The Mining Magazine

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EDITORIAL

ACCORDING to advices from Toronto received this month an electrostatic method of dust precipitation to be used in mine working places as a preventive of "silicosis" is to be tried. The method, which is ascribed to Dr. F. G. Banting, will be tested in an Ontario mine.

AT a meeting of the London Local Section of the Institute of Metals last week Mr. Robert Annan gave some interesting information as to the gold output of the world. As he pointed out, labour-saving devices underground, improved metallurgy, cheaper power, and transport by motor car and aeroplane were all contributing to render available deposits hitherto considered too low grade, complex, or remote.

THE figures relating to tin continue to give satisfaction, as visible supplies are still shrinking. Last month a new restriction agreement was concluded, the export quota having been raised to 40% as from January 1 next, with an additional 4% for 1934. Indo-China is now definitely participating in the scheme and others are expected to join. The United States consumption during the first seven months of 1933 amounted to 32,649 tons, as compared with 21,236 tons for the same period of 1932.

ONCE more Messrs. Mavor and Coulson, of Glasgow, have come forward to the Institution of Mining Engineers with the offer of £300 for a travelling studentship to be awarded for one year. Applicants for the award must be British subjects over 22 years and under 30 years of age who have graduated in mining from an approved school and who have had at least two years' underground experience in a colliery. The itinerary proposed by the successful candidate must include Canada or the United States.

AN important agreement affecting the steel trade in this country was successfully concluded last month, when it was announced that the Colvilles firm would take over the steel-plate business of Stewarts and Lloyds in Scotland and in the export market. The modern universal plate mill in Stewarts and Lloyds' Clydesdale works, Mossend, is to be reconstructed as a blooming mill and transferred to the new steelworks at Corby, where active reconstruction is now in progress. The other steel-making operations at the Clydesdale works are to be continued.

THE exchange market towards the end of last month became unusually disturbed when the United States Government announced its intention to purchase, through the Reconstruction Finance Corporation, newly-mined gold at a figure substantially greater than the world price. For the first few days the policy was confined to the domestic output, but on November 3 it was definitely announced that purchases had been made abroad. The main effect to date of this, the latest phase in President Roosevelt's effort to give the United States a stable dollar, has been a slump in the dollar exchange, the value on November 6 "crossing the line" and reaching its lowest level since August, 1914.

An Australian Jubilee

Although, perhaps, the present year cannot strictly be regarded as the jubilee of the discovery of the Broken Hill silver-lead-zinc deposits, it was in 1883 that the first ground in the present Broken Hill area was pegged by Charles Rasp, who marked out what was later known as Block 12. An earlier discovery of argentiferous galena had been made at Thackeringa, about 20 miles south-west of Broken Hill, while similar ore from Wilcannia, a place over 140 miles away to the north-west, had been shipped to England in 1880. Discoveries of gold about this time at Mount Brown temporarily diverted attention from Broken Hill, while the discoveries at Silverton, Apollyon Valley, and the Pinnacles were all made in 1883. It has been recorded by Mr. Donald Clark that individual prospectors were stimulated by the finding of large masses of chlorobromide and chloride of silver, many of them extremely rich, and these discoveries served to intensify the prospecting fever in the neighbourhood and, following the delimitation of Block 12, other ground was speedily marked out. Although success did not immediately follow the efforts of the earlier adventurers, the year 1883 may justly be considered as that of the foundation of the Broken Hill industry—perhaps, as one of our Australian con-

temporaries puts it, " one of the most potent factors in Australia's industrial development."

The Broken Hill Proprietary Company was floated in August, 1885, and in 1886 smelting operations were started on oxidized ore, four 30-ton smelters being erected at the end of the year. By 1900 the treatment of the Broken Hill ore was becoming increasingly complicated, as the amount of oxidized ore diminished and the complex lead-zinc sulphides then being mined presented a problem in ore-dressing, the solution of which was to have far-reaching effects. The story of the introduction of the flotation process as developed by Potter and Delprat is already well known, as well as the success of its application to the millions of tons of zinc tailings rich in silver and lead that had been stored in the area pending the solution of the treatment problem. Until 1912 the standard process employed was gravity concentration for recovering the lead and silver and flotation for the treatment of the rich blende tailings, selective flotation for the treatment of the whole ore being applied in the year named. The part that Broken Hill has played in aiding the solution of the complex lead-zinc ore problem is sufficiently obvious, so that its development may be held to have had beneficial effects on mining in general as well as on Australian industry in particular.

The important part that the Broken Hill Proprietary Company has taken in the development of Australian industry is, possibly, not sufficiently appreciated. In addition to its concentrating works at the mine it developed the smelting works and refinery at Port Pirie that were ultimately transferred to the Broken Hill Associated Smelters, whilst intimately connected with it is the Electrolytic Zinc Company at Risdon, Tasmania, which recovers the zinc from Broken Hill concentrates. Coincident with the development of metallurgical activities industrial development has gone on apace, the company having developed chemical works and fertilizer plant in connexion with its acid recovery processes. In addition, in 1915, steelworks were set up at Newcastle, a step that has necessitated the development of the iron ore properties at Iron Knob, South Australia, limestone quarries at Devonport, Tasmania, and collieries in New South Wales. Owing to the fall in the price of metals and the increased costs incident on the period of industrial depression through which the world has been passing, operations at Broken Hill itself have been largely suspended since June, 1930, and the company has turned its attention to gold mining in the Commonwealth. It has been investigating propositions in various parts of the continent during the past two years, while one of its related company's—Amalgamated Zinc (De Bavay's)—is developing the manufacture of paper from Tasmanian wood. An account of the activities of an undertaking such as the Broken Hill Proprietary Company tends to become little more than a recital, which leaves hidden the romance that might be apparent in the detached view. The organization has faced and overcome many difficulties attendant on the situation of its properties and the Australian climate, such as remoteness from the sea and the scarcity of water. After extracting millions of pounds' worth of metals from millions of tons of ore and paying vast sums in dividends and taxes there remains at least 16,000,000 tons of ore developed in the bottom levels of its mines—and who can say what lies below ?

The Institution Meeting

For the first meeting of the forty-third session of the Institution of Mining and Metallurgy held last month the programme provided a contrast of the old and the new, the two papers for discussion dealing with ancient mining methods and with modern technique in ore-dressing. The first was by Mr. O. Davies—a visitor—and dealt with " Roman and Mediæval Mining Technique," while in the second Mr. C. P. McMillin described " Milling Methods and Costs at the Alaska Mine Flotation Plant of the Southern Rhodesia Base Metals Corporation, Ltd., Southern Rhodesia." It had been intended—if time permitted—to discuss, in addition, Messrs. Taylour and Morley's paper on New Guinea, which was published with the August *Bulletin* of the Institution and of which an extract appeared in the September issue of the MAGAZINE, but this was not found possible, so much interest being taken in the first-named papers by the large number of members present that the time available was fully occupied.

Mr. Davies in his paper has submitted a scholarly account of much that he has seen in many parts of Europe and his paper has such a wealth of references attached as to make it of extreme value to those interested in work of this description. The object of

the paper is to compare Roman technical methods with the mediæval technique of central Europe and the author's research leads him to believe that a connexion of the two is highly probable. In central Europe, the author says, gold and silver mining does not seem to date back earlier than a few hundred years B.C., Tacitus having stated that in his day no such mines were known in Germany, and it is probable that Roman-trained workers founded the highly-finished technique for which the Germans later became famous. As the author points out, it is often difficult to decide whether an old working is Roman, as one can only be guided by objects found therein or by references in the works of contemporary writers, but it is certainly true that their work has been identified over a very wide area and that traces of their methods can be found in much of the mining carried out in the Middle Ages. The historical, however, soon gives way to the technical in Mr. Davies's paper and his researches have enabled him to discuss the organization of mining work in the olden days, the methods of prospecting and exploitation used, and the type of underground workings—galleries, shafts, drives, and drainage works—while haulage and survey methods are also dealt with. The author then goes on to consider ventilation and mining tools, concluding with a review of the evidence available from old smelting sites. Members were fortunate that Mr. Davies was present to deliver his paper and that his discourse was of interest was evidenced by the keen discussion that followed. This was opened by Mr. W. R. Rundall, other members taking part including Messrs. E. T. McCarthy, R. Annan, B. W. Holman, and W. Douch and Dr. L. L. Fermor.

In opening the way for discussion of the second paper Mr. Gray, the president, pointed out that there were several points with reference to it that members should bear in mind. First, the plant described was not designed for the work that it was eventually called upon to do, and, secondly, the paper was by a student and he therefore very thoughtfully suggested that any minor errors it contained might well be overlooked. The Alaska mine, the treatment plant of which is described by Mr. McMillin, is situated about 12 miles from Sinoia, in Southern Rhodesia, and the ore consists of malachite and chrysocolla in the oxidized zone and chalcocite with chalcopyrite and pyrite in the sulphide zone, these minerals being found in a schistose dolomitic country rock. The flotation plant erected was originally designed as a test plant for the Copper Queen lead-copper-zinc mine, which was opened up in 1927. After operating for a few months, however, this mine was closed down and about a year later the equipment was removed to the Alaska mine and erected on the Chezuwi Kopje, about one-third of a mile from the shaft. For details of the flow-sheet the reader may be referred to the paper, which is published in the October *Bulletin* of the Institution, and it will suffice here to say that it followed orthodox lines, the main difficulties standing in the way of success being those inherent in the ore itself. The ore stoped from above the 140-ft. level showed marked difference in constitution from that taken from below, while the presence of native copper often caused high values of that metal to be present in the classifier sand return and mill discharge. In opening the discussion Mr. Philip Rabone pointed out that an intermediate crusher between the primary breaker and the ball-mill would have resulted in reduced costs, but that otherwise it might be said that the best use had been made of the plant available. Dr. Cullen, who followed, felt that the difficulties referred to by the president in his opening remarks served as a basis for congratulation to those who had carried out the work, a feeling echoed by the later speakers, who included Messrs. F. Yeates, R. de Beer, and G. J. Brown and Dr. A. C. Vivian.

Metalliferous Mining in Britain

The annual report [1] of the Mines Department on the metalliferous mines and quarries of Great Britain made its appearance last month. This combines in one volume the reports of the divisional inspectors of mines and quarries under the Quarries Act, 1894, and the Metalliferous Mines Regulation Acts, 1872 and 1875, and, although it deals primarily with matters affecting the health and safety of workers in the quarrying and metalliferous mining industries, it also contains statistical and other information relating to employment, the output and value of minerals, the use of explosives and electricity, and the size and nature of workings.

During 1932 the uninterrupted decline in

[1] Reports of H.M. Inspectors of Mines and Quarries: Metalliferous Mines and Quarries, 1932. H.M. Stationery Office. Price 9d.

non-ferrous metal prices continued to affect the industry and the number of mines at work fell from 277 to 258, the selling value of the minerals recovered falling from £2,136,000 to £2,118,000 and the average number of persons employed from 9,773 to 9,305. While these figures show that there was no general improvement in conditions during the year under review, there were certain redeeming features. Among the chief minerals the output was higher than in 1931 in the case of tin and lead ores, barytes and witherite, and gypsum and anhydrite to the value of £223,000 in the aggregate, the production of the last-named being substantially greater than during the previous year. The closing down of the Llanharry iron-ore mine, in Glamorganshire, was averted, but three iron-ore mines were abandoned in the North-West Coast district and work at Ullcoats was suspended early in the year. In dealing with the health of the workers it is reported that attention has continuously been given to measures likely to minimize the harmful effects of dust, water-fed drills being used in the hæmatite mines or respirators provided where the provision of a water supply is impracticable. Dust traps of an improved type are used with power drills in the slate mines. At the Florence hæmatite mine, in Cumberland, where some of the ore is crushed for a special purpose, a dust extractor has been installed in connexion with the plant. Speaking generally it may be said that timber continually gives way to metal arches or girders for supporting ground and the latter material has proved particularly successful in the Devonshire potter's-clay mines, which are subject to excessive squeeze. In addition the use of concrete instead of timber for the construction of hoppers, bins, and ore-chutes underground is extending. Following the introduction of a Diesel locomotive into a gypsum mine in the North Midland division careful tests were carried out on the gases emitted from the exhaust under various conditions and it is satisfactory to note that in this case at least no serious harmful effects could be noted. As regards air conditions, the use of auxiliary fans for ventilating development headings and confined places continued to extend, but attention is drawn to the need for proper maintenance of the ducts, as in many cases there has been serious leakage. It is satisfactory to note from this section of the report that mining efficiency continues to improve and the position of the industry is such that advancement should follow quickly any betterment of general conditions.

The quarrying industry suffered severely from the stringent conditions existing last year. There was a reduction of $5\frac{1}{4}$ million tons in the quantity of mineral recovered at such workings as compared with 1931 and of over £$1\frac{3}{4}$ million in value, 5,164 quarries being at work, employing on the average 67,143 persons and producing $60\frac{1}{2}$ million tons of mineral with a net selling value of over £$12\frac{3}{4}$ million. The employment figure for this industry was at its lowest since 1922, the quarries most seriously affected being those dependent on the prosperity of the building and public works industries. Excavations producing ironstone, limestone, and dolomite, ganister and silica rock, fire-clay, moulding and pig-bed sand—*i.e.*, those quarries mainly dependent on the metallurgical industries—recovered $7\frac{2}{3}$ million tons of mineral, as compared with nearly 8 million tons in 1931 and $11\frac{1}{3}$ million in 1930. The Board of Trade Index for the same period shows that production in the iron and steel trade was about one-fourth less than in 1930 and in the non-ferrous group of metallurgical industries one-fifth less. At quarries working clay, limestone, igneous rock, sandstone, gravel and sand, and chalk $50\frac{3}{4}$ million tons of mineral were obtained, as compared with $55\frac{3}{4}$ million tons in 1931 and $52\frac{2}{3}$ million tons in 1930, the falling off in this respect being due to the abandonment of building and road schemes resulting from efforts to secure economies in national and local expenditure. The latest Census of Production relating to mechanical operations at quarries in 1930 tends directly to confirm the opinion previously expressed in these reports that such work was expanding. The census shows that at that date the mechanical and electrical power in use was 55% greater than in 1924, the latest year for which corresponding information is available. At the earlier date $1\frac{1}{2}$ times as much power was applied mechanically as electrically, whereas in 1930 power applied electrically was nearly one-seventh greater than that applied mechanically, the horse-power of motors in use in quarries in 1932 being 114,000, against 97,000 in 1930. As with the metalliferous mining industry, there is evidence that all-round efficiency of operation continues to improve and that the industry only awaits the return of better times to reap the benefit.

REVIEW OF MINING

Introduction. — The steadily-growing feeling of confidence in the future apparent in general business has been somewhat shaken during the past month by uneasiness as to the outcome of the American situation. The debt position remains in suspense and any definite solution of this problem must await a change in the American attitude. In this country conditions as regards employment continue to improve and there are now over half a million fewer unemployed on the register than in January last. Apart from tin, metal prices show little change.

Transvaal.—The output of gold on the Rand for October was 856,724 oz. and in outside districts 52,164 oz., making a total of 908,888 oz., as compared with 901,799 oz. in September. The number of natives employed in the gold mines at the end of October totalled 231,799, as compared with 230,774 at the end of September.

Several interesting items emerge from the reports of the companies of the Rand Mines group covering the three months to September 30 last. The City Deep has acquired from the Government the undermining rights of approximately 23 claims adjoining its south-eastern boundary, while the East Rand Proprietary has preparations in hand for sinking the new South-West vertical shaft. On the Rose Deep a capital expenditure programme amounting to approximately £350,000 is to be initiated, to deal with the area now being unwatered and the newly-acquired claims.

The Consolidated Gold Fields of South Africa has declared a final dividend of 2s. 3d., less tax, making with the interim payment in March 3s. per share for the year to June 30 last.

