its western margin, facing the Iron Mask range. The properties opened up in this belt include the Kingdom, Mazoe Belle, and Yellow Jacket Mines.

The veins are sometimes associated with inclusions of greenstone-schist and of quartz-schist in the granite, which are very numerous in this tract of broken country. The Kingdom reef is an inclusion of greenstone-schist, while the inclusions around the Mazoe Belle mine are mainly quartz-schist, usually micaceous, though greenstone-schist bodies also occur. The quartz-achist strongly resembles some of the rocks of the Iron Mask range.

The reef under development at the Mazoe Belle mine has granite on both walls and is a well-defined fissure vein striking east and west and dipping south at from 56 to 65°. Its proved length of strike is about 400 ft. but there are indications of its existence over a length of 640 ft. The fissure varies in width from a little over a foot to three feet and is occupied partly by vein quartz, usually white in colour but grey in places, and in texture glassy, granular, or laminated, with little sulphide mineralization, and partly by strongly sheared granite, in places resembling a schist.

Water level had not been reached in the workings when the writer visited the mine and as the sheared granite in the fissure should permit readily of downward percolation of water, there might be some secondary enrichment at that level.

TREATMENT OF GREAT BEAR LAKE PITCHBLENDE

Following the discovery of high-grade deposits of pitchblende in the Great Bear Lake area of the Canadian North-West Territories in May, 1930, samples were submitted to the Mines Branch, Canadian Department of Mines, for examination and investigation as to suitable methods of treatment. In the *Canadian Mining and Metallurgical Bulletin* for September R. T. Traill gives the result of the investigation and outlines the methods developed for the extraction of the radium content of the ore and for the recovery of the by-products. The following summaries of procedure are set out in the paper, one suitable for each of the two types of ore developed, and these are illustrated by the accompanying flow-sheets.

High-Silica Pitchblende Ore.—The suggested process for the extraction of radium from the high-silica type of pitchblende may be described as follows :—

The ore, ground to — 35-mesh, is leached with 20% (13·5° Bé) hydrochloric acid at a temperature about 90° C. with constant agitation for three hours. A solution of sodium nitrate is then added in such manner that oxidation will not be too rapid, nor frothing excessive. The amount of acid and nitrate required is governed by the composition of the ore. The total leaching time is about five hours and when completed the solution and residue are separated by filtration. Filtration must be carried out while the leach liquor is hot, as lead chloride separates out rapidly with cooling and tends to carry with it some of the radium. The residue is washed with boiling-hot water. The leach liquor and washings are combined and, while still warm, barium chloride and sodium sulphate are added and the whole agitated and allowed to cool. Agitation is continued for twenty-four hours, when the precipitate of radium-barium sulphate and lead chloride is allowed to settle. The precipitate so obtained is separated by filtration and washed with acidulated water to remove uranium and base-metal chlorides. The washed precipitate is then treated with an almost saturated solution of hot brine, whereby the lead chloride is dissolved, leaving the radium-barium sulphate insoluble, which is then filtered off and washed with boiling water. This radium-barium sulphate constitutes the concentrate that is ready for the refining process.

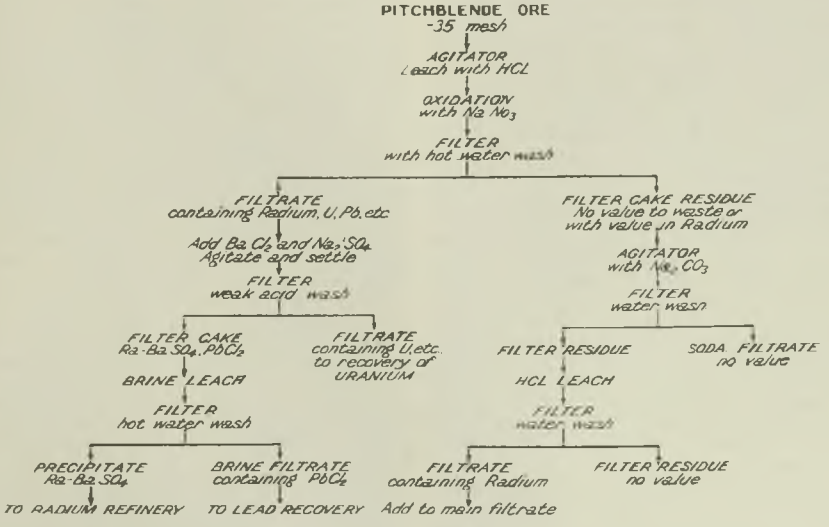


Fig. 1.—Flow-Sheet for Silica-Gangue Pitchblende Ore.

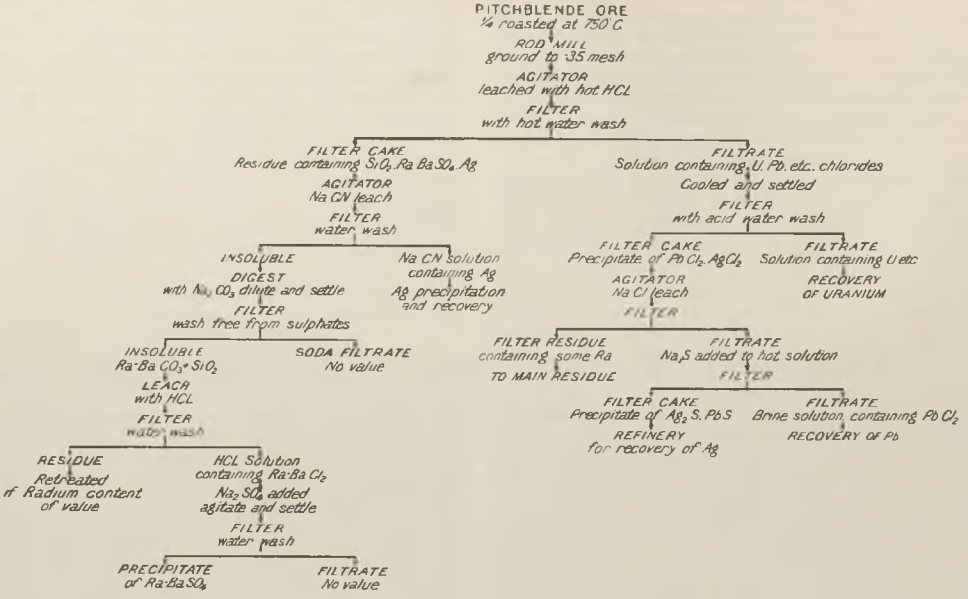


FIG. 2.—FLOW-SHEET FOR CARBONATE-SILVER PITCHBLENDE ORE CONTAINING BARYTES.