The quarterly report of the Simmer and Jack shows that the crushing capacity of the plant has been brought up to 90,000 tons a month and that a reduction in residue values has resulted.

The Vogelstruisbult Gold Mines Areas reports that during the three months to September 30 last shaft-sinking proceeded satisfactorily, while the Daggafontein Mines had extended its No. 5 South Haulage to within 2,650 ft. of the boundary.

Shareholders of West Witwatersrand Areas were informed last month that borehole No. E. 4 Farm Driefontein No. 118 had passed into the Witwatersrand Series at 2,964 ft.

The report of Witbank Colliery for the year to August 31 last shows a profit of £45,403, increasing the sum brought in to £125,286. After payment of dividends equal to 7½%, absorbing £25,841, and making other allowances £81,640 was carried forward. The coal dispatched from the mine during the year amounted to 698,851 tons, an increase of 7,084 tons when compared with the previous year.

Southern Rhodesia.—The output of gold from Southern Rhodesia during September was 56,790 oz., as compared with 56,147 oz. for the previous month and 50,198 oz. in September, 1932. Other outputs for September were : Silver, 11,014 oz. ; coal, 45,389 tons ; chrome ore, 1,113 tons ; asbestos, 2,624 tons ; iron pyrites, 1,134 tons.

The African and European Investment Co. published this month a report of the Bernheim Gold Mining Company, recently registered to acquire the Bernheim and Rothschild mines from the first-named company and the Lonely Reef.

Northern Rhodesia.—The output of gold from Northern Rhodesia during September was 313 oz., as compared with 286 oz. for the previous month and 148 oz. for September, 1932. Other outputs for September were : Copper, 9,823 tons ; zinc, 1,620 tons ; manganese ore, 867 tons ; mica, 550 lb. ; cobalt, 42,694 lb.

During the year to June 30 last Roan Antelope Copper Mines made a working profit of £317,455. After allowing for debenture interest, depreciation reserve, and local taxation, there was an unappropriated balance of £53,205. Deducting the debit balance brought in there remained £22,445 to be carried forward. During the year 1,594,860 short tons of ore, averaging 3·61% copper, was mined, 37,708 long tons of blister copper being produced at an all-in cost (exclusive of debenture interest, depreciation, etc.) of £22 7s. 1d. per ton, a figure showing a considerable reduction on that for the previous year. The ore reserves at the end of the year were estimated to be 104,113,000 tons, averaging 3·43% copper.

The report of the Rhokana Corporation for the year to June 30 last shows a gross profit of £360,724. After making allowance for depreciation and other items there was a net appropriable profit of £40,863, which has been carried forward. The Nkana mine produced 1,375,460 short tons of ore, averaging 4·66% copper, the smelter output totalling 48,579 tons of blister copper. Production costs for the half-year to December 31, 1932, averaged £22·151 per

ton of blister copper, or, allowing for debenture interest, £31·467 per long ton. The conversion operation carried out at that time has now almost eliminated the debenture charge and the total cost per long ton of blister for the half-year to June 30 was £21·584. The ore reserves have not been recalculated and remain at 270,780,000 short tons, averaging 4·3% copper. The refinery in course of construction at Nkana will have an initial capacity of 36,500 short tons per annum.

Gold Coast.—The return of the Ashanti Goldfields Corporation for October shows improved development figures. On No. 15 level of the Côte d'Or reef cross-cut No. 7 N.E. showed reef 11 ft. wide assaying 20·2 dwt., while in cross-cut No. 8 N.E. the width was 9ft. and the assay value 26·5 dwt.

During the three months to September 30 last the pilot plant on the Bibiani treated 3,407 tons of ore and recovered 1,871 oz. of gold, worth £12,096. A development circular issued this month showed that on No. 5 level cross-cut No. 13 E. exposed 20 ft. of reef, averaging 8·5 dwt. in value, while No. 15 E. showed reef of the same width assaying 50·5 dwt.

The report of the Consolidated African Selection Trust for the year to June 30 shows a profit of £161,406, increasing the sum brought in to £212,529. Dividends equal to 25% absorbed £62,444, while £39,500 has been placed to general reserve. After allowing for taxation, £84,399 was carried forward. Negotiations recently concluded with the Sierra Leone administration grant the company exclusive diamond-mining rights over practically the whole of the Colony.

Kenya.—Good developments on their properties in the Kakamega goldfield were announced last month by Tanganyika Concessions and the Tanami Gold Mining Syndicate. On the Kimingini property of the first-named good ore is being opened up at the 100-ft. level, while its continuance at the 200-ft. level has been indicated by diamond drilling. The Tanami syndicate also reports good ore at 65 ft. depth on Horst's Reef and at 25 ft. on Ross's Reef on the Rosterman property.

Tanganyika.—It was announced last month that the capital of Tanganyika Diamonds had been increased to £300,000 by the creation of a further 600,000 5s. shares.

Australia.—The accounts of the Broken Hill Proprietary for the year to May 31 last show a profit of £313,617, after providing £300,482 for depreciation and £34,127 for debenture interest. Dividends paid absorbed £298,771, equal to 2s. per share. The company's interest in gold mining is to be continued and the treatment plant at Hannan's North mine, Kalgoorlie, was brought into commission in April last.

Cabled advices from Australia give the profit of the North Broken Hill for the year to June 30 last as £166,565, increased by the sum brought in to £568,511. Dividends absorbed £105,000 and £68,324 has been appropriated for plant, leaving £395,187 to be carried forward. During the year 313,782 tons of ore was treated, producing 60,130 tons of lead concentrates and 57,746 tons of zinc concentrates. The ore reserves in all sections above the 1,850-ft. level were estimated at 4,500,000 tons.

Shareholders of Mount Isa Mines were informed early this month that a labour dispute had resulted in the temporary cessation of underground work.

The report of the Lake View and Star for the year to June 30 last shows a profit of £439,305, increasing the sum brought in to £470,832. Dividends paid during the year absorbed £267,500, while £50,000 has been placed to reserve and, after making other allowances, £19,434 was carried forward. During the year 468,625 tons of ore was milled yielding bullion worth £722,866. The ore reserves at the end of the year were estimated to be 2,161,600 tons, having an average value of 32s. per ton calculated at the standard price for gold.

Boring results obtained on the Bulletin lease were reported last month to shareholders of the Wiluna Gold Corporation. No. 4 hole entered ore at 472 ft. and this continued to 608 ft., the last section being estimated as below the outcrop and assays showed 11 ft. in this section going 50s. 3d. per ton. No. 5 hole is to be started 150 ft. south of No. 4.

Austral Development reported last month continued good developments from the bores on the Triton Gold property, on locations fixed by geophysical work. No. 15 bore-hole shows lode material at a vertical depth of 330 ft., the value being 5·12 dwt. over 4 ft.

Shareholders of Electrolytic Zinc of Australasia have been informed that the cabled summary of the report for the year to June 30 last shows a profit of £223,093, which, with the sum brought in, gives an available balance of £239,283.

Malaya.—The accounts of the Perak River Hydro-Electric Power Company to July 31 last show revenue amounting to £109,420, as compared with £154,265 for 1931–2. In the return of Malayan Tin Dredging for October it is stated that an agreement had been concluded with the Perak River company for the sale of the tin company's electric power station.

Siam.—A circular to shareholders of Kamra Tin Dredging states that mining rights have been acquired over approximately 600 acres of new ground.

India.—Early this month developments on the new Dhobani lode were reported to shareholders of the Indian Copper Corporation. From the new shaft a cross-cut at 125 ft. showed 4 ft. of lode assaying 6% copper.

The intention of the Central Provinces Manganese Ore Company to make a return of 10s. capital on each £1 share was announced last month. The capital will then be £500,000 in 10s. shares.

Burma.—During the year to June 30 last the accounts of the Consolidated Tin Mines of Burma showed a surplus of revenue over expenditure of £13,301, as compared with £4,042 for the previous year. The debit balance brought in has now been extinguished, a credit of £281 being carried forward. The production of mixed concentrates for the year amounted to 1,144 tons.

Canada.—It was announced last month that a merger of the Huronian Mining and Finance Company, Keeley Silver Mines, and Vipond Consolidated Mines was proposed. The name of the new company will be Anglo-Huronian, Ltd.

Venezuela.—About the middle of last month 215,993 shares of 5s. each in the Amarilla Gold Mines were offered for subscription and promptly applied for. The Treasury, however, took exception to the issue, as it involved capital going abroad. As this meant that anyone taking up the shares might be unable to dispose of them through the usual channels, applicants were given the right to withdraw their offers, but they evidently did not do so, as at the end of the month allotment letters were posted in respect of the whole issue.

Spain.—A circular to shareholders of San Finx Tin Mines (in liquidation) states that a new company has been formed with a capital of £18,750 in 9d. shares and a loan capital of £6,016 in 5% debenture stock.

Portugal.—Shareholders of Lagares Tin Mines have been advised that it would now be profitable to operate the mines. A scheme has been proposed whereby prior charges will be discharged by the issue of 2s. shares in a new company. Under guarantee of the Camp Bird company 200,000 of these are offered to members of the company.

Cornwall.—In order that it may be possible to distribute dividends the South Crofty proposes to write off 1s. 3d. from each 5s. share and after dividing the new 3s. 9d. shares into 1s. 3d. units to amalgamate four of these into new 5s. shares. The cancellation of capital will provide £32,500 for writing off losses and leave an issued capital of £97,500.

It was announced last month that work had been restarted on the Lady Gwendoline mine of Wheel Reeth Tin, the mill having been in operation since September 1 last.

Imperial Smelting Corporation.—The accounts of the Imperial Smelting Corporation for the year to June 30 last show a profit of £137,472. Adding the sum brought in there was an available total of £151,876. Preference dividends absorbed £134,538, leaving £17,338 to be carried forward.

François Cementation.—During the year to March 31 last the François Cementation Company made a trading profit of £31,433. After making various allowances and adding the sum brought in, there was an available total of £39,631. Certain sums were transferred to reserve and preference dividend payments brought up to September 30, 1932, leaving £21,303 to be carried forward.

London, Australian, and General.—The report of the London, Australian, and General Exploration Company for the year to July 31 last shows an excess of expenditure over income of £2,030, which has been mainly met by a transfer of £2,000 from reserve. It is stated that an agreement has been reached with the Italian Government with regard to the Raibl mine and that a new mill is being erected there.

Selection Trust.—Particulars of this new registration are given elsewhere in this issue. The company is to acquire the assets of the Canadian Selection Company and it is anticipated that four shares of 10s. each in the new undertaking will be exchanged for each share held in the Canadian company.

Trinidad Leaseholds.—During the year to June 30 last Trinidad Leaseholds made a profit of £293,407, making, with the sum brought in, an available total of £362,385. Of this £196,734 is absorbed as dividends, equal to 15%, and, after making other allowances, £68,991 was carried forward.

THE NKANA SMELTER

By A. D. WILKINSON and F. L. BOSQUI

The authors, smelter superintendent and research engineer respectively, describe the plant installed and operated in Northern Rhodesia by the Rhokana Corporation, Ltd.

The smelter of the Rhokana Corporation, Ltd., at Nkana, Northern Rhodesia, is situated at an altitude of 4,080 ft. and at a distance of some 2,800 ft. in a south-easterly direction from the primary crushers of the concentrator adjoining Central shaft. Designed at the site by I. H. Wynne, the plant is arranged primarily for the treatment of Nkana copper concentrates, but is at the same time well equipped to handle concentrates and direct smelting ore from outside sources.

Excavations were started in the latter part of 1930 and the pouring of concrete for the buildings was begun on January 6, 1931, the first blister copper being cast on March 19, 1932—less than fifteen months later. During this period, which included several months of heavy tropical rains, some 10,000 cu. yd. of concrete was poured and 4,000 tons of structural steel erected under the supervision of A. Ek, with a labour force of 60 to 80 Europeans and about 800 natives. The steelwork was fabricated by Head, Wrightson, and Co. in England and the boiler plant equipment furnished and erected by International Combustion, Ltd.

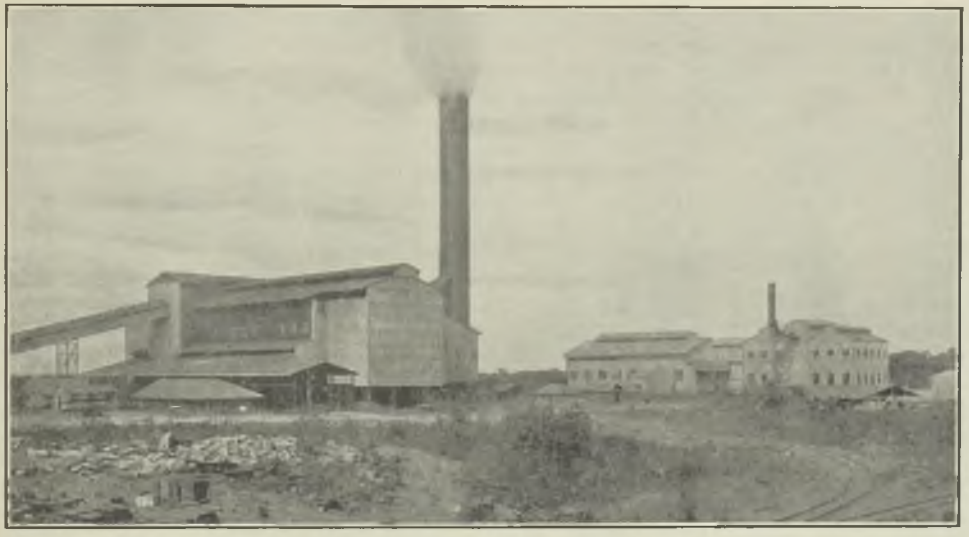


Fig. 1.—General View of Smelter and Power Plant looking South-East.

The smelter consists of the reverberatory and converter plant, with the necessary storage, mixing, and conveying system, boiler plant, flue system, and stack. The main smelter building occupies an area of about 100 yd. square and includes the copper handling shed and railway siding, converter aisle, reverberatory house, and waste-heat boiler plant, to the south of which, at a distance of 40 ft., stands the 30-ft. by 300-ft. brick-lined steel stack for reverberatory and converter gases. Additional plant, covering an area some three times as great, comprises the coal stock pile and receiving bins, with a coarse and fine crushing plant and sample mill for the preparation and sampling of foreign ore and flux, in addition to the filter plant, stock storage building, and fine storage bins for handling the local concentrate. The whole of this plant is interconnected by an efficient and flexible system of belt-conveyors.

Coal Storage and Receiving Bins.—By reference to the accompanying diagrammatic flow-plan (Fig. 2) it will be seen that an earth-filled ramp 1,200 ft. long, with a gradient of 1·5%, carries the railway line to the coal storage gantry (1) and receiving bins (2). Coal is unloaded from the railway cars by hand and stock-

piled beneath the gantry over a 9 ft. high by 10 ft. wide concrete draw-off tunnel, the top of which is at ground level. This tunnel extends for a distance of 188 ft. parallel to and 31 ft. below rail level, providing storage for some 5,000 tons of coal. Withdrawal is effected by progressively removing wooden planks which cover a continuous slot opening in the roof of the tunnel and allowing the coal to run through a hopper mounted on rails on to a 30-in. belt-conveyor which runs the full length of the tunnel and empties on to a second belt of the same size running under the receiving bin.

The receiving bin (2) for the storage of ore and fluxes is a steel structure of the suspension type, 150 ft. long by 20 ft. wide by 23 ft. deep, having straight sides and a curved hopper bottom and divided into six 500-ton pockets with double discharge gates. One of these pockets is subdivided into two 250-ton compartments. The 4-ft. square discharge openings are provided with Moore belt and roller bin gates delivering to a Link Belt Co. pan feeder, which discharges on to the 30-in. belt from coal storage. This belt delivers ore or flux to the crushing plant, or in the case of coal to the by-pass coal conveyor system.