CARBONATE-BARYTES-GANGUE PITCHBLENDE ORE.—For the extraction of radium from the carbonate-barytes-silver type of pitchblende ore the procedure recommended may be briefly set out as follows :—

The ore, crushed to ¼-in. size, is roasted in a suitable furnace at a temperature of 750° to 800° C. The roasted ore is ground to 35-mesh and leached with hydrochloric acid (13·5° Bé) for about three hours. The insoluble is then separated by filtration and washed with hot water to remove lead salts. From the cooled filtrate lead chloride and a small amount of silver chloride are recovered and the uranium solution treated for recovery of uranium. The insoluble residue, containing the radium and barium, silver, and silica, is then leached with an alkaline solution of sodium cyanide to dissolve the silver. The cyanide solution carrying the silver is separated by filtration and the silver recovered by precipitation as sulphide with sodium sulphide or as metallic silver with zinc or aluminium. The residue, now free from silver, is heated with a boiling solution of sodium carbonate to convert the radium and barium sulphates to carbonates. The insoluble, containing the carbonates, is filtered off, washed thoroughly to remove excess alkali and sodium sulphate, and the carbonates dissolved in C.P. hydrochloric acid. The chloride solution is then filtered, the insoluble, consisting mostly of silica, well washed, and the radium and barium reprecipitated by the addition of a slight excess of sodium sulphate solution or sulphuric acid. After about 24 hours' agitation the precipitate of radium-barium sulphates is allowed to settle and recovered by filtration. The precipitate so obtained constitutes the radium concentrate ready for refining.

RECOVERY OF URANIUM.—Although no attempt has been made so far to conduct large-scale tests on the recovery of uranium, small-scale tests indicate that this should present no serious difficulty. Methods already established are quite applicable and the general scheme may be briefly outlined as follows :—

The main acid-leach filtrate carried, as shown in the test results, practically all of the uranium in chloride solution, together with iron, copper, lime, etc. Excess of sodium carbonate precipitates the base-metals, leaving the uranium in solution as sodium uranyl carbonate. The base-metals precipitate is removed by filtration, the uranium solution neutralized with acid, and sodium uranate precipitated by the addition of sodium hydroxide. The sodium uranate is separated by filtration, washed and dried, and prepared for market according to the colour, purity, and grade required.

CONCLUSIONS.—Investigation of the presently available pitchblende ores from the Great Bear Lake area indicates that they can be readily treated for the recovery of radium. The ores examined comprise two distinct types, differing widely in gangue-forming elements, one being a highly-siliceous-gangue pitchblende and the other a carbonate-barytes-gangue pitchblende carrying silver. No single process would appear to be economically suited to the treatment of the two types of ore for recovery of radium and for reasons of greater efficiency and better economic operation two separate processes are suggested.

Plant operation on the unit principle is advisable in working with such high-grade and valuable material and when, for the most part, similar chemicals and equipment are applicable to both processes the two-process plan should be quite feasible. Units capable of treating 100 kilograms (220 lb.) of ore per charge, based on present grade of ore, are suggested. Laboratory tests on a scale one-tenth this capacity have given satisfactory results, the uranium and radium extractions being well over 90% in all tests and all operations, such as filtrations and washing, have been performed without difficulty.

The procedure recommended for the high-silica-type ores is simple and direct, requiring a minimum of operations and time to produce a high-grade radium concentrate.

The procedure for the carbonate-barytes-silver pitchblende, though involving a greater number of operations and longer time, is equally efficient and also permits of a high recovery of the silver content.

No attempt has been made to estimate costs of operation, as these are dependent upon variables that cannot be determined with sufficient accuracy from laboratory-scale operations.

BLASTING WITH LIQUID OXYGEN

In *Mining and Metallurgy* for September progress in blasting with liquid oxygen (Lox) at Chuquicamata is described by W. D. B. Molter. The author points out that during the early development of blasting with liquid oxygen explosives the trend of experiment was towards increasing the effectiveness of the explosive. Its characteristic of becoming inert after evaporation of the oxygen content made a strong appeal from the standpoint of safety, especially with missed holes. It later became apparent, however, with practical use of this explosive, that Lox lacked certain other safety characteristics. As its effectiveness was increased it became more subject to detonation by impact. The object of the present paper is to show the steps taken by one operating company to achieve greater safety in the large-scale handling of liquid oxygen explosives.

The author then goes on to describe the additions to the plant for the manufacture of Lox cartridges at Chuquicamata and outlines the research work carried out on the property in an endeavour to eliminate the causes of premature explosions. Earlier work at the United States Bureau of Mines (R.I. 3169) is referred to and the author says that the standard mixture first adopted for the manufacturing of cartridges after the Bureau of Mines' tests consisted of 76% granular carbon, 10% calcium carbonate (whiting), and 14% moisture. At the beginning of the experiments at the Bureau Holderer had discovered that moisture alone acted as a desensitizer for granular carbons. The mine staff followed up this idea and found that a mixture of 80% granular carbon and 20% moisture, with no whiting, gave more consistently insensitive results than did the mixture containing whiting. The average of the results on the impact machine for the mixture containing 20% moisture was a drop of 54·6 cm. for " ten no explosions " and the lowest result obtained was 36 cm. In addition this mixture has a higher combustible content and, due to its higher moisture, is better from a practical standpoint in that practically no " dusting " occurs in case of a broken cartridge ; in other words the stream of oxygen rising in the churn drill-hole carries practically no finely-divided carbon and is therefore not an explosive mixture. This cartridge mixture was thereupon adopted as the standard mixture for a Lox absorbent. It apparently shows no practical diminution in strength compared with low-moisture-content mixtures. The effectiveness of this cartridge mixture has been determined by actual blasting practice.

Comparing the above sensitivity tests, as determined on the impact machine, with fixed explosives, it has been found that the ammonia-gelatine dynamites of from 60 to 90% equivalent strength used at Chuquicamata give " ten no explosions " with a minimum drop of from 28 to 43 cm., depending upon their class. On the other hand the free-running explosives which are of 60% equivalent strength give " ten no explosions " at a minimum drop of 150 cm. This is direct proof of the fact that Lox, based on a granular carbon absorbent containing 20% moisture, is less sensitive to impact than the ammonia-gelatines in constant use for churn-drill hole blasting on the property.

Practical experience of several years with Lox has shown that the calculated burden in the drill holes per pound of explosive can be 15% greater with Lox than with the fixed high explosives. The actual breakage per pound of explosives, however, has been from 15 to 25% greater with Lox compared with the high-grade fixed explosives.

Air-gap tests—detonations by influence—carried out at the mine, as well as at the Bureau of Mines, confirmed the impact tests and showed that the mixture now being used is of greatly reduced sensitivity.

A difficulty in Lox blasting when small cartridges are used is the relatively short effective life of the explosive. This difficulty becomes less apparent as the size of the cartridge is increased. At Chuquicamata the practice is to use cartridges of two different sizes. One size is 6¾ in. diameter by 21½ in. long, to be charged into an 8-in. churn drill-hole. The other is 9 in. in diameter by 21½ in. long, for charging into a 10-in. churn-drill hole. The 6¾-in. cartridge is soaked in liquid oxygen until it absorbs oxygen to a ratio, expressed in terms of dry combustible in the carbon, of about 3·5 to 1. The 9-in. cartridge is soaked to a ratio of about 3·8 to 1. The evaporation of the oxygen from the cartridge starts immediately upon removal from the soaking box. With the 6¾-in. cartridge it reaches the carbon dioxide point, where the oxygen-carbon ratio is 2·66 to 1, in half an hour. It reaches the carbon monoxide point, where the oxygen-carbon ratio is 1·33 to 1, in about two hours. It is customary to blast these cartridges when the oxygen-carbon ratio is 2 to 1—that is, midway between the two points—as the cartridges at that ratio of oxygen are very effective. With the 6¾-in. cartridges this point is reached in one hour after removal from the soaking boxes. With the 9-in. cartridge the carbon dioxide point is reached in 45 minutes, the carbon monoxide point in about 2¾ hours, and the 2 to 1 ratio point requires almost 1½ hours.

These tests are carried out in the churn drill-hole, where the evaporation is slower than in free air and more accurately represent actual practice. The data show that the time element is not seriously detrimental to the use of Lox in the blasting of churn-drill holes such as are used at Chuquicamata. It becomes a question of organization of the loading crews so that the holes can be loaded and tamped and the blast detonated within a period of about an hour.

Continuing the discussion of the experiments, a careful study was made of pressures developed in a tamped drill hole and concluded that pressures so developed could do no damage *per se*. However

cartridges and tamping were blown out of drill-holes when the tamping was damp and when it consisted of fine and coarse material so as practically to seal the hole. The tamping material used is the tailing from the leaching plant. The practice of washing the tamping material was instituted to take out the fines and thus to allow a free passage of the excess oxygen.

An artificial equivalent of a drill-hole was set up, consisting of casing fastened to the structures of a bridge. This was used to test for deformation of the cartridge on dropping and similar purposes. As a result of the tests on cartridge material and to avoid the rupture of the cartridge bags, No. 10 duck is used entirely in the manufacture of these bags and the three bottom cartridges to be loaded in each hole are double-sacked.

In carrying out these tests it was found that the tamping material, when shovelled down a string of casing with a free discharge at the bottom, carried a stream of sparks as it emerged. It was then found that crushed limestone caused no sparks of this nature. Therefore, it was decided to introduce a small bag of crushed limestone on top of the last cartridge of each charge before the tamping material is shovelled into the holes, a practice that is carried out in the loading of all holes. Incidentally, monel-metal shovels are used entirely for shovelling the tamping.

Tests were carried out in the artificial drill holes to determine the relative quantities of finely-divided carbon carried up in the churn-drill hole by the ascending gaseous oxygen. The 80% granular carbon and 20% moisture gave the best result in this respect, showing the least dusting.

Since the earlier tests on the original mixture, consisting of 65% granular carbon and 35% of gas-black, had shown occasional detonations on dropping rocks down a drill hole on top of the cartridges, this test was repeated with the new cartridge material. Over 2,000 rocks were dropped on the cartridges, consisting of granular carbon alone in 8-oz. and 12-oz. bags, without the occurrence of a single detonation or explosion.

It has been stated that Lox will not detonate instantly on coming into contact with a flame, even when confined. This was proved to be incorrect, for a cartridge was detonated as the result of being ignited by an ordinary safety fuse at the bottom of a churn drill hole.

There is no question as to the advantages, from the standpoint of safety, that Lox has over fixed explosives, owing to its becoming inert after the evaporation of the oxygen. This allows a missed hole to be cleaned out with absolute safety after proper time has elapsed to be certain that an explosive mixture no longer exists. With large cartridges, such as are used at Chuquicamata, it may be advisable to wait for several days before attempting this, but in connexion with these large blasts this waiting period introduces no hardships. Missed holes, however, are rare with the use of Cordeau.

Upon completion of a long series of tests carried out at Chuquicamata, after the safety of the explosives had been thoroughly demonstrated, blasting with this material was resumed on a commercial scale and ,with every success. Those responsible feel confident that in Lox, as handled under our practice, they have an explosive that introduces no hazards greater than those of fixed explosives and has several safety advantages over fixed explosives, such as no storage problems and no dangers from cleaning out or digging into missed holes. However, due to the curtailment of operations and to the resulting large stocks of fixed explosives on hand in the magazines, it was decided again temporarily to discontinue the use of Lox in order to deplete the large stocks of fixed explosives before they should spoil with age. Blasting by this method was therefore discontinued in May, 1932, although one blast was fired in October of that year, and the total tonnage blasted to date has amounted to 7,145,000 tons.

In the early use of Lox it had not been considered that it could compete with black powder made locally in Chile on account of the low cost of that explosive. However, shortly before blasting with Lox was temporarily stopped in 1932, the staff at the mine had developed an economic method for blasting the shattered ground by means of Lox instead of black powder. For this purpose 10-in. churn-drill holes were used, together with the 9-in. Lox cartridges. The blasts showed an actual saving in cost over those in which black powder had been used in the same type of ground. This greatly extends the possible application of Lox at Chuquicamata.

Comparing Lox blasting costs with those applying to fixed high explosives, the fact that some 15 to 25% more ground is broken per pound of Lox (the weight estimated at the time of firing) and the fact that the cost of Lox per pound at the time of firing is greatly below the cost of the fixed high explosives make a material saving by the use of this explosive. In calculating the cost of Lox for this purpose interest on the plant investment and depreciation of the plant are taken into consideration, as is necessary for a proper comparison.

An outline of the method of blasting procedure developed as a result of these experiments, and which embodies the safety features, is given below : Liquid oxygen is manufactured and is constantly drawn off into the vacuum-wall storage containers. In the cartridge plant the necessary cartridges are packed with the standard mixture of granular carbon containing 20% moisture and these cartridges are stored in an airtight storage room properly humidified to maintain the moisture content at the uniform percentage.

When preparing for a blast and before placing the cartridges in the soaking boxes samples are taken from random cartridges for checks on the moisture content. All cartridges are passed through a gauge ring and over-size cartridges, if any, are rejected. The cartridges to be used are then subjected to a blast of high-pressure air to blow off any adhering carbon dust. They are packed in a vertical position into special soaking boxes mounted on flat cars, each box holding 60 cartridges. Before filling them each box is swabbed out and then blown with high-pressure air to remove any residual fine carbon from the last soaking. The soaking boxes are well grounded at all times when in use. Rope-soled shoes are provided for everyone working around the boxes—in fact, for everyone working in connexion with the blast.

The flat cars are moved to the siding which passes through the end of the Lox plant and are spotted opposite the flexible metallic delivery hoses. The Lox is forced in by an air pressure of 15 lb. per sq. in. from the storage containers (which are installed in pits below the floor level) and the liquid oxygen is discharged into the soaking boxes. When all the boxes on the flat cars have been filled the train

is moved and spotted immediately above the bench, the face of which is to be blasted.