Crushing Plant and Sample Mill.—The coarse crushing plant (3) adjoins the bin structure and houses a 16-in. by 30-in. Hadfield jaw-breaker, driven through a Tex-rope drive by a 75 h.p. motor. The feed belt is provided with a 40-in. electromagnet for the removal of tramp iron and delivers the feed to a 3-in. grizzly situated above the crusher for the elimination of undersize. The crusher is normally set to break to 3 in.

The crusher discharge and grizzly undersize pass by means of a 24-in. conveyor 110 ft. long with a rise of 34 ft. to the fine crushing plant (4), which is also situated in line with the railway gantry and bin structure. The material discharges on to a $\frac{3}{8}$-in. Ton-Cap Hum-mer screen, the oversize from which passes to a $5\frac{1}{2}$-ft. Symons cone crusher, driven by a 150 h.p. motor and set to reduce to about $\frac{1}{2}$-in. mesh. The undersize from the screen, together with the crusher product, is picked up by a second conveyor 128 ft. long, which elevates the material 40 ft. 6 in. to the sample mill tower (5). This belt is provided with a Merrick Weightometer.

The sample-mill equipment includes a Snyder splitter taking a 10% cut, a set of 14-in. by 30-in. rolls driven by two 15 h.p. motors, set to $\frac{1}{8}$ in. and provided with a shaking feeder, for crushing the first cut, a bucket and chain cutter taking a 5% cut of the rolls product, and a sample floor for the final cutting down of the 0·5% sample obtained. The rejects from each cut pass through steel chutes to either one of two 20-in. conveyors delivering to the fine storage bins. The double conveyor way is 380 ft. long with a lift of 45 ft. and connects the sample mill with the bins in two stages. The conveyors of the first stage carry the material to the junction tower (6), where concentrate is picked up, and, if desired, any one or all products may be by-passed by means of shuttle conveyors direct to the main conveyors (referred to later) without passing through the fine storage bins (9).

Filter Plant and Concentrate Storage.—The flotation concentrate, which is pumped through 2,500 ft. of 3-in. pipeline from the concentrator to the filter plant (7), is reduced to 8–10% moisture on one or two of the three 11 ft. 6 in. by 12 ft. diam. Oliver filters installed. The filter product falls on to a 20-in. conveyor 160 ft. long, supplied with a Merrick Weightometer, delivering to the previously mentioned junction tower. From this point it may be conveyed directly to the fine storage bins or unloaded by a Robins tripper on to a 28-ft. length of shuttle conveyor delivering to the concentrate stock storage building (8). This is 168 ft. long by 61 ft. wide by 44 ft. high to the roof trusses and is divided into six 56-ft. by 30 ft. 6 in. sections by concrete walls 10 ft. high by 12 in. thick, providing storage for 15,000 tons of concentrate. Distribution into the sections is effected by a 60-ft. span electric crane equipped with a 3-yard clam-shell grab, which is also used for reloading. In this case the contents of the grab is dumped into 20-ft. diam. conical-bottom hoppers situated at the east end of the building and equipped with pan feeders for discharging on to a 20-in. belt-conveyor system, which returns the concentrate to the junction tower.

Fines Storage Bin and Poidometers.—The second section of the double conveyor way mentioned above connects the junction tower with the fines storage bin. Each conveyor is equipped with a Robins tripper

and is so arranged that products from the crushing plant and concentrate may be independently conveyed at the same time to different pockets of the storage bin. This bin is constructed of steel and is also of the suspension type. It is divided into six hopper-bottom pockets 25 ft. long by 20 ft. wide by 23 ft. deep, each of which is subdivided by means of wooden partitions into compartments holding 275 tons of concentrate or 225 tons of lime-rock or ore.

Mixing of the reverberatory furnace charge is accomplished by feeding the correct proportions of concentrate, secondaries, ore, or flux from the compartments of the bin on to a 170-ft. length of common 30-in. conveyor, which delivers the mixture on to the main conveyors (referred to later). These proportions are obtained by means of twelve 30 in. by 4 ft. 6 in. Schaffer Poidometers, one of which is placed under each compartment and fed through a small chute. The machines are provided with counters for recording the total weight passed and also with an interlocking automatic start and stop mechanism, thus insuring that a constant feed of each material is delivered to the common conveyor at all times. This method of mixing avoids making up large charges, while the proportions may be changed at a moment's notice ; and for such reasons is more flexible and efficient than the use of the usual mixing beds or bins. Concentrate is prevented from hanging up in the bin compartments by an effective system of high-pressure air connexions for blowing down. The air hoses leading into the bin hoppers are clearly seen in the photograph of the poidometer installation shown in Fig. 4. The installation is an unusually large one and is found to be very efficient in operation.

Main and Distributing Conveyors for Coal and Charge.—Referring again to the flow-plan, it will be seen that the flow of coal proceeds from the by-pass at the coarse crusher (3) past the filter plant to the station (10) which is situated below ground level. The 20-in. conveyors for this purpose travel at a speed of 300 ft. per min., through tunnels built of reinforced concrete and also just below ground level. Delivering to the same point will be seen the two conveyors from the junction tower (6), which by-pass the fine storage bins, as well as the poidometer discharge conveyor carrying the furnace charges. (The lines extending from this station (10) to the fine

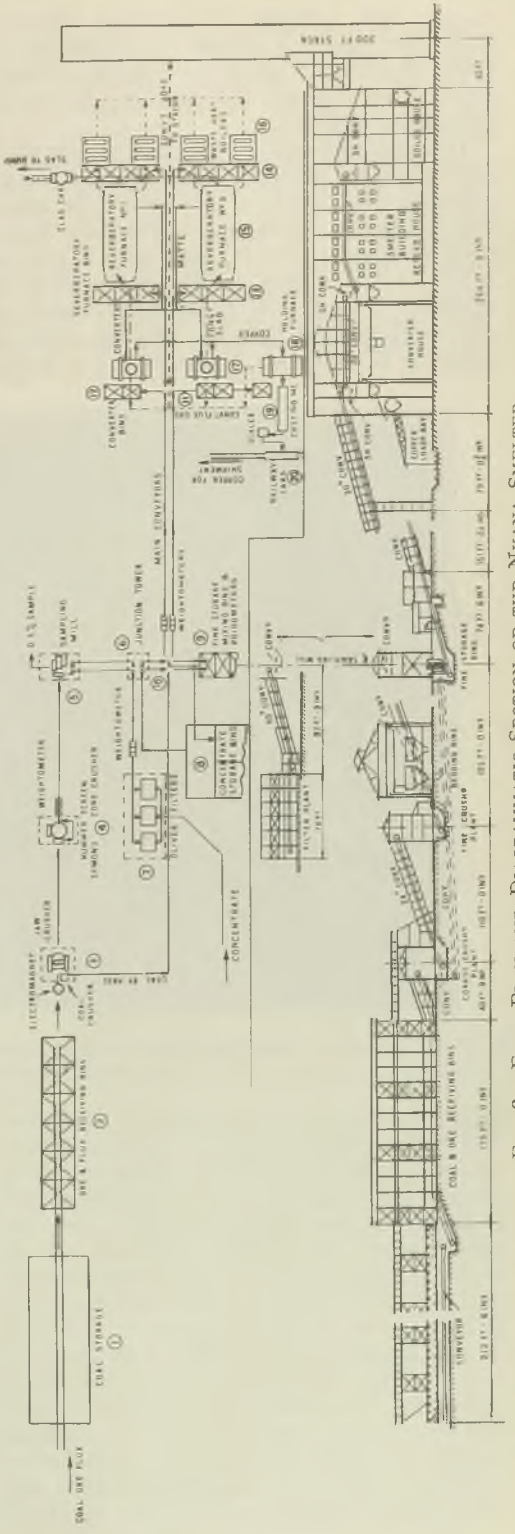


Fig. 2.—Flow-Plan and Diagrammatic Section of the Nkana Smelter

storage bins indicate the normal delivery from the junction tower to storage as above described; these conveyors, though immediately above the station, have no connexion with it.)

The underground station (10) is provided with a system of two-way chutes and gates whereby the various products discussed may be fed to either one of the two 30-in. main conveyors, 347 ft. long with a rise of 1 in 3·8, delivering to the main smelter building. Each of these belts, with a rate of travel of 300 ft. per min. and a capacity of 200 tons of material per hour, conveyor junctions and shown on the flow plan by a break in the flow lines.

Distribution of coal and charge to the converter and reverberatory bins and coal to the waste-heat boilers is obtained by means of reversing shuttle conveyors, which are supported on special carriages some 10 ft. below and running transversely to the main system.

Coal and Charge Bins.—The converter bins (12) consist of five steel hopper-bottom pockets 20 ft. long by 11 ft. wide by 18 ft. deep, subdivided into two compartments by $\frac{1}{4}$-in. steel partitions, each compartment

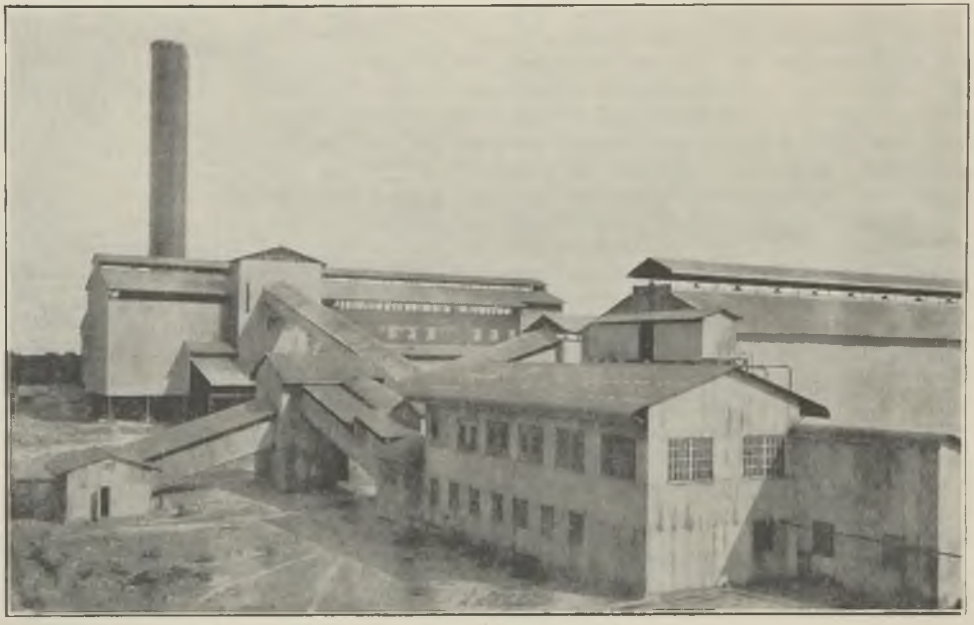


Fig. 3.—General View of Smelter looking South. Concentrate bins on right, filter plant in foreground, junction tower in centre.

is driven through speed reducers and gear and pinion reduction by a 35 h.p. motor. A Merrick Weightometer on each conveyor records the weight of coal or furnace charge delivered to the smelter building. The steel gantry which carries the conveyors, as can be seen in the two general views of the plant (Figs. 1 and 3), enters the building at a height of 68 ft. above ground level and from this point (11) the belts discharge first on to one set and then on to a second set of horizontal conveyors moving in the same direction and carried across the building on the converter flue gantry. Transfer to the distributing conveyors is effected by two-way chutes located at each of the main

holding 35 tons of coal or 70 tons of silica. In the case of the coal compartments discharge is effected through 2-ft. square openings and 9-in. pipe chutes to the converter coal pulverizers. In the case of the silica compartments feed to the converters is controlled by means of 20 in. by 4 ft. 6 in. Schaffer Poidometers, the discharge from these machines being passed through chutes to steel boats or Garr gun for charging the converters.

The reverberatory furnace bins (13) have six 20-ft. long by 14-ft. wide by 20-ft. deep steel pockets of the same general design as the converter bins, but not subdivided, and having a capacity of 100 tons of coal

or 285 tons of concentrate each. Discharge of concentrates takes place through hand-operated gates into mine cars for furnace charging, while the coal passes direct through nearly vertical chutes to the pulverizers which fire the furnaces.

The eight pockets of the waste-heat boiler bins (14), which are 15 ft. long by 13 ft. 6 in. wide by 18 ft. deep and hold 125 tons of nut-size coal each, are similarly discharged direct to the coal pulverizer auxiliary firing units located immediately below the bins and in a line with the fronts of the boilers.

spotted within the tunnel during tapping of the furnaces. The cross-section through the converter aisle in Fig. 5 shows clearly these relative levels. The slag cars are filled at the same level in the slag tunnel, the tracks of which open out to the slag dump on the east end and swing round to the converter aisle on the other end. At present the matte tunnel trackage terminates at the slag tunnel, but by a system of cross-overs to be installed as more furnaces are built the lines from each tunnel will curve into a common line outside the boiler house. With this arrange-

FIG. 4.—POIDOMETER INSTALLATION. Twelve machines for the continuous automatic making up of furnace charges.

REVERBERATORY FURNACES.—The two reverberatory furnaces are housed in a building 140 ft. long by 80 ft. wide, occupying the space between the converter aisle and the waste-heat boiler house. The furnaces are arranged with the firing end on the converter aisle and are spaced at 80 ft., between longitudinal axes. Between the furnaces is situated the reinforced concrete matte tunnel, which is 114 ft. in length and connects the transverse slag tunnel at the flue end of the reverberatories with the converter aisle. The tunnel has an inside width of 17 ft. and 11-ft. clearance from roof to rail level, the latter being 13 ft. below the slag bottom of the furnaces and approximately the same level as the converter aisle floor, thus providing ample drop from the matte taps to the matte cars, which are

ment it will be possible to haul the matte cars through any tunnel back to the converter aisle.

A drawing of one of the reverberatory furnaces is shown in Fig. 7. Each furnace has an inside length of 90 ft. 3 in. and an inside width of 26 ft. at the slag line, with 11 ft. 8 in. clearance from tap-hole level to the inside spring of the arch at the centre of the furnace. The wall foundations were laid down first and lateral reinforcing provided by groups of three $1\frac{1}{4}$-in. rods at 30 in. spacing and flaring out within the side wall foundations to take the bottom thrust of the buckstays. The position of the anchorage for the end stays is seen in Fig. 7. These consist of twelve $2\frac{1}{2}$-in. longitudinal reinforcing rods 27 ft. long and tied to a common joist within the furnace

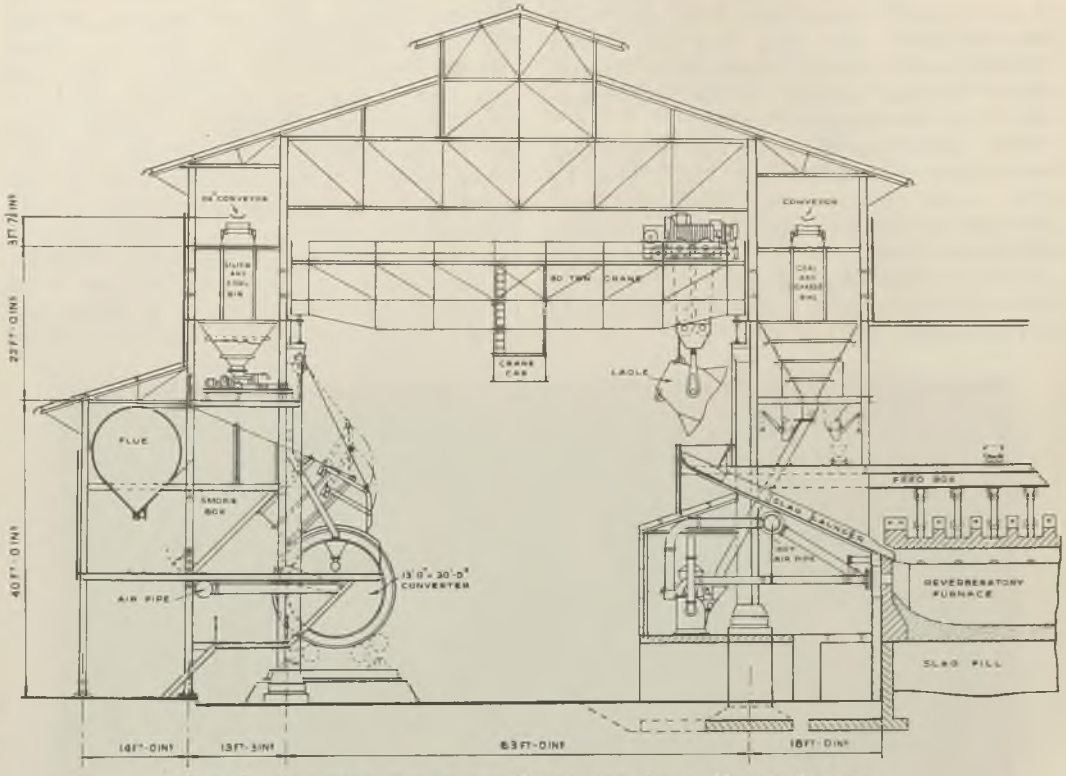


FIG. 5.—SECTION THROUGH THE CONVERTER AISLE, NKANA SMELTER.

bottom. The side-wall foundations are 7 ft. thick and are carried to a height of 15 ft. in two steps, the first supporting the furnace side walls and the second forming a 4-ft. buckstay backing. The end-wall foundations attain a maximum height of 16 ft. in two steps over a width of 7 ft. 3 in., providing additional strength and a base for the end stays.

A 6-ft. thickness of a weak mixture of concrete, poured after construction of the wall foundations, carries the slag bottom of the furnace. The first 5 ft. of the latter was laid down before completion of the furnace by melting slag from an old dump in a blast-furnace, temporarily installed close by, and tapping into a ladle, which was then lifted and poured by means of an erecting crane. This was carried out in such a way as to ensure overlapping seams between the solidified blocks to produce finally a single monolithic structure. The last foot of slag was put in after completion of the furnace and only allowed to cool sufficiently to solidify before normal furnace charging was begun.

The 3-ft. thick silica-brick side-walls of the furnace narrow to 18 in. above the maximum slag line, giving a width of 28 ft. between side-walls at the charge-hole level. The walls at the fire-bridge flare out to a thickness of 6 ft. at the floor, while a 12 in. lining of magnesite brick let into the side and end walls extends from the bottom to the top of the slag-fill the whole way round the furnace and is further extended to a level well above the matte line from the charging point towards the flue end, attaining a thickness of 30 in. at the matte taps.

The reverberatory arch, with a radius of 35 ft., is built of 18-in. silica brick and is reinforced by 12 in. deep by 18 in. wide ribs opposite buckstays for 60 ft. of its length from the bridge wall. The arch is horizontal throughout its full length, although it was originally designed with drop at the front end.

The uptake for furnace gases extends the full width of the arch, with a depth of 6 ft. 6 in. from the furnace front wall. The two boiler flues, of which only one shows in the plan, offset from the front of the uptake in opposite directions at an angle of 35°

to the longitudinal axis of the furnace. Each of these flues, which have a cross-sectional area of 69 sq. ft., is 9 ft. 8 in. long from furnace front wall to boiler entrance. High-alumina fire-brick is used in the uptake and flues, while the roofs are constructed of Dietrick suspended arch tile. The back wall of the uptake is supported on a relieving arch over the furnace arch, both of which are shown in the end section of the reverberatory drawing.

There are 18 side-wall buckstays spaced at 5-ft. centres and of box beam construction, being built up of two 15-in. by 6-in. I beams riveted to 14-in. by $\frac{1}{2}$-in. cover plates. The bottoms are held by the buckstay backing, as described, and the tops by $2\frac{1}{4}$-in. square tie rod. The end-wall buckstays are held at the bottom by a 12-in. by 6-in. beam tied to the foundation rods, as mentioned in the description of the furnace bottom, and at the top by a $25\frac{1}{2}$-in. by 12-in. compound beam bolted to the skew-back supports. Each of these supports, which acts also as a longitudinal tie rod, is built of four 6-in. by 3-in. channels with $24\frac{1}{2}$-in. by $\frac{1}{2}$-in. cover plates. They are seen in a position to take the thrust of the arch in the end section of the drawing.

There are eleven 9-in. charge-pipes on each side of the furnace spaced between buckstays and entering on a line 6 in. from the inner side of the side wall, as well as six other pipes across the back arranged to fettle the bridge wall. There is no provision, however, for fettling between the charging area and the front wall. The charge floor is 10 ft. above the top of the furnace arch and the charge hoppers are fed from 18 cu. ft. side-dump mine cars, running on light rails and hand trammed from the charge bin gates. Hot converter slag is charged by means of a launder (see cross-section through converter aisle) leading from the converter aisle through the top centre of the bridge wall.

Each furnace has four tap-holes for drawing off the copper matte, the two on the matte tunnel side being placed 16 ft. and 26 ft. from the front wall or flue end of the furnace, while the two front tap-holes are situated at a distance of 4 ft. on either side of the skim door, which is centrally placed. The tapping plate holder is a cast steel block held by the buckstays and the brickwork of the walls and the plate itself, which is cast from blister copper, is 6 in. thick and has a $3\frac{1}{2}$-in. tapping hole. Plates made thus are found to be satisfactory for the grade of matte handled. The level of the skimming door for the removal of slag is about 23 in. above the matte taps and this level is varied by the use of 2-in. skimming plates held by the cast steel skimming block.

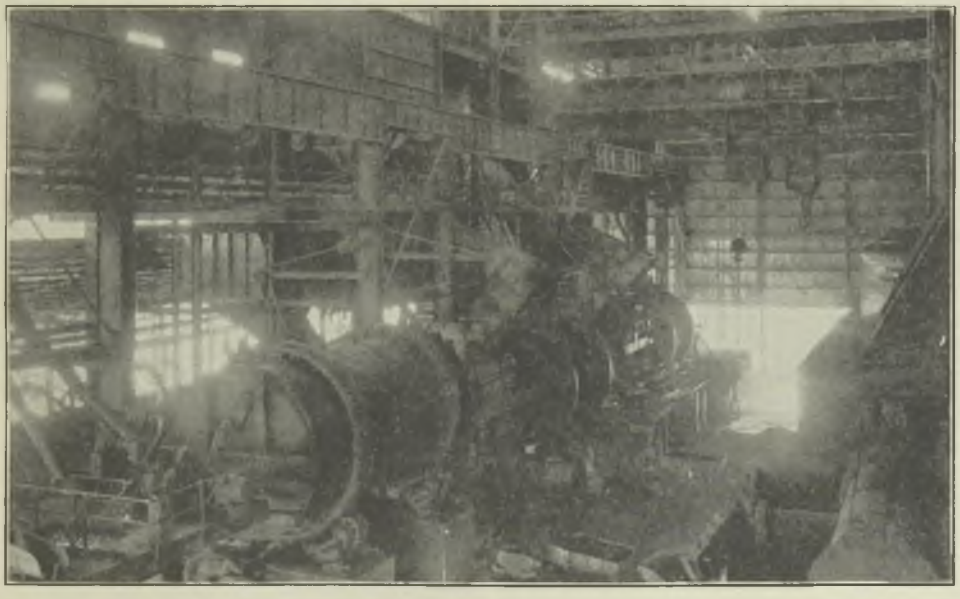


Fig. 6.—Converter Aisle. View looking east, with holding furnace in foreground.

Three International Combustion Impax 3½-ton per hour unit coal pulverizers are installed for firing each furnace (Fig. 10). The machines are provided with integral exhausters, 100-h.p. driver motors, and 1-h.p. feeder motors. A 36-in. bustle pipe from the waste-heat boiler forced-draught fans supplies, through 18-in. take-offs, primary air to the pulverizers and secondary air to the burners. In the case of the former the 350° F. preheated air is held down to 180° by admission of outside air. The six burners are made of 9-in. pipe and may be served in groups of two or three by the pulverizers, thus leaving any one machine as a stand-by and allowing the use of either four or six burners according to the amount of coal it is necessary to burn. The position of these burners will be seen by reference to the furnace drawing. The two outer ones are pitched slightly inwards and downwards.

The coal supplied to the smelter is washed, peanut size with an ash content of 10–11% and calorific value of not less than 13,250 B.Th.U. It is railed 600 miles from the Wankie Colliery Company's mines in Southern Rhodesia. The pulverizers are set to give a product of which 95% will pass a 100-mesh screen and the reverberatories run with a short flame, not exceeding 50 to 60 ft. in length. As a result of using both forced- and induced-draught fans the draught is remarkably steady. At a distance of 10 ft. back of the uptake it ranges from 0·03 to 0·07 ins. of water, depending, of course, upon the amount of coal burned.

Slag is skimmed off into 200 cu. ft. M.H. Treadwell Co. slag cars. The slag train of one to three cars is handled by a 15-ton Jeffrey locomotive with overhead trolley, operating on a 500-volt d.c. supply. The pots are tilted by a 20-h.p. series-wound d.c. motor controlled from the cab of the locomotive. Matte is tapped into 200-cu. ft. ladles, which fit into heavily constructed ladle trucks running on standard 3 ft. 6 in. gauge tracks. When tapped from the front of the furnace the matte is delivered to the converter aisle by the above locomotives; when tapped from the side of the furnace it is hauled through the matte tunnel by means of an electric single-drum hoist.

The reverberatory charge consists of raw concentrates, matte shells, converter slag shells, as well as holding furnace slag and dust from the waste-heat boilers. At the present time, with normally high-grade concentrates, no flux is necessary. As before mentioned, the concentrates are charged by means of side-dump mine cars hand-trammed from the concentrate charge bins. The secondaries, loaded into boats in the converter aisle, are dumped on to the reverberatory charge floor, where they are shovelled into cars and charged direct into the furnace without mixing with concentrates. A summary of operations for the year ending June 30, 1933, is shown in Table I.

TABLE I

TOTAL MATERIAL SMELTED FOR THE YEAR ENDING JUNE 30, 1933

Reverberatory Charge, dry short tons.

Concentrates	98,444	tons
Mine Ores, Foreign Slag, etc.	390	,,
New Copper-Bearing Material	98,834	,,
Limerock	351	
Converter Secondaries	21,296	,,
Total Solid Charge	120,481	tons

ASSAY VALUES

	Concentrates Charged.	*Molten Converter Slag Charge.*	*Matte Produced.*	*Slag Produced.*
% H_2O	7·69	—	—	—
% Cu	54·92	5·24	61·70	0·82
% S	23·3	1·15	22·79	—
% SiO_2	4·76	21·96	—	33·90
% Al_2O_3	0·58	2·88	—	6·58
% Fe	9·09	—	8·18	—
% FeO	—	47·60	—	38·01
% CaO	0·36	1·11	—	1·98
% MgO	0·36	1·15	—	1·52

FUEL CONSUMPTION

	Tons.
Average tons per day New Material	272
Gross tons Coal per ton New Material	0·206
Net tons Coal per ton New Material	0·081
Average tons per day Solid Charge	330
Gross tons Coal per ton Solid Charge	0·169
Net tons Coal per ton Solid Charge	0·066

The net coal tonnage is the gross tonnage less equivalent coal for steam production in waste-heat boilers which is returned as a credit to smelting operations.

Under the conditions summarized in the table an unprecedented life of 413 days was obtained with No. 2 Reverberatory arch, during which period 142,000 tons of charge material was smelted without interrupting firing.

WASTE-HEAT BOILERS.—The waste-heat boiler installation (16) occupies a 140-ft.

by 75-ft. extension of the reverberatory furnace building and at the present time consists of four International Combustion tri-drum water-tube type boilers of 70,000 lb. per hour evaporation rating each, equipped with super heaters and constructed on the water-wall principle. Two boilers are connected to each furnace by means of the uptake and flue chambers roofed by suspension arches as described. Each boiler is provided with two 3-ton per hour coal pulverizers for auxiliary firing and by means of a balanced-draught system is designed to be operated on waste heat alone, combined waste-heat and auxiliary firing, or, by lowering a double system of dampers, on direct firing alone.

The boiler flue gases are drawn downwards through air-heaters by two induced-draught fans per boiler, each fan having a capacity of 40,000 cu. ft. per min. at 7 W.G. rating and driven by a 110 h.p. motor. The air-heater exit gases pass into a 12-ft. diam. hopper-bottom flue running the length of the boiler house and opening by means of an uptake section into the main flue and stack. A single 40,000 cu. ft. per min. forced-draught fan for each boiler, driven by a 200 h.p. motor, supplies preheated air at 400° F. and 14 W.G. to the unit pulverizers of the boilers themselves and the burners and pulverizers of the reverberatories as described, while the waste gases are reduced in temperature from 660 to 400° F. Ash is discharged dry from the boilers, which are equipped with slag-preventing screens, while the usual means are provided for the removal of dust from the air-heaters and flues.

The practice at the present time is to operate one of the boilers on the "down" furnace on direct firing and one or two others on waste-heat, using as little dual firing as possible. Maximum continuous loads of 110,000 lb. evaporation per boiler at 350 lb. gauge pressure and 750° F. are maintained with average direct-firing evaporation of 9·0 lb. of water per lb. of coal and waste-heat evaporation of 5·5 lb. per lb. of coal burnt in the reverberatories. Some 25–30% of the total steam requirements are derived from waste heat and so great is the economy effected by this installation that 62·5% of the fuel consumed in the reverberatory furnaces is available for steam production and, as shown in the foregoing table, is returned as a credit to smelting operations. Of the 4,400 tons of coal having an average calorific value of 13,300 B.Th.U. consumed in a recent 30-day month 1,560 tons was used for smelting (and waste-heat firing) and 2,840 tons for direct firing, on which a boiler house efficiency of 80% was obtained. Make-up water is treated in a Paterson water purification plant using ammonium sulphate coagulant. Condenser cooling water circulates *via* a 36-in. main through five Worthington-Simpson forced-draught cooling towers, each provided with four fans driven in pairs by two 37-h.p. motors.

In addition to the waste-heat plant there is the original boiler plant used during construction and before completion of the main units, containing two International Combustion boilers of 40,000 lb. evaporation each, fired by a single 3½-ton unit pulverizer with a third interconnected unit as a spare. This installation, which is available for use at any time, provides an effective stand-by steam plant for emergencies. The power plant and this boiler

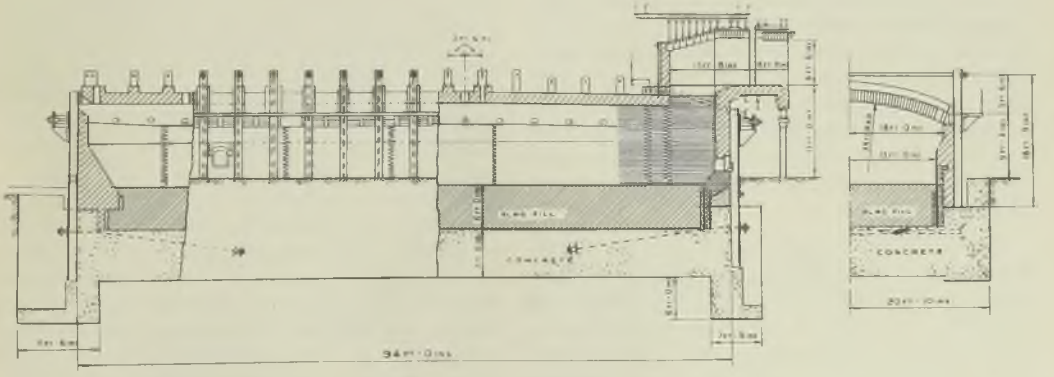


Fig. 7.—Sectional Side and End Elevations of Reverberatory Furnace, Nkana Smelter.

house with stack are seen in the general view of the smelter looking south-east (Fig. 1).