At the site of the blast an electrical survey has then been made to determine if there are any stray currents in the ground emanating from the power lines or electrified railways. Protective bonding is then installed to equalize such differences in potential. This survey is repeated just before loading. Third rails and power cables in the neighbourhood of the shot are cut for 50 metres on each side of the shot and watchmen are posted there. Yellow flags isolate the area and no one not connected with blasting operations is allowed to enter. The churn drill-holes are carefully inspected, and none may be loaded with Lox that is—

(*a*) Crooked enough so that the bottom may not be seen when inspecting it with a mirror, or

(*b*) When there is danger of rocks sloughing off the side, or

(*c*) When projections are likely to cause a cartridge to lodge.

The few holes that come in the above classifications are loaded with dynamite. In addition to the inspection with a mirror a heavy iron dolly is dropped into the hole and six blows are given to explode any stray cap, exploder, or dynamite that might be present. Cordeau is then placed so as to extend the length of the hole and a yellow wooden plug inserted in the casing, which plug must not be removed until ready to load the cartridges into the hole. The following regulations are also adhered to :—

(*a*) No fires are allowed within 200 metres of the loading area.

(*b*) No smoking is allowed near explosives. This rule is never violated.

(*c*) Rubber mats are used to receive Lox-carrying trays.

(*d*) No person is allowed within the loading areas who is not wearing rope-soled shoes.

(*e*) Monel-metal shovels are used exclusively for handling tamping.

Upon the arrival of the train of flat cars at the loading site runways are placed on to the cars; the Lox cartridges are quickly removed from the soaking boxes on to carrying trays which are handled like stretchers by two men ; the men run to the loading positions and dump their trays on to the rubber mats at the respective holes. A loading crew quickly drops the specified cartridges into each hole and a tamping crew follows them immediately.

As soon as all holes have been tamped the lines of Cordeau in each hole are connected to the trunk lines of Cordeau which extend in each direction beyond the blast ; at the last moment the electric detonators are connected to each end of the Cordeau trunk lines, the leads from these detonators being carried to a special railway car designed for the control of the blast. This car derives its current from the power lines and contains the switches for the detonation of a blast. In the meantime locomotive whistles have given warning and when all is clear the electrician in the blast control car closes the switch and detonation takes place.

SULPHUR MINING UNDER WATER

The mining of sulphur from under Lake Peigneur, Louisiana, by the Frasch process is described by L. O'Donnell in *Chemical and Metallurgical Engineering* for September. The author says that sulphur in the Gulf Coast country is found in the cap rock overlying salt domes. Oil is also found in the cap rock or on the sides of domes. Due to immense pressure, beds of salt at depths of close to five miles have become plastic and, in the form of a plug, have forced their way through faults or fissures to a point close to the surface of the ground. Jefferson Island is one of a group of five islands rising above the marsh. Its elevation is caused by a salt plug distorting the underground and surface strata. It is believed, in fact, that there are two separate domes at Jefferson Island, one under the hill and the other under the basin of the lake. No doubt in some past era the dome under the lake was also characterized by an elevation, but owing to the solution of the salt by migratory waters, the ground has subsided, leaving the basin which forms the lake. The size of the Lake Peigneur dome is approximately that of the lake, about two miles long and one mile wide.

Salt at Jefferson Island rises to within 95 ft. of the surface. A shaft has been sunk and salt is now being mined at the rate of about 8,000 cars per year by the Jefferson Salt Mining Co. The Jefferson Lake Oil Co., Inc., after drilling a number of dry oil wells around the edge of the dome, decided as a last resort to make a location in Lake Peigneur. At a depth of about 650 ft. limestone cap rock was struck. At 660 ft. the bit picked up traces of sulphur and continued deeper with increasing quantities of sulphur to a thickness of 208 ft., when anhydrite terminated the sulphur zone. At a depth of 871 ft. pure rock salt was struck. It was indeed a surprise and a pleasant one to find a salt dome under Lake Peigneur, for the high purity of the sulphur encountered, together with the great thickness of the deposit, gave all indications of a very rich find.

The cap rock above the salt is divided into three parts. At the top is a thin layer of porous limestone containing much calcite. Underlying this is the sulphur zone. This zone is of varying thickness and contains limestone, similar to that in the upper zone, together with calcite and sulphur of non-uniform richness and irregularly distributed thickness. The sulphur is sometimes found in thin layers, again in very small crystals even microscopic in size, again as large crystalline masses in columns extending upward through the beds. It is sometimes found in the shape of stalactites and in the openings and crevasses made by circulating waters. Sometimes it appears as perfect crystals, nearly transparent and bright yellow in colour. Again, these crystals are pale amber (colour, apparently, has nothing to do with the purity). In other parts of the deposit amorphous sulphur is found, powdery and soft in appearance and of a pale yellow colour. Large volumes of hot sulphide waters are circulating in the sulphur zone. Below the sulphur zone is a layer of anhydrite or calcium sulphate. This zone is very thin and is directly over the salt. All of these zones merge into each other and at times are difficult to outline definitely.

In May, 1931, after excellent sulphur indications had been found in a number of wells the Jefferson

Lake Oil Co. decided to produce this sulphur commercially and proceeded with the construction of a plant. The first foundations of the new plant were laid October 18, 1931, and the first sulphur was successfully produced on October 20, 1932. The method of sulphur mining used at Barba, Louisiana, is the Frasch process. With this method the sulphur is melted in the cap rock by means of superheated water and is then raised to the surface in a molten state by the use of compressed air. Since enormous quantities of water are necessary to provide sufficient heat for large-scale mining by the process the power plant is one of the most important factors in the development of a sulphur project. The power plant was designed to provide about 1,500,000 gallons of water per 24 hours. This water must be free of all scale and foreign substance so as not to plug the lines that distribute it to the field and the individual wells. The temperature of the water is about 320° F. and its pressure must be above 100 lb. gauge so as to maintain this temperature.

Since the mining operations are being conducted in the middle of Lake Peigneur the question arose as to the best location for the power plant. As it would have been very costly to build in the lake near the site of mining operations it was decided to construct the plant on the shore of the lake and pump the water a distance of about a mile to the mining operations. The situation chosen on the lake shore has an elevation higher than the surrounding territory. This high ground afforded sufficient bearing for spread-foot foundations and effected considerable saving through elimination of piling.

With the erection of the plant a reservoir of 20 acres area and of 50 million gallons capacity was constructed as storage for water to provide for continuous operation. Water from this reservoir is pumped directly into the water-treating plant by means of two 600-g.p.m. pumps. The water-treating plant comprises two 40,000-g.p.h. Cochrane units. These are of the hot-process type, using lime and soda ash for treatment. Water to be treated is continually analysed by a competent chemist to insure zero hardness. After treatment the water is passed through six filters filled with non-silicate filter material.

During the softening process the water is heated to a temperature of about 218° F., using mainly exhaust steam from the turbine-driven pumps. A continuous blow-down of 5% from the boilers is also discharged into the water-treating plant, thereby conserving the heat energy in the blow-down and re-treating the blow-down water before it is returned to the boilers. Two water circuits are maintained after the water leaves the softener. In one system the water passes directly into the boilers ; in the other it passes into the high-pressure mine-water heaters. The boiler water is further treated with sodium sulphate, so as to correct the sulphate-carbonate ratio and prevent caustic embrittlement. Anhydrous sodium phosphate is also added to the boiler water to reduce the hardness to zero and prevent silicate scale. Sludge from the water-treating plant is discharged into a mud pit to be used as drilling mud in the sulphur wells to be drilled in the lake.

Steam at about 100 lb. pressure is provided by five Babcock and Wilcox Class H boilers, each of 600 h.p. capacity. The boilers are designed to operate continuously at 200% rating. They are of fusion-welded drum construction. The greatest part of the steam passes from the boilers into the mine heaters. These heaters are of the Cochrane jet type and operate at 100 lb. gauge pressure. Here the 218° water from the water-treating plant is heated to about 320°, at which temperature the water is pumped from the heaters to the mine by means of mine-water pumps. These pumps raise the pressure of the water to about 250 lb. gauge.

Pumps and Compressors.—All pumps are Cameron centrifugals driven by G.E. Curtis impulse-type, single-stage turbines, exhausting at 5 lb. back pressure. This pressure of exhaust steam is necessary to maintain a temperature of 218° in the water-treating plant. High-pressure air for the mine is furnished at 500 lb. gauge pressure by Ingersoll-Rand steam-operated, three-stage compressor units. Temperature recorders are provided throughout the plant to record the various temperatures of fresh water, treated water, and mine water. Other instruments such as steam-flow meters, pressure gauges, recording thermometers, and oil meters permit the operating engineers to keep a continuous check on the operating efficiency of the plant.

In designing the plant lay-out, every consideration had to be given to continuous operation for after the plant is once started up it is absolutely impossible to shut it down. If it were to be shut down for any period of time the sulphur in the lines would freeze as would the sulphur in the wells, thereby causing immense financial loss and damage in the mining operations. For this reason duplicate pumping equipment, heaters, and boilers have been provided throughout the power-plant system. The piping arrangement was designed so that any duplicate pump could operate at any time, and with any heater. Although the pressure is only 100 lb. extra-heavy valves and fittings are provided throughout so as to insure continuous operation.

Development.—It was necessary to do a great deal of pioneer work in the production end, as this was the first time in the history of sulphur mining that the operations were to be carried out in the middle of a lake and over water. With the power plant situated on the shore of the lake, about a mile from the centre of mining operations, it was necessary to build a trestle from the power plant to the point of mining. Creosoted piling and timbers were used for the construction of this trestle which carries five pipe lines: hot water, steam, cold water, air, and sulphur. The hot-water line, steam line, and sulphur line are insulated with 3-in. of mineral wool covered by galvanized iron. Many carloads of mineral wool were used in this installation. Large expansion joints had to be provided for the lines as the pipe expands under temperature about 2 ft. in every 1,000 ft. The lines terminate at the sulphur station where booster pumps are located for forcing water down into the wells. Here also is the steam-jacketed collecting sump of 40 tons' capacity, used to accumulate sulphur from the wells. Steam-jacketed centrifugal sulphur pumps transfer the liquid sulphur from the bin to the storage vats, which are on the shore of the lake near the rail-road terminal. The sulphur solidifies in these vats. It is then blasted down and loaded into cars by means of a locomotive crane. These vats are about 160 by 500 by 40 ft. high.

Mining.—Successful working of the Frasch process depends on keeping the underground strata of the dome at sufficient temperature to melt sulphur. This makes it necessary that the strata also be pressure-proof, as sufficient pressure must be

maintained to keep the water at the melting temperature of sulphur, which is above 240°. Since the wells used for mining the sulphur are very similar to oil wells, an oil well rotary rig is used for drilling. In the first operations on Lake Peigneur this rig was installed on top of piling, but this was found to be a very expensive process, so a drilling rig was developed which could be placed on top of a barge and floated from well to well. This barge is of steel construction and is permanently equipped with a complete set of drilling machinery. All machinery on the barge is operated by electricity supplied by submarine cable at 2,300 volts. The barge is held in position by means of four 8-in. pipes at its corners, passing through the barge and into the lake bottom. The barge is maintained level by a very accurate distribution of the drilling machinery. Since the level of the lake rises as much as a foot in a 10-hour period, a telescopic joint was devised to take care of this change in elevation during connexion to the casing of the well.

Whereas it takes three or four days to move the average drilling rig, this rig has been moved from one well to another in as short a time as 10 minutes. Although the barge cost in the neighbourhood of $8,500, it is estimated that as much as $5,000 is saved per well by its use. Seventy wells have been drilled successfully. A number of the large oil companies have copied the barge and it has been used in other marine operations in drilling for oil.

In operating with this barge, a surface casing is first set to shut off the lake water and silt. This is a 12-in. pipe about 40 ft. long. A 10-in. hole is then sunk rapidly to cap rock, a distance of 600 ft. An 8-in. casing is set in the hole and cemented. After allowing the cement to set, the hole is drilled and cored to the bottom of the sulphur-bearing formation. The well is then equipped for sulphur mining, the equipment including a 6-in., a 3-in., and a 1-in. line, set concentrically. An 8 by 6-in. stuffing box is provided at the surface so that the 6-in. line can expand in the 8. Similarly a 6 by 3-in. and a 3 by 1-in. stuffing-box are provided. Two sets of holes are drilled in the 6-in. pipe at about the bottom of the sulphur-bearing formation. The lower group is used as a strainer for the sulphur as it enters the 6-in. pipe. When it is melted the sulphur drops to the bottom of the well, as its specific gravity is twice that of water. The upper group of holes is used as an outlet for water pumped into the well. Between the two groups of holes is a seat or seal which supports the string of 3-in. pipe. The 1-in. pipe is supported from the top of the well by means of a coupling on the stuffing-box.

In steaming a well the procedure is as follows: The water from the plant at about 320° is forced down into the well between the 3-in. and the 6-in. pipes at a pressure of about 100 to 250 lb. This water, having a specific gravity of 0·9, rises to the top of the dome, melting sulphur as it rises. The melted sulphur (specific gravity about 2) drops to the bottom of the well where it is forced up the 3-in. pipe a short distance by the dome pressure. The compressed air of varying pressure under 500 lb. raises the sulphur to the surface. Under certain conditions sufficient sulphur will be melted by the water to permit the well to operate for weeks and months at a time. Under other conditions, sufficient sulphur is not melted and the sulphur elevation lowers so that hot water enters the 3-in. pipe. Coming to the surface such water flashes into steam when it reaches the atmosphere pressure and the well is said to "blow." Air is then cut off from the well and water is pumped down the 3-in. and 6-in. pipes until sufficient sulphur is again melted, which usually requires about a three-hour period.