Converter Aisle and Cranes.—A cross-sectional drawing of the converter aisle through one of the converters and reverberatory furnaces is shown in Fig. 5. The aisle is 280 ft. long by 60 ft. wide by 68 ft. 6 in. to the roof trusses, which have a 63-ft. span and are supported by steel columns spaced at 20-ft. centres. Heavy compound columns tied into the roof columns support the crane rail girders, which are built of 36-in. web-plate for the 20-ft. spans and 60-in. web-plate for the 40-ft. spans over the converters and holding furnace (see Fig. 6).

Two 80-ton electric cranes supplied by the Wellman Smith Owen Engineering Corporation with 20-ton auxiliary lifts serve this building. These cranes have a 60-ft. span from rail centres and a lift of 50 ft., with a speed of long travel of 300 ft. per min. The 500-volt d.c., 80-h.p. hoist motors are equipped with diverter control to give lifts of 15 ft. per min. for loads up to 40 tons and 10 ft. per min. in excess of 40 tons. Automatic solenoid brakes and dynamic load brakes are fitted throughout. The main cross travel is designed as a bridge structure to span the travel of the auxiliary trolley and the two hoisting drums are arranged at each end to give a four-point suspension of the box girder lifting beam through 16 falls of 1-in. rope operating over four sheave wheels. Laminated trunnion loops or bails are hung from each end of the beam for lifting the matte ladles. The auxiliary lift carries a $3\frac{1}{2}$-in. shank size hook supported by 1-in. rope on two sheave wheels.

Matte shells and converter slag shells are dumped into heavily-constructed flat-bottom bins located on the south side of the converter aisle and 10 ft. above the floor. The material is broken by ball and by hand, shovelled off into ladles for unloading on to the reverberatory charge floor, and charged into the furnace as previously mentioned. The bins are seen in the right foreground of Fig. 6.

Converters.—The two 13-ft. by 30-ft. Pierce Smith converters (Fig. 17 on the flow-plan) are located opposite the reverberatory furnaces, as will be seen by reference to the sectional drawing and photograph (Figs. 5 and 6). The forty-five $1\frac{1}{2}$-in. tuyeres with a pitch upwards of $7\frac{1}{2}^{\circ}$ are placed on a line 3 ft. $3\frac{1}{2}$ in. below the horizontal diameter of the converter in blowing position. Air is supplied at 15–20 lb. pressure by two turbo-blowers situated in the power plant. Each converter is fired by a No. 3 Impax coal pulverizer located axially with the furnace to allow free movement of the inlet fuel pipe, which enters the shell at a point 30 in. above the axis in order to clear the metal splash. Fuel is only required in emergencies, so that during normal operation the coal consumption is negligible.

The $1\frac{1}{4}$-in. steel shell is lined with magnesite bricks of various sizes to give a 13-in. thickness on top of the furnace, 15-in. on the front, and 18-in. on the bottom, at the tuyere line, and on the ends, while a 2-in. backing of granular, dead-burnt magnesite is used throughout between brickwork and shell. Peripheral and longitudinal expansions are provided by the use of corrugated partition paper.

The tilting mechanism consists of a 75-h.p. 500-volt d.c. reversible motor, driving through a reduction gear and fitted with an automatic solenoid brake. The controllers for this mechanism are situated on an operating platform at the ends and above the converters. In addition to light signals, the governor gear of the turbo-blowers supplying air from the power house to the converters is electrically controlled from this platform, an arrangement which ensures rapid adjustment of blower output to requirements.

Each converter has a production capacity of 60 to 100 tons of blister copper per charge. Weighed amounts of silica are delivered from the poidometers, as described, and charged by means of a Garr gun or boat. During-slag making it is found that very little cold material can be used on account of lack of heat, whereas during the copper blow a considerable amount of such material can be remelted. For the year ending June 30, 1933, the converter plant produced 54,460 tons of blister copper, while the blister copper production per converter day actual blowing time was 277 tons.

Holding Furnace and Casting Machine.—The holding furnace (18), which is seen in the foreground of the illustration of the converter aisle, is of the same general dimensions and construction as the converters and is actuated by the same type of tilting mechanism. The pulverized fuel firing is also carried out as described for the converters, but the coal consumption in this

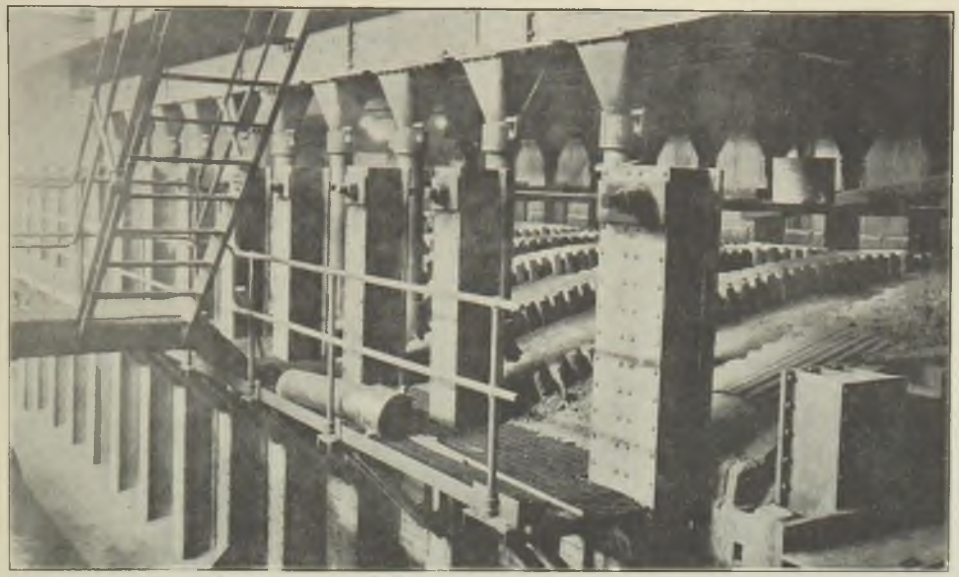


FIG. 8.—No. 2 REVERBERATORY FURNACE. Showing charge pipes and ribs of roof arch from firing end. The furnace had been in continuous operation for 400 days when this view was taken.

case runs up to 100 tons per month. The 4-ft. diam. brick-lined outlet flue is carried down outside the furnace so that its centre line coincides with the axis of rotation of the furnace, enabling the latter to be tilted without cutting off the flue. The furnace has a 15-in. magnesite brick lining, with the same backing and expansion arrangements as described for the converters. The 4-ft. by 6-in. mouth is provided with a brick-lined steel cover hinged at one side and automatically lifted by means of cables when the furnace is tilted to receive a charge, the cables being attached to the shell and carried over snatch blocks which are fixed to the steelwork above. These details, together with the firing arrangements, are seen clearly in the illustration.

On the skimming floor side of the furnace, on a line at right angles to the diameter through the mouth, three ports are provided, the centre one being fitted with a cast steel spout for pouring, while the two end ones are used for poling or skimming. The latter are, of course, placed at a slightly higher level to prevent metal running out while pouring from the centre opening. The skimming floor, at a level of 18 ft. above the casting floor, is continuous with the converter operating floor and extends the full length of the building back of converters and holding furnace. The converter punching floor is situated midway between the skimming and casting floors.

Copper is poured from the holding furnace to an hydraulically-operated spoon and thence to one of the straight-line casting machines (19). The second machine, of identical size and capacity, is fitted with an electrically-tilted cradle for pouring direct from a ladle and serves as a spare only. Each machine holds 50 moulds 27 in. by 15 in. by $3\frac{1}{2}$ in. deep, which are cast from blister copper in the converter aisle, and make a blister bar weighing approximately 300 lb. The machines are driven by a 500-volt 15-h.p. d.c. motor through a reducing gear and pinion shaft to give a linear speed of 15 ft. per minute. The movement of the chain of moulds, the hydraulic pouring spoon, and the tilting furnace are controlled from an operator's platform close by and protected from splash with wire gauze. Cooling is effected by a system of overhead sprinklers and the steam taken off by a wooden housing and stack.

The copper handling floor, shown in Fig. 10, is 278 ft. long and 43 ft. wide and adjoins and runs parallel to the converter aisle on the side opposite the reverberatory furnaces. The floor is of concrete, with depressed railway tracks along the outer side, both

floor and tracks being roofed over for the full length of the building.

The blister copper bars discharged from the casting machine on to this floor are removed by natives with warehouse trucks. After chipping and weighing they are transferred to railway cars (20) for shipment.

Flue System and Stack.—The flow of gases is shown as a dotted line in the flow-plan. The converter hoods, having cross-sectional dimensions of 12 ft. by 8 ft., deliver into the 12-ft. diam. converter flues is also supplied with V-bottom sections and clean-out gates spaced at 5-ft. centres. These gates are discharged into a dust car running on light rails along the floor of the gantry between the coal and charge conveyors, earlier described. Near the end of the gantry the 20-ft. by 13-ft. uptake flue from the waste-heat boilers enters the main flue. The dust car passes through this uptake in a tunnel provided for the purpose no to the gallery connecting the boiler house with the stack and so under the clean-out

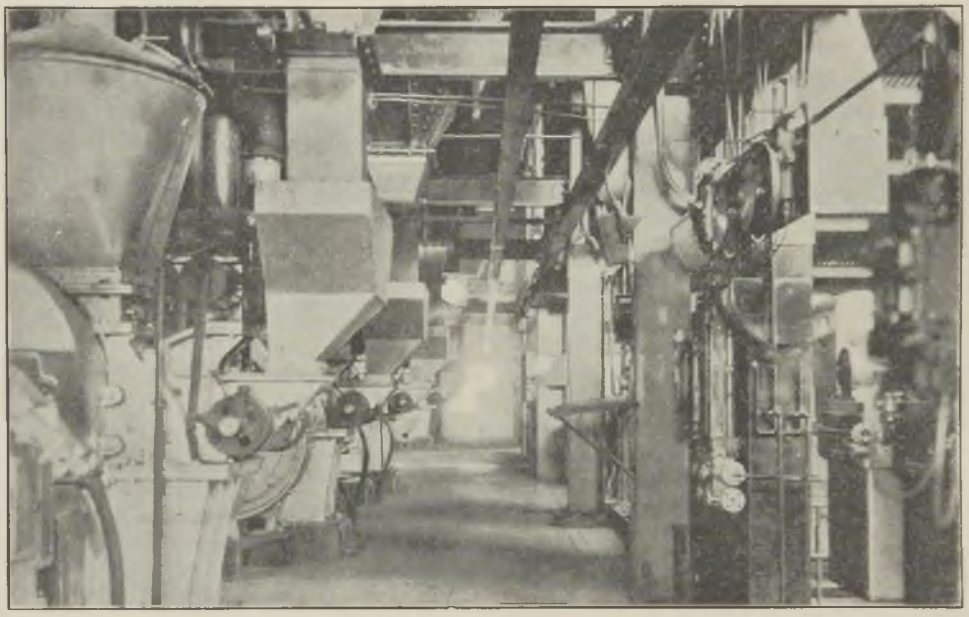


Fig. 9.—Unit Coal Pulverizers, as installed for reverberatory furnaces and auxiliary firing on waste-heat boilers.

paralleling the converter aisle (see Fig. 5), with a centre line 32 ft. 6 in. above floor level and equipped with V bottoms and clean-out gates. The holding-furnace flue delivers down 10 ft. to a dust pit and thence into a 6-ft. diam. 45° up-cast flue, which opens into one end of the converter flue. It is supplied with a 4-in. brick lining and a control damper. The converter flues from each end of the building deliver into 8 ft. 6 in. by 12 ft. uptakes 55 ft. high and opening into the main flue.

The main flue, which carries the converter gases to the stack, is 264 ft. long by 17 ft. in diameter, with a centre line 86 ft. 6 in. above ground level. The flue is carried on a special gantry structure above the crane level for the full width of the building and gates of the hopper-bottom flue section, which enters the stack in a 30-ft. by 12-ft. opening 85 ft. from the ground. The general cross-section shows this stack connexion clearly.

The stack has an inside diameter of 30 ft. and is 300 ft. high. Below the flue intake level there is a steel ash cone with a 10-in. diam. chute and a clean-out gate outside the shell. The foundations consist of an 8-in. reinforced concrete floor 72 ft. in diameter and 17 ft. below ground level, strengthened with 12 radiating and heavily-reinforced ribs 3 ft. 6 in. wide. An 18-in. thick cone of concrete 15 ft. high carries the 31 ft. 6 in. outside diam. by 7 ft. 6 in. deep by 2 ft. 6 in. thick reinforced concrete foundation ring which supports the heavily-flanged steel base of the stack and to which

it is tied by twenty-four 11 ft. 4 in. long by 3½ in. diam. foundation bolts. The shell of the stack is built up of 6 ft. by 12 ft. by $\frac{7}{16}$ in. tapering with height to ¼-in. sheet, held by double rows of rivets and reinforced every 10 ft. with 4 in. by 3 in. by ½ in. by [illegible] in. angle rings, which also support the brickwork lining. The lining consists of a single thickness of burnt brick having a ¾-in. asbestos backing, while lead flashing protects the angle rings against corrosion. The stack contains 281 tons of steel and 504 tons of brick and mortar, while the foundations contain 937 tons of concrete and 46 tons of reinforcing bars, giving a total weight, including miscellaneous items, of 1,780 tons, in addition to which some 1,200 tons of earth fill covers the concrete base.

Fig. 10.—Copper Handling Floor. Showing straight-line casting machines, scales, and railway cars.

Power Plant.—A concrete tunnel some 300 ft. long connecting the waste-heat boiler house with the power plant carries two 14-in. steam mains, as well as feed-water and condensate lines. The equipment of the power plant includes two 10,000-k.w. 3,300-volt 3-phase 50-cycle 3,000-r.p.m. Metropolitan-Vickers tandem-type direct-driven turbo-generators, with electrically-driven auxiliaries. These sets are fitted with 4-stage feed-water heaters, the last stage of which collects condensate from the whole plant and supplies the boilers with water at 260° F. by means of multi-stage centrifugal feed pumps operating against a pressure of 450 lb. per sq. inch.

One of the above generators has sufficient capacity to supply al power requirements at present. There is also available the original installation of two 3,000-k.w. 3,300-volt 3-phase 50-cycle Metropolitan-Vickers self-contained geared turbo-generators with speed reduction from 5,000 to 1,000 r.p.m. and positively-driven auxiliaries. Air for the smelter converters is supplied by two 20,000 cu. ft. per min. Brown Boveri turbo-blowers with steam-driven auxiliaries and remote control from the operating platform of the converters, as described.

The electrical control and distribution panels are of the most modern type. Totally-enclosed iron-clad switchgear is used throughout, while the main switches are electrically operated from a remote d.c. control board. For this purpose and for protection in emergencies a 250-ampere-hour storage battery installation is provided, supplied by two motor-generator charging sets. The 3,300 bus-bar voltage is stepped up to 11,000 volts for long distance transmission and down to 550 volts and lower for general consumption.

The use of 3,300-volt synchronous machinery wherever possible throughout the plant gives the system a resultant power factor of 93%, while the over-all efficiency of the power plant on the basis of calorific value of fuel to kilowatt output is 17·5% and the coal consumption 1·52 lb. per kilowatt-hour sent out.