Production Capacity.—Based on the experience of older sulphur mining operations, the power plant at Barba was designed for a capacity of about 300 long tons of sulphur per day. The production has been far greater than this amount; it has reached over 1,400 long tons per day at times and is now averaging over 1,200 long tons per day. This success is due in part to a thorough understanding of mining conditions at the Lake Peigneur dome by the field operating crew and in part to most efficient operation of the power plant. The very modern and efficient machinery also is a contributing factor. In the mining operations every consideration has been given to the principles of thermodynamics involved. Since the beginning of production on October 20, 1932, nearly 200,000 long tons of sulphur has been produced. This sulphur as it comes from the wells is 99·92% pure. One well has produced nearly 50,000 tons and is still producing continuously.

Future of Frasch Process.—Successful mining of sulphur since 1893 has involved the solution of hundreds of seemingly insolvable mechanical problems. The process as practised has been perfected to the last detail. But it should be borne in mind that most of the sulphur produced so far has been mined under ideal conditions. Since many of these ideal deposits are on their way toward exhaustion, future developments in the Gulf coastal country will involve some very interesting new problems. One of the first of these problems is the one that has more or less been solved at Barba—that is, mining from beneath water and marsh lands. Even here there are many details yet to be contended with; among these is the subsidence of the lake bottom. Another problem to be solved is the mining of deep deposits. In the solution of all of the problems is the question of costs. Added to the high production costs accompanying severe mining operations are increased taxation and excessive royalty demands. On this account all new departures involving higher costs must be considered carefully, for there is always a possibility of increased competition from pyrites and by-product sulphur.

Sedimentation.—A paper by R. F. Stewart and E. J. Roberts presented before the Institution of Chemical Engineers on October 6 last gave the results of a survey of the theory and practice of the sedimentation of fine particles in liquids. The authors say that practical interest in sedimentation lay for a long time almost entirely with the metallurgical industry and the engineers in this field contributed greatly both to the theory and practice. At the present time, sedimentation equipment is a vital part of many other industries and its field of use is continually expanding. The basic theory is old, but its limitations and modifications are still but partially developed. Especially in the realm of flocculent suspensions is the underlying theory incomplete. Practical testing methods for determining sizes of machines to be used are available, but the invention and development of new machines will no doubt be greatly stimulated by further investigation of the many interesting phenomena observed in practice and as fresh problems are uncovered.

SHORT NOTICES

Hand Tramming.—The equipment necessary for hand-tramming operations is discussed by Lucien Eaton in the *Engineering and Mining Journal* for September.

Mine Organization.—In *Revue de l'Industrie Minérale* for August 15 the rational organization of work in mines is discussed by P. Audibert.

Jelubu Dredge.—A paper by E. F. Harris on the construction of the Jelubu dredge, F.M.S., delivered before the Dredging Association of Southern Malaya, is reproduced in the *Far Eastern Review* for August.

Tacheometrical Levelling.—R. McAdam gives the results of a practical and theoretical investigation into the precision of tacheometrical levelling in the *Colliery Guardian* for September 29.

Flotation of Mother Lode Ore.—In the *Engineering and Mining Journal* for September the remodelled plant of the Idaho Maryland Mines Co. at Grass Valley, California, is described by E. W. Ellis.

Dusty Coal.—A method for determining the dustiness of coal or coke is described by A. R. Powell and C. C. Russell in *Industrial and Engineering Chemistry* (Analytical Edition) for September 15.

Welding.—"Welding and Allied Processes for Engineering Purposes," a Cantor lecture delivered before the Royal Society of Arts by A. Stephenson in March last, is reproduced in the *Journal* of the Society for September 15.

Placer Gold.—The use of the microscope in the evaluation of placer-gold deposits is described by A. L. Crawford in *Mining and Metallurgy* for September.

Geophysics.—H. Lundberg and F. Kihlstedt discuss geophysics applied to geology in the *Canadian Mining Journal* for September.

Electrical Prospecting.—R. P. du Ceccatty describes the electrical prospecting of the sub-soil and the application of the various methods in mineral prospecting in the *Revue de l'Industrie Minérale* for September 15.

Migration of Gold.—A research carried out in New Guinea on the chemical migration of gold is described by R. Blanchard in the *Engineering and Mining Journal* for September.

Saddle Reefs.—In *Metall und Erz* for September 1 Dr. E. Seidl discusses the tectonics of the saddle-reef formations in southern Australia.

Thunder Mountain, Idaho.—C. P. Ross describes the geology of the Thunder Mountain mining district, Idaho, in *Economic Geology* for September-October.

Asbestos Mining in Russia.—Russian asbestos-mining methods are described by W. A. RuKeyser in the *Engineering and Mining Journal* for September.

Gold Mines of Le Châtelet.—The geology of the gold mines of Le Châtelet (Creuse) and the methods of mining employed there are described by M. Filippini in the *Revue de l'Industrie Minérale* for September 1.

Lead Scrap.—Lead scrap and its effect on the lead market is discussed by S. Tzach in the *Engineering and Mining Journal* for September.

Sedimentary Volcanism.—Dr. H. G. Kugler describes the effects of sedimentary volcanism in Trinidad in the *Journal* of the Institution of Petroleum Technologists for September.

Mining Laws of Norway.—In *Tidsskrift for Kjemi og Bergvesen* of Oslo, No. 3, 1933, H. H. Smith has extracted the United States Bureau of Mines Information Circular No. 6654 and calls attention to certain minor mistakes contained therein.

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.*

35,922 of 1931 (396,690). C. R. Kuzell, Arizona. Complex sulphide ores are given an intensive oxidizing treatment in order to recover volatile elements in their gaseous state and to form an iron oxide melt from which copper may be directly recovered by a converting operation.

2,137 of 1932 (395,760). K. W. Young and Imperial Chemical Industries, Ltd., London. Plumbiferous pyrite ores are subjected to a controlled roasting operation by which the lead sulphide is volatilized and recovered in that form.

2,404 of 1932 (396,058). Vereinigte Stahlwerke A.-G., Dusseldorf. Iron or manganese ores containing arsenic or antimony are heated to a high temperature and treated with a mixture of CO_2 and a reducing gas, by which means the antimony or arsenic content can be eliminated.

4,468 of 1932 (396,460). General Electric Company, H. W. B. Gardiner, and A. B. Jackson, London. A reciprocating pump in which the inlet valve is adapted to be open during part of the delivery stroke, and which thereby returns some liquid back towards the supply tank, is found useful for the pumping of mineral pulps.

19,521 of 1932 (397,288). J. G. Stein and Co., J. F. Hyslop, and R. Mackenzie, Bonnybridge, Stirlingshire. Roasted shale is treated with hydrochloric acid, the resulting chloride solutions being evaporated and the residue treated by air or steam to recover the acid. The residue is then heated in a reducing atmosphere to produce a mixture of inert alumina and soluble iron oxide.

24,093 of 1932 (396,233). D. MacLean, Brakpan, Transvaal. A classifier consisting of a circular tank with raised conical bottom and central discharge, the last being fed by a spiral blade device.

26,817 of 1932 (397,314). Hauser and Co. and J. B. Ostermeier, Augsburg, Germany. Device for the location of ore-deposits by a geophysical method.

28,329 of 1932 (397,319). C. T. Rauschenbusch and F. Rauschenbusch, Kirchen a.d. Sieg, Germany. Elutriation apparatus for the separation of mineral particles of differing specific gravity, characterized by the use made of back pressures as an aid to separation.

29,489 of 1932 (395,912). Fried. Krupp Krusonwerk A.-G., Magdeburg-Buckau, Germany. Ball- or tube-mill installations whereby separated coarse material is dried before being re-introduced into the mill.

36,343 of 1932 (396,608). F. Wiesner and V. Malik, Chrudin, Czecho-Slovakia. A series of concentric shells utilized as the wall of a ball- or tube-mill are used as a combined drying plant.

9,205 of 1933 (397,061). New Jersey Zinc Co., New York. Improvements in the "reflux column" used for zinc purification.

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.

Textbook of Fire Assaying. Second edition. By Prof. E. E. BUGBEE. Cloth, octavo, 299 pages, illustrated. Price 18s. 6d. London: Chapman and Hall.

On the Mineralogy of Sedimentary Rocks: A Series of Essays and a Bibliography. By Prof. P. G. H. BOSWELL. Cloth, octavo, 393 pages. Price 21s. London: Thomas Murby and Co.

Mineral Deposits of the Canadian Shield. By Dr. E. L. BRUCE. Cloth, octavo, 428 pages, illustrated. Price 25s. Toronto: The Macmillan Company of Canada.

Minerals and the Microscope: An introduction to the study of petrology. Third edition, with the section on petrology entirely rewritten and enlarged. By H. G. SMITH. Cloth, octavo, 124 pages, illustrated. Price 5s. London: Thomas Murby and Co.

The Mineral Industry: Its Statistics, Technology, and Trade, 1932. Vol. 41. Edited by G. A. ROUSH. Cloth, octavo, 680 pages. Price $12·00. London: McGraw-Hill Publishing Co.

Elements of Optical Mineralogy: Part II, Descriptions of Minerals. Third edition. By Prof. A. N. WINCHELL. Cloth, octavo, 459 pages, illustrated. Price 37s. 6d. London: Chapman and Hall.

Mines Department: List of Mines in Great Britain and the Isle of Man, 1932. Paper covers, 359 pages. Price 10s. London: H.M. Stationery Office.

The Country Around Holmfirth and Glossop: Geological Survey of Great Britain. Explanation of Sheet 86. By C. E. N. BROMEHEAD, W. EDWARDS, D. A. WRAY, and J. V. STEPHENS, with notes by G. V. WILSON and W. LLOYD. Paper boards, 194 pages, illustrated. Price 4s. London: H.M. Stationery Office.

Gold in Canada, 1933. By A. H. A. ROBINSON. Canadian Department of Mines Publication No. 734. Paper covers, 92 pages, illustrated. Price 20 cents. Ottawa: Mines Branch.

Nyasaland Protectorate: Water Supply Investigation Progress Report No. 2, 1932. Paper folio, 21 pages, with appended statistics, plates, and maps. London: Crown Agents for the Colonies.

South Australia: Department of Mines Review for Half-year ended December 31, 1932, No. 57. Paper covers, 103 pages, illustrated. Adelaide: Department of Mines.

British Guiana: Lands and Mines Department Report, 1932. Paper folio, viii + 14 pages. London: Crown Agents for the Colonies.

Rubber in Chemical Engineering. By H. P. STEVENS and M. B. DONALD. Paper covers, 57 pages, illustrated. Price 1½d. London: The Rubber Growers' Association.

Gold: Reprint from the *Times*. Cloth, octavo, 238 pages, illustrated. Price 6s. London: Times Publishing Co.

The Art of Water Finding, with notes on the effect of metals. By M. E. POGSON. Paper covers, 32 pages, illustrated. Price 1s. 8d. Lindfield, Sussex: British Society of Dowsers.

COMPANY REPORTS

Consolidated Main Reef.—This company was formed in 1896 and works gold-mining properties situated on the West Central Rand. The report for the year to June 30 last shows that a record tonnage of 1,013,058 tons of ore was mined, the amount milled, after sorting out waste, being 892,500 tons, which yielded 290,509 oz. of gold, worth £1,497,058. The revenue was increased by the osmiridium and silver recovered to £1,498,872. Working costs amounted to £1,088,490 and the working profit to £410,382, dividends declared during the year absorbing £166,696, equal to 13¾%. The ore reserves at the end of the year were estimated to be 2,343,460 tons, averaging 6·4 dwt. in value, as compared with 1,793,740 tons, averaging 6·8 dwt., at the end of the previous year. These figures are calculated on the standard price for gold and it is estimated that under present conditions there are 1,087,800 tons of ore, averaging 3·9 dwt. in value, which can be included in the reserves, giving a combined total of 3,431,260 tons, averaging 5·6 dwt. in value.

New Modderfontein.—Formed in 1888, this company operates gold-mining properties on the Far East Rand. The report for the year to June 30 last shows that a record tonnage of 2,082,000 tons was milled, yielding 698,855 oz. of gold, worth £3,577,545, silver and osmiridium recovered bringing the total revenue up to £3,587,854. Working costs totalled £1,538,385 and the working profit was £2,049,469, dividends equal to 102½% being declared during the year and absorbing £1,425,000. The available ore reserves at the end of the year were estimated to be 5,300,700 tons, averaging 7·3 dwt. in value, calculated on the 1932 price for gold. This figure shows a decrease of 794,300 tons in amount and 0·4 dwt. in value when compared with the figures for the previous year. Under present conditions there are available an additional 2,317,000 tons of ore averaging 3·2 dwt. in value.

Modderfontein East.—This company, formed in 1917, works a gold-mining property on the Far East Rand. The report for the year to June 30 last shows that 908,500 tons of ore was crushed and yielded 252,652 oz. of gold, worth £1,307,626, silver and osmiridium bringing the total revenue up to £1,311,406. Working costs totalled £920,429, leaving a working profit of £390,977. Dividends declared during the year absorbed £209,431, equal to 22½%. The available ore reserves at the end of the year were estimated on the standard price for gold and totalled 2,045,700 tons, averaging 5·9 dwt., as against 1,997,000 tons, averaging 6·0 dwt. at the end of the previous year. Under present conditions it is estimated that there are immediately available an additional 1,949,000 tons averaging 3 5 dwt. in value.