Electric Furnace.—An Electromelt tilting furnace has recently been installed at the west end of the converter aisle in

a position to be served by the cranes. The furnace has a rating of 2,500 k.v.a. using a 100-volt 3-phase 50-cycle current stepped down from 3,300 volts by an oil-cooled, double-wound transformer and is of the arc type, with 12-in. diam. self-feeding electrodes. The crucible has an inside diameter of 6 ft. 5 in. with a depth of 15 in. and holds about 3 tons of molten charge. A magnesite brick bottom and silica brick sides and roof are provided. The furnace is used to reduce converter-slag rich in cobalt for the production of high-grade cobalt-copper-iron alloys.

THE NIGERIAN GOLDFIELD

By W. RUSS, Ph.D.

A general description by a member of the Geological Survey of conditions in a colony where gold mining is now being actively developed.

INTRODUCTION.—The presence of gold in many parts of Nigeria was first reported by Dr. J. D. Falconer as a result of investigations carried out by him while in charge of the Mineral Survey of Northern Nigeria instituted by the Colonial Office in 1904. Since then mining has been carried on by several small companies, but mostly by individuals, over a period from 1914 to the present time. With the exception of a little work done on a small scale on reefs at Remi, Minna, and Birnin Gwari, where about 300 oz. was won, all the gold obtained has been alluvial. Mining activity has been confined almost wholly to the clearance of stream and river beds, hence the life of the goldfield has been a fitful one, as will be seen from the data given in Table 1.

TABLE 1

Year.	*Output.*	*Year.*	*Output.*
1914	350 oz.	1825	1,010·45 oz.
1915	1,396 ,,	1926	133 ,,
1916	2,422·9 ,,	1927	22 ,,
1917	2,865·7 ,,	1928	86 ,,
1918	1,414·6 ,,	1929	192 ,,
1919	319 ,,	1930	260 ,,
1920	724·5 ,,	1931	700 ,,
1921	218·25 ,,	1932	2,700 ,,
1922	701·75 ,,	*1933	8,295 ,,
1923	945 ,,		
1924	1,441·56 ,,	Total	26,197·71 ,,

* January–July.

In 1931 the finding of nuggets in the Kazai area ranging up to 17 oz., coupled with reduction of activity on the tinfields and the high price of gold, has been followed by a fresh burst of activity on the goldfield and the returns show a record for the present year of 8,295 oz. from January to July. In 1926 investigation of the goldfield, relatively unknown geologically, was undertaken by the Geological Survey and a block of country extending from Minna to Birnin Gwari, and covering approximately 8,000 square miles, was selected for examination. The survey has been assisted by having the advantage of an excellent series of contoured maps made in advance by a body of Royal Engineers operating under the direction of the Surveyor-General. A geological edition of the 7½ standard sheets which cover this area is now available.

The result of the investigation has been to demonstrate—

(*a*) The structure of the field.

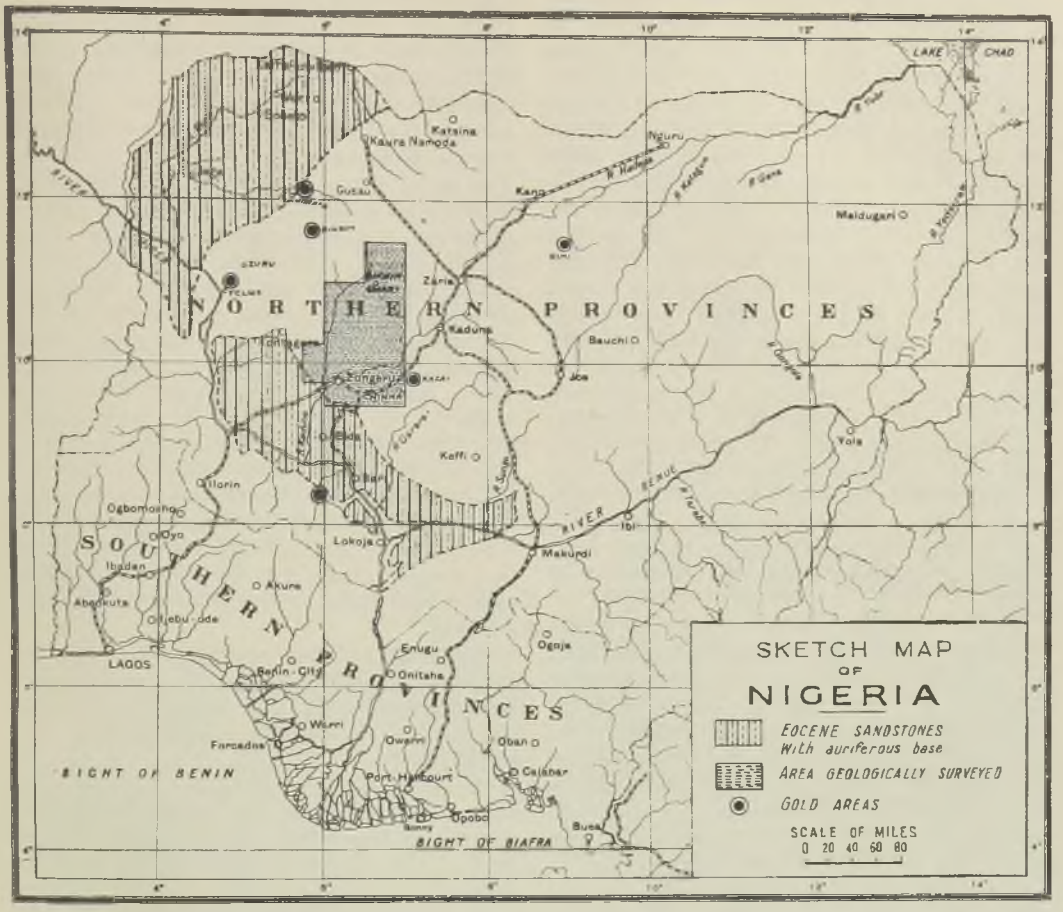
(*b*) The importance of tectonics—shatter belts, etc.

(*c*) The widespread presence of river terraces, some of which are gold bearing.

(*d*) The presence of banket at the base of the Nupe Sandstone Series, which covers several thousand square miles of country adjacent to the goldfield area.

The sketch map (Fig. 1) shows the chief gold-bearing areas in addition to the area surveyed. Gold is widespread. In addition to areas indicated, many rivers in the Southern Provinces—for example, in Oyo and Abeokuta Provinces and in Calabar District—show values of gold, but little work has been done on them and so far gold has not been discovered in payable quantities.

GEOLOGY.—The only sedimentary rocks in the surveyed area are a patch of Eocene sediments in the extreme south-west, referred to as the "Nupe Sandstone Series." This series of about 500 ft. of sandstones and grits, with interbedded pebble beds and conglomerates, is part of a wide strip of sandstones that flank the River Niger throughout its course through the Northern Provinces. The series originally extended over most if not the whole of the area surveyed, as is evidenced by relics in the form of pebble beds, boulders of banket, and thin skins of



sediments in widely scattered localities resting directly on the crystalline rocks of the Archæan complex which occupy the remainder of the area.

With the evidence of boulders of banket in three localities and one auriferous conglomerate in situ at the base of an outlier indicating an auriferous base to the Nupe Sandstone Series, the author made a rapid reconnaissance of a portion of this strip of sediments—namely, that lying between Kontagora and Jebba—with a view to proving the existence of banket at the base of the series. Exposures of basal beds are very rare, but in one locality near Jebba a bed of hard siliceous conglomerate was discovered at or very near the base of the series (base unseen). At this exposure the rock was found to be barren. In the detached localities, however, the rock is auriferous and there is no doubt whatever that the base of the series, which covers several thousand square miles, is auriferous in places. It is reported that banket has been found at Yelwa by miners working there, but no details are available. The remainder of this strip of massive sandstones—*i.e.*, other than the portion between Kontagora and Jebba—which stretch from the boundary of the Protectorate to Lokoja, a distance of nearly 400 miles, has never been investigated in detail, but the author hopes next dry season to examine the series north of Yelwa.

With the exception of the above mentioned Eocene sandstones in the extreme southwest the whole of the area consists of an Archæan complex of gneisses, schists, older gneissose granites, and minor intrusives. Of primary importance to the miner are the schists, which lie scattered over the surface of the complex in twelve considerable outcrops, varying in size from 300 square miles

down to less than 10 square miles. The rocks of this group, which consist principally of chlorite and mica schists, with some carbonaceous schists, have been thrown by earth movements into a series of sharp, closely-packed folds, with a pitch of about 30° to the north. The crests of these folds are filled with auriferous quartz, giving rise to saddle reefs. These bodies of quartz are in the form of an inverted " V," the apex of the V being thick and the limbs thinning with depth. A vertical section would show a series of such V's or " saddles " one above the other. As the axes of the folds pitch to the north, it will be seen that a horizontal section (such as the surface of the ground) will also give a succession of V's or saddles one within the other. It is owing to this structure of fragmentary reefs that the general scarcity of major lodes is due. Such major lodes as have been found are due to the infilling of fault fissures arising from excess of pressure after the formation of folds.

Older Granite.—The term " Older Granites " is a comprehensive name used to include a series of gneissose granites related in petrological and chemical characters. Moreover it distinguishes them from the " Younger or Plateau Granite " of the tinfields. They penetrate the gneisses at various points throughout the area and are exposed in 18 outcrops varying in size from two or three square miles up to 70 square miles and cover a total area of about 300 square miles. The older granites can readily be recognized in the field, as they form all the most striking features of the topography. In their typical development, as in the fine group of inselbergs at Kusheriki, the rock is a coarse porphyritic biotite granite, with large prismatic felspars. The older granites, however, will be found to vary considerably in structure, texture, and in petrological and chemical character. They are remarkably free from intrusives, which are confined to a few poorly-developed acid veins. The outcrops of older granites were mapped in the expectation that they would be found to be the parent of the auriferous dykes of the area. This genetic relationship, however, remains to be established. It is probable that the gold-bearing dykes are a product of hydato-genesis and are not generally of direct igneous origin.

Tectonics.—A result of the examination of the area has been to reveal the existence of a lattice of major faults and shatter belts, with a general trend N.N.E.–S.S.W. and E.S.E.–W.N.W. Examples of the crossing of such lines of rupture may be seen in the right-angular orientation of the ridges and foliation of the rocks in the Kazai area and again in the torsion of quartzites at Makachi from a N.S. to nearly an E.W. direction. The major lines of weakness are frequently marked by a series of subparallel faults or shattered ground, particularly those in a N.N.E.–S.S.W. direction, and the movements have been accompanied by much shearing and shattering of the rocks and frequently by silicification. The east to west faulting is of the nature of tear faulting. These major lines of weakness have been utilized for the passage of mineralizing solutions, which have resulted in the deposition of auriferous quartz veins on a gigantic scale and in the silicification of country rock. After due consideration has been given to the proximity of schist belts, it is to the location of shatter belts that the prospector should look rather than to the proximity of older granites.

Economics.—The sources of gold are fivefold—(1) river beds, (2) terraces, (3) terrestrial deposits, (4) quartz reefs, and (5) banket—auriferous conglomerates and pebble beds.

(1) *River Beds.*—Nearly 99% of the gold so far won in Nigeria has been derived from the clearance of present-day stream and river beds. This is still the main source of supply.

(2) *Terraces.*—The last earth movement to which the area under consideration has been subjected was one of depression to the south. This has resulted in the rejuvenation of the whole river system and the lining of all the rivers of the area with terraces, some of which are auriferous. This source of gold has so far remained untouched, but will doubtless receive more adequate attention from prospectors as present-day river beds become worked out.

False Terraces.—At Guwa, about 1½ mile south-west of the village and about 120 ft. above the present level of the Kaduna River, the summit of a flat topped hill, with an area of about half a square mile, consists of a coarse pebble bed having a maximum thickness of 10 ft. This is a relic from the base of the Nupe Sandstone Series and should not be regarded as an ancient terrace of the Kaduna River. Similarly at the headwaters of the River Getamya, near Alawa, several acres of pebbles strew the ground

adjacent to this small stream. Here again and elsewhere the base of the Nupe Sandstone Series appears as river terraces. In the two cases quoted they were found to be barren, but there is no reason why they should not carry gold values.

(3) *Terrestrial Deposits.*—Some of the wooded ridges of the Kazai area 30 miles east of Minna have their slopes well covered with terrestrial deposits having good values of coarse gold at the base, which rests directly on a rock bottom. Although the gold is little worn and has not travelled far, no lode has yet been discovered in this area. Again at Beni, 10 miles to the south, gold occurs accumulated round grass roots.

(4) *Quartz Reefs.*—Saddle reefs have been worked at Birnin Gwari, where about 300 oz. were won. Samples of the auriferous reefs from this area recently submitted to the Imperial Institute for assay yielded—

Gold . . .	5 dwt. 6 gr. per ton
Silver . . .	5 ,, 16 ,, ,,

As the gold is in the metallic condition and the quartz veins are plentiful, this field promises to be an economic one at the present price of gold. Many schists of this area are carbonaceous, especially those 3 miles east-north-east of the town of Birnin Gwari. A lode in the Minna area has been proved over a length of 1,000 ft. with an average width of about 3 ft. Gold values run up to 17 dwt. and sulphides occur in part of the reef. This lode belongs to that group mentioned in an earlier paragraph as arising from the overthrust of saddle reefs. In this instance the lode is accompanied by a number of lesser subparallel reefs. Another lode at Remi, 50 miles S.E. of Kano, having an average width of 2 ft. and exposed for $\frac{1}{4}$ of a mile, shows values of from 4 dwt. up to 2 oz. per ton. The above occurrences—of saddle reefs at Birnin Gwari and lodes at Minna and Remi—represent the sum total of payable reefs so far located. Obviously this is a very inadequate showing for this primary source and it is almost certain that with further prospecting other payable reefs will be found.

(5) *Banket—auriferous conglomerate and pebble beds.*—At Guwa (Long. 6·31 E., Lat. 9·55 N.), Laie (5 miles to the east), and 5 miles south of Wushishi hard siliceous boulders occur buried in the soil. These are gold bearing. They are undoubtedly relics of banket originally formed at the base of the Nupe Sandstone Series, which once covered the area. The rocks constituting this series are now to be found covering several thousand square miles flanking the River Niger and elsewhere adjacent to the gold belt. Examination of these rocks in the Kontagora–Jebba region yielded several horizons of pebble beds with small gold values and in one locality north-east of Jebba there occurs a basal bed of hard siliceous conglomerate not less than 10 ft. thick and identical with the banket boulders of Guwa and Laie. This outcrop, however, proved to be barren. The value of this potential source of gold has yet to be proved. That it requires extensive prospecting and considerable expenditure will probably delay its thorough investigation, but rich deposits may well lie locked up at the base of this series of sandstones awaiting the hand of the prospector.

Summary.—The five sources of gold in Nigeria are :—(1) River beds, (2) terraces, (3) terrestrial deposits, (4) quartz reefs, and (5) banket. Almost the whole of the gold formerly won in Nigeria has been derived from class 1—*i.e.*, merely by the clearance of present-day stream and river beds ; at the present time all is derived from (1) and (3). With the exception of a very little work done on quartz reefs, no prospecting, much less mining, has been done in the other three classes. In spite of 20 years of fitful mining, the industry is still confined to the alluvial stage through which most of the chief goldfields of the world have passed in their youth. No doubt as long as small capital must show an immediate return activity will be thus confined, but in spite of mounting returns activity confined to present-day river beds is not sufficient to establish a long-lived industry. In view of the high price of gold and the low cost of labour, the present seems to be a favourable time for the establishment of the goldfield on a firmer basis by intensive prospecting of the various classes of gold deposits and reefs in Nigeria by large companies or associations. The possibilities of the Nigerian goldfield appear to warrant optimism as to its future, but its development into an important field will largely depend on whether it receives the intensive and thorough prospecting that its potential resources merit. Its river terraces, some of which are auriferous, remain unexplored. The same might almost be said of the quartz reefs and lodes, so trivial has

been the quantity of gold discovered. No doubt many reefs and lodes have been passed over unrecognized through careless prospecting and much missed through the fineness of the gold in places. Much careful prospecting remains to be done. The value and extent of the banket has yet to be proved but, in view of the enormous area covered by the Eocene Sandstones at the base of which the banket lies, a thorough investigation of this source may well yield results of the first magnitude.