Nourse Mines.—This company was formed in 1894 and operates gold-mining properties on the Central Rand. The report for the year ended June 30 last shows that 853,200 tons of ore was crushed, yielding 239,479 oz. of gold, worth £1,220,326, the silver and osmiridium recovered increasing the total revenue to £1,222,395. Working costs amounted to £993,487 and the working profit to £228,908. Dividends declared during the year, equal to 13¾%, absorbed £107,754. The available ore reserves at June 30 last were estimated to be 1,767,100 tons, averaging 5·9 dwt. in value, as compared with 1,501,900 tons, averaging 6 1 dwt., at the end of the

previous year. Under the conditions now obtaining in South Africa it is estimated that an additional 1,844,600 tons of ore, averaging 4·0 dwt. in value, could be included in the reserves.

Rooiberg Minerals Development.—Formed in 1908, this company works tin-mining properties in the Waterberg district of the Transvaal. The report for the year to June 30 last shows that the main plant treated 24,064 short tons of ore assaying 2·41% metallic tin, while the alluvial plant, operating only part of the year owing to water shortage, treated 18,952 tons of material, the total output from both plants amounting to 722 long tons of concentrates, containing 61·58% tin. The accounts show a working profit for the year of £32,490 and, after allowing for the sum brought in, there was an available total of £42,830. Of this amount £4,962 was allowed for plant repairs, exploration, and taxation, £15,000 transferred to reserve, £9,000 absorbed in the payment of a dividend, equal to 5%, and £13,868 carried foward.

Sherwood Starr.—This company, formed in 1923, operates gold-mining properties in Southern Rhodesia. The report for the year ended June 30 last shows that 66,900 tons of ore, averaging 27s. 1d. per ton, was milled, yielding 20,584 oz. of gold, the recovery from current slimes re-treated and from concentrates treated at the Cam and Motor mine bringing the total yield to 21,383 oz., worth £90,665. The accounts show a balance of £18,162 to be carried to the appropriation account and this, added to the sum brought in, gave an available total of £30,957, of which £25,000 was absorbed as dividends, equal to 25%, and the balance of £5,957 carried forward. The ore reserves at the end of the year were estimated to be 278,000 tons, averaging 38s. in value, as compared with 246,000 tons, averaging 44·5s., at the end of the previous year.

Naraguta Durumi Areas.—This company was formed in 1929 and owns alluvial tin properties in Northern Nigeria. The report for the year ended March 31 last records the closing down of production operations in April, 1932, and the handling of its quota, assessed at 52 tons per annum in July, 1932, by the parent company. The accounts for the year under review show a working profit of £432, against a loss of £180 for the previous year.

Rukuba Tin.—Formed in 1924, this company operates alluvial tin properties in Northern Nigeria. The report for the year to March 31 last shows that the areas continued to be worked under the tributing agreement with Tin Fields of Nigeria, Ltd., the year's output amounting to 16½ tons, against 26¼ tons in the previous year. The accounts show a working profit of £16, as compared with a loss of £377 for the previous year.

Tin Fields of Nigeria.—This company, formed in 1928, operates alluvial tin properties in Northern Nigeria. The report for the year to March 31 last shows that the combined quota production of the company with that of Rukuba Tin amounted to 28½ tons, as compared with 63½ tons in the previous year. The accounts show a profit of £237, increasing the sum brought in to £327, which was carried forward.

Temoh Tin.—This company was formed in 1927 and owns alluvial tin property in the Batang Padang district, F.M.S. The report for the year to June 30 last shows that the dredge remained closed during the year, the proceeds from the sale of its quota covering maintenance expenses. The accounts show a loss of £1,091, offset by income tax reserve not now required. The carry forward has been increased to £7,666. Dredging operations were resumed on July 1 last.

Renong Tin.—This company, formed in 1913 to acquire alluvial tin areas in Lower Siam, is now working ground in the Rasa district, F.M.S. The report for the year to June 30 last shows that 250·34 tons of tin ore was produced by Nos. 2 and 3 dredges from 701,654 cubic yards of material. The accounts show a profit of £9,782, which, added to the sum brought in and increased by the transfer of £2,500 from reserve, gave an available total of £30,512. Of this amount preference dividends and sundry items absorb £9,388, while £3,357 has been absorbed as a dividend, equal to 2½%, leaving £17,767 to be carried forward.

Peña Copper.—Formed in 1900, this company works the Peña copper mines, situated in the Province of Huelva, Spain. The report for 1932 shows that the mine output totalled 53,476 tons, of which 46,950 tons was added to the heaps for leaching, the remainder being exported. The output of fine copper as precipitate was 576 tons, as compared with 757 tons in the previous year. Shipments of ore during the year totalled 53,962 tons, against 49,074 tons in 1931. The accounts show a profit of £3,025, a profit on the sale of investments increasing this to £5,181, which added to the sum brought in gave a total of £23,594 to be carried forward.

DIVIDENDS DECLARED

Ayer Hitam.—1½d., less tax, payable Oct. 6.
Bangrin Tin.—2s., less tax, payable Oct. 17.
Champion Reef.—1s. 3d., less tax, payable Oct. 14.
Chosen Corporation.—6¾d., less tax, payable Sept. 30.
Fresnillo.—10 cents, less tax, payable Sept. 30.
Gopeng.—3d., less tax, payable Sept. 30.
Mount Coolon.—1s., less tax, payable Oct. 26.
Murex.—2s., less tax, payable Oct. 6.
Mysore.—9d., less tax, payable Oct. 21.
New Vaal River Diamond.—6d., less tax, payable Oct. 21.
Penawat.—5%, less tax, payable Sept. 30.
Pengkalen.—Pref. 6d., Ord. 3d., less tax, payable Oct. 14.
Rawang Tin.—3d., less tax, payable Oct. 21.
Renong Tin.—6d., less tax, payable Oct. 11.
Siamese Tin.—9d., less tax, payable Oct. 17.
Sons of Gwalia.—1s., less tax, payable Oct. 27.
Tekka-Taiping.—3d., less tax, payable Oct. 28.
Transvaal G.M.E.—6d., less tax, payable Nov. 10.
Tronoh.—1½d., less tax, payable Oct. 7.

NEW COMPANIES REGISTERED

B.A.N.Z. Mines.—Capital: £10,000 in 10s. shares. Objects: To search for, excavate, and mine ores, smelt, calcine, manipulate and treat, and to obtain asbestos, gold, platinum, silver, tin, lead, copper, zinc, coal, petroleum, and other metals, etc. Directors: Reginald H. Redford, Fredk. W. Merrick. Office: Peek House, 20 Eastcheap, E.C. 3.

Gold Coast (Ankobra) Gold Properties.—Capital: £1,000 in 2s. shares. Objects: To act as mine owners, mining engineers.

Trinidad Investments.—Capital: £1,000 in £1 shares. Objects: To acquire lands, heritages, etc., bearing oil or containing beds, veins, and deposits of petroliferous or bituminous substances, etc. Office: Gordon Street, Glasgow.