RECOVERY OF SULPHUR FROM SULPHUR DIOXIDE

By ARTHUR J. CADDICK, M.I.M.M.

The author gives the result of his investigations for the reduction of sulphur dioxide by incandescent carbonaceous matter, together with a résumé of the work of other investigators.

In an article published in the MAGAZINE for April, 1929, the writer dealt with the production of sulphur from pyrites by sublimation or volatization and it is proposed on the present occasion to review the procedure adopted by different investigators for the recovery of sulphur from sulphur dioxide gas by the use of incandescent carbonaceous matter.

The production of sulphur dioxide from sulphur minerals is a proved commercial process in everyday use—methods for cleaning the gas are numerous, efficient, and cheap, and it can be safely assumed that clean gases containing sulphur dioxide are a practical possibility. Any process which would yield elementary sulphur commercially from sulphur dioxide gas would have wide application for the treatment of rich and poor sulphur ores. Experiments conducted by the writer have shown the possibility of running a five-floor, multiple hearth furnace, 20 ft. in diameter, continuously for the production of sulphur dioxide with material of only 11% sulphur content. Here, therefore, the author will consider in detail the production of sulphur from sulphur dioxide by reduction with incandescent carbonaceous matter as a means whereby sulphide ores may be made to yield their sulphur content by preliminary roasting and subsequent reduction of the gases, or for the recovery of sulphur from smelter gases.

The reduction of sulphur dioxide by carbonaceous matter has long received the attention of chemists and as far back as 1833 is mentioned in a pamphlet by Vivian. A patent by Lee in 1844 consists of passing the sulphurous acid gases through a fire of ordinary coal or coke so arranged to maintain at a red heat a flue or chimney filled with bricks, the products of combustion passing into this flue through interstices in the brickwork. The contact action of the brick surface (probably because of the ferric oxide contained therein) caused the interaction of any undecomposed sulphur dioxide and the hydrogen sulphide and carbon disulphide produced in contact with the fuel, so that little but free sulphur vapour escaped.

In 1854 Spence patented a pyrites kiln containing a central vertical earthenware tube filled with coke and so arranged that the products of combustion in the kiln passed downwards again through this tube, whereby the sulphur dioxide became largely deoxidized to sulphur, and shortly after he found that the same result could be brought about by simply mixing coke and pyrites in alternate layers in an ordinary kiln.

In 1880 W. E. A. Hartmann, of Swansea, took out a patent for the conversion of sulphurous acid into hydrogen sulphide. Sulphurous acid gas was mixed with steam, preferably superheated, and forced through an air-tight, or nearly so, vessel filled with incandescent coke or charcoal or ordinary coal or a mixture. The mixture of gases issuing from the coke were said to contain all, or nearly all, the sulphur as hydrogen sulphide, provided it had been passed over with sufficient slowness. Heinrici also claims to reduce sulphur dioxide by incandescent carbon to sulphur, while Vadner (German Patent 276568) also refers to the production of sulphur from sulphurous acid gases by passing them through red-hot coke.

Ruthenberg in 1912 passed the sulphurous gases through an electrically-heated coke column and then through a chamber where sulphur is precipitated and ultimately through a sealing liquid into a chimney.

F. R. Carpenter (U.S.A. Patent 925751—1909) invented a process in which furnace gases are first freed from solid particles, mechanically carried over, and are then

passed through and over glowing carbon to reduce sulphur compounds, air being admitted from time to time to maintain the temperature of the carbon. The reduced gases are then further heated to decompose subsidiary sulphides and cooled so as to condense and separate the sulphur. In further reference to the work of the same investigator, F. R. Carpenter (U.S.A. Patents 871912 and 925751) obtained sulphur from sulphurous acid gases, after being water scrubbed, by passing them through towers containing red-hot coke, where both sulphur dioxide and water are reduced as follows :—

$$2SO_2 + 2H_2O + 3C = 2H_2S + 3CO_2$$
$$SO_2 + H_2O + 3C = H_2S + 3CO$$

The resulting mixture of H_2S, CO_2, and CO, after admitting the necessary amount of air, is passed through chambers containing iron oxide (Claus kiln).

Haenisch and Schroeder (British Patent 6404—1895) pass sulphurous acid gas through cylinders filled with coke heated externally by producer gas, the products from the coke cylinder being passed through another cylinder filled with open brickwork, this cylinder also being externally heated. In this second stage the undecomposed sulphur dioxide, carbon monoxide, carbon disulphide, and carbon oxysulphide act upon one another so that, if the current has been properly regulated, ultimately only carbon dioxide and sulphur are obtained. Or else the sulphur dioxide is at once treated with carbon monoxide according to the equation—

$$SO_2 + 2CO = 2CO_2 + S$$

This process was tried on a large scale at Oberhausen.

Experiments conducted at Ducktown for the production of elementary sulphur from smelter gases were as follows: The gases were first cleaned in a Feld gas scrubber and the cleaned gas was delivered to the sulphur reduction furnace wherein the sulphur dioxide was reduced to elementary sulphur by reaction with incandescent coke maintained at a temperature of 1100 to 1300° Centigrade by the passage of an electric current through the coke mass. The cleaned gas contains normally 6% sulphur dioxide, which reacts with carbon according to the equations—

$$2SO_2 + 2C = 2CO_2 + S_2$$
$$\text{or } 2SO_2 + 4CO = 4CO_2 + S_2.$$

Under these conditions the sulphur vapour present in the exit gases has a partial vapour pressure of about 14 mm. (normal barometric pressure at Ducktown being about 725 mm.). This corresponds to a condensation temperature of about 255° Centigrade, at which point sulphur vapour of this partial pressure begins to condense as liquid until a temperature of 115° Centigrade is reached, corresponding to a partial vapour pressure of sulphur of about ·03 mm. With a slow rate of cooling of the gases, at least 95% of the sulphur vapour should be condensed in the liquid form, or, if the temperature drops below 115° Centigrade and if the gases are not slowly cooled, the sulphur vapour passes directly into the solid phase and collects as flowers of sulphur. More rapid cooling will result in the formation of fume of impalpable fineness. It was found important that the moisture content of the gases be kept as low as possible to prevent the formation of hydrogen sulphide, which seriously interferes with the reactions in the reduction furnace.

In British Patent 20716 and French Patent 472957 the gases, previously purified from dust, are passed through a tower filled with red-hot coke, where a mixture of carbon dioxide, oxysulphide, and monosulphide is formed. This is oxidized to sulphur and carbon dioxide in another tower, heated by the first, into which, through a special pipe, an excess of sulphur dioxide is passed.

W. F. Lamoureaux and C. W. Renwick took out patents (U.S. Patent 1140310, British Patent 2834—22.2.1915, and French Patent 477795) for a process which consists in passing the sulphur-bearing gases through a red-hot carbon column, which reduces the sulphur dioxide and sulphur trioxide to sulphur. They call attention to the fact that this reaction has its velocity enormously increased by raising the temperature. For instance, in some gases from pyritic smelting

5%	of the SO_2	was	reduced	at	800° C.	in 5 sec.
34%	,,	,,	,,	,,	900° C.	,, 5 ,,
83%	,,	,,	,,	,,	1,000° C.	,, 5 ,,
91%	,,	,,	,,	,,	1,100° C.	,, 5 ,,
96%	,,	,,	,,	,,	1,200° C.	,, 5 ,,
98%	,,	,,	,,	,,	1,300° C.	,, 5 ,,

They state it is not possible to keep up a temperature in the coke column high enough to perform this reduction in a sufficiently short space of time without the use of external heat. This they obtain by passing an electric current through the coke column, using this current to obtain the required temperature.

Table 1.

Products of Reduction.

Ingoing Gas. Sulphur Dioxide, % by Volume.	% by Weight of Total Sulphur in Gas.		% by Volume.			Coke Used % as on Sulphur in Original Gas.
	Elementary Sulphur.	*Sulphur as Hydrogen Sulphide.*	*Carbon Dioxide.*	*Carbon Monoxide.*	*Oxygen.*	
2·84	21·07	75·28	7·96	1·46	·33	103·1
3·38	21·74	65·03	12·86	1·23	·30	103·1
4·38	19·27	68·95	15·31	·95	·35	103·1
5·28	25·84	61·48	15·90	·80	·47	91·5
6·56	40·19	64·11	11·70	1·00	2·00	63·26
7·67	30·13	11·22	8·75	·26	·74	66·37
8·20	13·50	nil	5·81	·15	1·50	67·08
9·54	31·26	nil	7·46	·20	·88	68·30
10·84	4·61	nil	4·40	·60	1·40	68·30

In a further patent (U.S.A. 1169726—1916) W. F. Lamoureaux heats gases containing sulphur dioxide to the reaction temperature and then maintains contact with incandescent carbon for a definite time, the waste heat of the outflow gases being utilized for heating the inflow gases before passing them into the reaction chamber. Schaurer-Kestner states that at a white heat the reaction takes place according to the equation

$$2SO_2 + 3C = 2CO + CO_2 + 2S$$

In September, 1918, the American Smelting and Refining Co., of New York, took out British Patent 144306 for a process which consists in passing a hot mixture of sulphurous acid gas and air through a coke column maintained at incandescence by adjusting the amount of air in the mixture, the sulphurous acid gases being reduced to sulphur.

G. C. Howard (English Patent 144306—1920) discovered a means whereby gases containing sulphur dioxide are cooled to remove flue dust and metallic fumes and then treated with water or other solvent to dissolve the sulphur dioxide. The latter is boiled off, dried by cooling and passing through strong sulphuric acid, and liquefied. The liquid is fed to expansion coils, where it is once again changed to the gaseous form, at the same time cooling a quantity of air so that it deposits the greater part of its moisture content. This air is mixed with the gaseous sulphur dioxide and the mixture, which is substantially free from moisture, is passed through a preheater into a reduction furnace packed with incandescent coke, where the dioxide is reduced to sulphur, the air present helping to maintain the requisite temperature by burning a certain amount of the coke. The hot gases from the furnace serve to heat fresh gases in the preheater and are then passed to cooling towers and bag houses for collecting the contained sulphur.

A series of experiments conducted by the writer to ascertain the content of sulphur dioxide of the ingoing gas at which a coke column could be maintained in an incandescent condition (no steam being introduced) showed this to be about 7% SO_2 by volume, a summary of the results obtained being given in Table I.

Assuming that the sulphur existing as hydrogen sulphide in the treated gas would by admixture with the amount of sulphur required as sulphur dioxide for the equation

$$2H_2S + SO_2 = 2H_2O + 3S$$

yield a 70% recovery by this reaction, then the sulphur recovery from the gas treated by coke and the additional sulphur dioxide for the interaction with hydrogen sulphide would be as shown in Table 2.

Table 2.

Sulphur Dioxide content of Ingoing Gas, % by Volume.	Elementary Sulphur Recovery. %	Coke consumed per ton Sulphur Recovered. %
2·84	73·75	1·03
3·38	67·93	1·14
4·38	68·17	1·12
5·28	69·14	1·01
6·56	81·41	·59
7·67	39·67	1·58
8·20	13·50	4·97
9·54	31·26	2·18
10·80	4·61	14·81

Following these investigations a further series was conducted in continuation to ascertain the effect of varying amounts of steam, the steam being admitted at the bottom of the coke column together with the ingoing sulphur dioxide gas. For these trials a gas of 7 to 8% sulphur dioxide was used (Table 3).

TABLE 3.

GAS AFTER REDUCTION.

Ingoing Gas. Sulphur Dioxide, % by Volume.	% by Weight of Total Sulphur in Gas.		% by Volume.			Coke Used % as on Sulphur in Original Gas.	Steam Used % as on Sulphur in Original Gas.
	Elementary Sulphur.	*Sulphur as Hydrogen Sulphide.*	*Carbon Dioxide.*	*Carbon Monoxide.*	*Oxygen.*		
7·85	44·91	1·50	13·82	·58	2·22	111·98	40·37
7·98	47·42	26·53	13·69	·22	1·43	78·31	96·04
7·98	58·15	18·42	17·23	·44	1·44	74·77	101·08
7·91	37·44	8·47	14·57	·50	1·22	41·86	79·28
7·49	21·24	11·28	12·22	·23	·46	87·84	135·13
7·78	22·56	nil	17·47	·20	·73	111·34	1175·09

TABLE 4.

Ingoing Gas. Sulphur Dioxide, % by Volume.	Steam Used % as on Sulphur in Sulphur Dioxide Gas.	Sulphur Recoverable.	Coke Used per ton Sulphur Recoverable.	Steam Used per ton Sulphur Recoverable.
		%	Tons.	Tons.
7·85	40·37	46·13	2·41	·87
7·98	96·04	66·46	1·04	1·28
7·98	101·08	70·95	1·12	1·30
7·91	79·28	44·45	·90	1·71
7·49	135·13	31·31	2·65	4·08
7·78	1175·09	22·66	4·91	51·88

TABLE 5.

GAS AFTER REDUCTION.

Ingoing Gas. Sulphur Dioxide. % by Volume.	% by Weight of Total Sulphur in Gas.		% by Volume.			Coke and Steam. Used % as on Sulphur in Ingoing Gas.	
	Elementary Sulphur.	*Sulphur as Hydrogen Sulphide.*	*Carbon Dioxide.*	*Carbon Monoxide.*	*Oxygen.*	Coke.	Steam.
7·72	31·88	4·82	7·84	2·35	5·23	240·85	5·34
7·47	28·20	46·89	16·05	·15	1·39	—	—
7·16	22·97	61·22	16·21	·75	1·54	131·36	5·28
7·93	37·26	54·24	17·13	·59	1·64	129·97	5·85
7·91	37·22	45·30	17·74	·47	1·40	230·37	10·50
7·81	42·44	40·57	17·70	·42	1·39	96·44	7·86
6·89	27·15	69·17	16·65	·67	1·69	112·74	8·00

TABLE 6.

Ingoing Gas. Sulphur Dioxide, % by Volume.	Steam Used % as on Sulphur in Ingoing Gas.	Sulphur Recoverable.	Coke Used per ton Recoverable Sulphur.	Steam Used per ton Recoverable Sulphur.
		%	Tons.	Tons.
7·72	5·34	36·07	6·52	·15
7·47	—	62·73	—	—
7·16	5·28	66·80	1·50	·06
7·93	5·85	74·11	1·38	·06
7·91	10·50	69·14	2·71	·12
7·81	7·86	70·69	1·13	·09
6·89	8·00	74·14	1·12	·08

Estimating that by the addition of the sulphur dioxide required to combine with the hydrogen sulphide and a yield from this reaction of 70% of elementary sulphur from the sulphur content of the hydrogen sulphide and the added sulphur dioxide, the effect of varying amounts of steam are shown in Table 4.

In a further series of investigations the effect of using small amounts of steam was as shown in Table 5.

Estimating the recoverable sulphur in the same way as for the previous two series of investigations, the recoverable sulphur and steam and coke consumptions are shown in Table 6.

LETTER TO THE EDITOR

"The Northern Rhodesian Copper Fields"

SIR,—I have read with great interest Dr. Cullen's excellent account of the early history of the Northern Rhodesian copper fields. . . . I note that Dr. Cullen does not include my "Guide to Mining in Rhodesia" amongst his authorities. This is no doubt why he has done an injustice to the chief of all the pioneers—namely, T. G. Davey, consulting engineer of the Rhodesia Copper Company, who died a few years ago, I regret to learn, in impoverished circumstances. Not only did Davey do a wonderful amount of exploratory work under most difficult conditions with the assistance of a fine body of men he brought out from Australia and elsewhere as prospectors, but he himself located the great Broken Hill lead and zinc outcrops. The influence of this on the mineral industry in Northern Rhodesia was very great and it is scarcely too much to say that the success of lead smelting operations at Broken Hill during the War paved the way for the ultimate development of the copper deposits to the north of it. It may further be pointed out that Davey fully realized the synclinal nature of the Roan ore-body and described it in terms which admit of no misunderstanding in his report of 1905.

F. P. MENNELL.

Bulawayo,
September 20.

BOOK REVIEWS

Textbook of Fire Assaying. By EDWARD E. BUGBEE. Second edition. Cloth, octavo, 299 pages, illustrated. Price 18s. 6d. New York: John Wiley and Sons; London: Chapman and Hall.

In preparing the second edition of his textbook of fire assaying the author, while retaining the many good features of the previous edition, has included a considerable amount of fresh material. The most important addition to the text is a chapter on the treatment of ores and products which contain metals of the platinum group. This chapter increases the scope of a volume intended, primarily, for the use of students and, as the manipulation is described with considerable detail, it should enhance its value as a reference work for the practical assayer.

C. W. DANNATT.

Petroleum Development and Technology, 1933. Transactions of the Petroleum Division of the American Institute of Mining and Metallurgical Engineers. Cloth, octavo, 426 pages, illustrated, Price $5.00. New York: American Institute.

The 1933 edition of this well-known annual publication is of the usual excellent standard. The first 269 pages are occupied by chapters on stabilization, economics, and production engineering and engineering research. These are followed by 145 pages devoted to production, in which a short résumé is given of the most recent developments in the leading producing regions of the world, followed by a short chapter summarizing the position of refining. When it is mentioned that the article dealing with Persia is written by Sir John Cadman, the value of the various articles comprising the production chapter may be appraised. The whole work forms a valuable summary of the present day position of the industry and its development and is a recognized standard work of reference.

MURRAY STUART.

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

NEWS LETTERS

BRISBANE

September 28.

Mount Isa.—A matter of importance during the past month as affecting the future of Mount Isa has been the granting by the Queensland Government to Mount Isa Mines, Ltd., of a further concession in railway freights over the 600 miles of transport between the mine and the coast at Townsville and Bowen. Mr. Webster, the chairman of the company, is satisfied that the revised rates will afford welcome relief to Mount Isa and will, in conjunction with the financial and other aid given by Mining Trust, Ltd., and the American Smelting and Refining Company, make any prospect of the Mount

Isa company being forced to decrease or suspend operations owing to low metal prices more remote, if Australia does not lag behind the rest of the world in the adjustment of currency and the consequent benefit to primary producers. At the mine good progress was made during August in picking up the ground that had fallen in the stope in Doherty's shaft on the Black Rock lode and installing the square-set system of timbering. The new shaft being sunk from the main haulage level in the Lawlor (Rio Grande) section is well under way. This shaft it is intended to sink to a depth of 200 ft. Improvements and additions to the smelting works are progressing favourably. In the following table are given details of the Mount Isa production for August, with comparative figures for July :—

	July.	*August.*
Ore mined, tons	61,331	66,268
Ore milled, tons	63,406	65,985
Assaying—Lead, per cent.	9·2	10·4
Silver, oz.	9·2	10·4
Lead concentrates produced—		
Flotation, tons	9,407	11,704
Assaying—Lead, per cent.	39·4	41·6
Silver, oz.	16·1	18·4
Jig, tons	1,845	1,278
Assaying—Lead, per cent.	43·8	42·0
Silver, oz.	17·3	17·0
Silver-lead bullion produced, tons	4,170	4,862

Revival of Mount Morgan. — Mount Morgan, Ltd., the company that has taken in hand the task of resuscitating the once famous Mount Morgan mine, is pursuing its course with increasing vigour. The output is becoming larger and work is in progress for its further increase and for the greater efficiency and capacity of the treatment plant. The monthly advance in production is indicated by the following figures relating to operations during August, with those for the preceding month in parentheses :—Ore produced, 13,330 tons (10,626) ; ore concentrates, 12,575 tons (9,645), producing approximately 612·24 tons (405·61), estimated to contain 2,797 oz. (1,917) of gold and 28 tons (46) of copper ; gross value, taking gold at £7 per oz. and copper at £37 a ton, £20,615 (£15,137) ; number of men employed, 350 (356). The underground surface work at the mine in August showed good progress.

Mount Coolon.—Three directors of the Mount Coolon Gold Mines, Ltd. (Messrs. Colin Fraser, G. C. Klug, and A. Stewart), after inspecting the company's mine at Mount Coolon, North Queensland, have reported to the head office in Melbourne that mining and smelting operations are proceeding smoothly and that working costs are improving. The opening up of the 450-ft. level, it is stated however, has unfortunately been disclosing unpayable lode material, the block that is being stoped at that horizon having a length of only 110 ft. out of 446 ft. so far explored. As a consequence the question of shaft-sinking has been deferred until the results are available from a diamond-drilling campaign in search of other deposits. The necessary equipment for the campaign is being obtained from Mount Isa. By this means the lode will be tested at the 600-ft. horizon by drilling from the 450-ft. level. The 450-ft. horizon and other parts of the mine will also be tested. The ore reserve of Mount Coolon is estimated to be enough to maintain milling operations on the present scale for more than two years. Official reports for August show that during that month the treatment plant continued to operate on cyanide residues. In a four-week period ended August 22 4,061 tons of mine ore and 663 tons of old tailings were treated for a return of gold worth £12,093 and of silver valued at £85.

Oil from Coal and Shale.—The ever-declining condition of the coal industry in Queensland and, indeed, in all the coal-producing States of the Commonwealth, has led to renewed attention being called to the possibility of utilizing coal resources by means of one or other of the processes for extracting oil from them. In this connexion the British firm, Imperial Chemical Industries, Ltd., has made a proposal to the Federal Government to erect a hydrogenation plant for the production of 30,000,000 gallons of petrol annually, but the Minister in Charge of Development has expressed serious doubts as to whether this process has reached the stage when it can be regarded as an economic proposition. Later, however, London mail advices have shown that the British Government is aiding the company mentioned and the question is to be fully examined in Australia before the Commonwealth Government decides what it is prepared to do in the matter. The Newnes Investigation Committee, in New South Wales, in a progress report states that, with an adequate plant, that State could produce 20,000,000 gallons of oil from shale each year. The committee estimates that there are more than 40,000,000 tons of good shale at Baerami

and Newnes and it expects that with a modern cracking plant something like 5,000,000 gallons of oil could be produced there annually at a cost of 8d. a gallon. All the work at Newnes for opening up the tunnels on both sides of the Capetee Valley, as well as for sampling and measuring the oil-shale seam, has been completed. It is now understood that the final decisions will depend upon the reports on the subject submitted to Mr. L. J. Rogers, the Commonwealth expert, for study overseas.

Trade with the East.—So far as Queensland is concerned, hope is still entertained of gaining an outlet for that State's coal by establishing a trade with the East. A conference which has been sitting in Brisbane for some time has recommended, amongst other things, that a delegation of two be sent abroad to endeavour to secure such a trade and this suggestion has just been accepted by the Government.

Gold Production.—An increase of 53,100 oz. to 384,760 oz. occurred in the gold yield for Australia in the half-year ended June 30, by comparison with the same period of 1932, and compared with the June, 1931, half-year the increase, at 125,350 oz., was approximately 50%. Of the individual States Western Australia maintains its premier position as the leading producer, while Queensland has displaced Victoria as the second largest producer.

Bendigo Gold Mining.—Information supplied by the chairman (Mr. Angus Mackay) at the half-yearly meeting, held in Melbourne, of the Hercules Gold-Mining Company, N.L., Bendigo, shows that since the rich reef was discovered in June, 1932, dividends totalling £90,000, or 30s. a share, have been paid. The company holds £6,900 in cash, after providing for the 2s. dividend paid on August 31, from which a further dividend of 2s. a share is to be paid in a fortnight. Mr. Mackay said that the reef had exceeded expectations and it might rank as one of the richest ever known in Bendigo. The outlook at the mine is not as promising as it has been, because south of the winze values have not been maintained recently. However, there are still large reserves of payable stone south of the winze and there is a large area unworked north of the winze, which may prove to contain valuable ore.

JOHANNESBURG

October 4.

Rand Leases (Vogelstruisfontein) Flotation.—The Government, in its determination to "let the public in on the ground floor," stipulated that 400,000 shares of 10s. each in the new Rand Leases (Vogelstruisfontein) company were to be offered the public at par, applicants to be residents of the Union. This stipulation occasioned the greatest rush for mining scrip in the history of the Rand and attracted the small investor to such an extent that more than 12,200 sent in amounts varying from 10s. to £25. There were 36,000 applications for 6,050,000 shares representing £3,025,000, but as only £200,000 was called for £2,825,000 will have to be returned.

Jameson Raid Recalled.—A new company, to be known as the Vlakfontein Consolidated Estates and Gold Mining Co., is to be registered shortly to mine approximately 3,000 claims including, in a compact block, portions of Doornkop 46, Zuurbult 53, Luipaardsvlei 10, the southern tongue of Uitvalfontein, and Vlakfontein 45. The whole of the ground is in a basin enclosed by an outcrop. The ground includes that part where the Jameson raiders surrendered to General Cronje on January 2, 1896—in fact, the mill-site selected is within 200 yards of the obelisk raised to the memory of the fallen raiders.

State Milling.—Pointing out that there are various gold-bearing areas in the Transvaal suitable for the employment of thousands of phthisis men and unemployed miners, if some form of central milling and treatment on a cost or percentage basis could be devised to assist them to gain a livelihood, the South African Reduction Workers' Union has put before the Minister of Mines the details of a scheme for the establishment of a State milling system to handle gold-bearing reef obtained from claims worked by individual owners and small mining syndicates.

Northern Transvaal (Messina) Copper.—It is reported that No. 2 bore-hole of Northern Transvaal (Messina) Copper, Ltd., located about 600 yds. east of No. 1 bore-hole, has reached a depth of 260 ft. The geophysical survey work carried out in this section of the company's property gave strong indications of underlying minerals, although, as was also the case at No. 1 bore-

The Sub Nigel Gold Mine, Heidelberg District.

hole, no evidence existed at the surface by way of outcropping rocks to indicate the underlying copper-bearing formation. Summarizing the results to date from this and No. 1 bore-hole, it is claimed that they have so far conclusively proved the value of the geophysical survey methods, as mineral-bearing ground has been located on sections of the company's property where surface indications and outcrops are non-existent.

Vaal River Gold.—For the past eighteen months Mr. F. Kingsley and an associate have been developing reef outcrops on the Free State banks of the Vaal River and to-day the enterprise exists as one of the best equipped "outside" mines of the Union. A 5-stamp battery was erected, but within six months this had to be increased to 10 stamps. A 70 h.p. Ruston-Hornsby crude-oil engine serves as a power plant and dynamos are installed to convert this to electric power. All pumps and hoists are driven electrically and the jackhammers underground are worked by compressed air. All the underground workings are electrically lighted. A fine house has been built, together with the necessary mine buildings, stores, offices, blacksmith's shop, and compound, and to-day the personnel consists of ten Europeans and 100 natives. The reef Mr. Kingsley has exposed and is now working is an extension of the Witwatersrand Series and runs 80 in. wide, his property including approximately four miles of this reef, which outcrops all the way. It is understood that a company with a large capital is in process of being floated to take over the property.

Kaokoveld Expedition.—The Kaokoveld, that dreary, desolate stretch of country along the coastline in the northern section of South-West Africa, is a prohibited area, consequently it is not surprising that rumours of diamonds being found there by illicit seekers should persistently crop up. Major du Preez, head of the C.I.D. in South-West Africa, has recently returned from an expedition into the area and as a result the Administration are now thoroughly convinced that diamonds have not yet been discovered in the Kaokoveld.

Gold in South-West Africa.—For 40 years it has been known that gold could be found in the Rehoboth area. At different times efforts have been made to commercialize the gold discoveries, but very little has been achieved. It was only towards the end of 1931, when the Windhoek Gold Mines, which had been working claims at Neuras, some ten miles from Rehoboth village, went into liquidation and the holdings were disposed of to a Capetown syndicate headed by Dr. J. P. van der Horst, that developments of a sensational nature took place. The pegged area covers approximately 50 square miles and it is estimated that there are approximately 100 Europeans and 500 natives working on the goldfields. The Weenen Basin, some 60 miles west of Rehoboth, is now attracting attention and claims have been pegged there. Assays from this area have given high results, but the inaccessibility of the place detracts somewhat from its prospects. It lies behind the Gansberg, a flat table-shaped mountain, and from there to the valley there is a drop of 4,000 ft. in eight miles. A further new area has been discovered between Rehoboth village and the Neuras mine.

Abandoned Coal Mines.—Mr. Arthur Emanuel, secretary of the Natal Mine Workers' Union, has provided startling figures in connexion with the departed glory of the Natal coal-mining industry. He maintains that in 1921 there were 850 Europeans employed by the industry, whereas to-day there are only 405, including officials. As a contrast to Mr. Emanuel's assertions, however, it appears that the coal trade of Natal is improving steadily and its September figures of export will probably be the highest for two years, one colliery alone having booked 20,000 tons for shipment in the first half of September. In the first half of August over 43,000 tons were exported, which is more than double the quantity exported during 1932. The total sold (export and bunker) for the six months ended June 30 was 1,484,964 tons, valued at £398,140.

VANCOUVER

October 11.

Bridge River.—With the exception of confirmatory reports in regard to the importance of the latest discovery of a bonanza ore shoot at the Bralorne mine there have not been any marked developments in this field during the past month. At the B.R.X. property better values have been encountered in narrow parallel veins, but as regards the main showing the position is described as affording proof of a large body of low-grade ore of an average value, between $5 and $6 per ton. The main drive on the California vein has reached the intersection between the foot-wall and hanging-wall branches, where the ore-body is stated to be 15 ft. wide. Diamond drilling work by Consolidated Mining and Smelting Company on the Bridge River Consolidated property is reported to have proved the downward extension of the Why-Not vein, indicating commercial ore, but official details of this development are not published. Promotion enterprise is represented by several new incorporations and activities in various directions. Congress Gold Mines, Ltd., has been incorporated to develop holdings comprising 12 claims near the Wayside property. Bridge River Ogden Mines, Ltd., has been organized with a capital of 2,000,000 shares of no par value to explore an area lying to the west of the main ore showings of the district and on the opposite side of Cadwallader Creek. A. J. Gaul is consulting engineer for this company and is also directing work for another Vancouver association, known as Bridge River Associated Mines, holding a group of 13 claims and fractions to the north of the B.R.X. properties. Work is in progress in many other sections, notably at the Wayside and Taylor properties and at the upper end of Cadwallader Creek, where Colonel H. H. Yuill has been advising upon exploration work. In general it may be said that surface and near-surface exploration through the current season has not disclosed evidence of further important mineralization, but high hopes are entertained in connection with developments at depth.

Cariboo.—With the main objective of the extensive developments that are in progress at the Cariboo Gold Quartz property yet to be reached, this operation is still more or less a prospect. Production is being subordinated to the requirements of exploration and development but the general opinion of engineers who have now had an opportunity to examine the workings is that there is justification for the belief that the operation will develop into one of major importance as depth is attained. A recent feature of considerable interest in the development of this field is the formation of Cariboo Amalgamated Gold Mines, Ltd., to operate on 17 groups of claims, covering an area of over 6,000 acres, which are said to represent the special selection of Fred. M. Wells as a result of extensive prospecting over the whole area. Among these holdings the Moose Creek group is said to cover a lateral extent of over five miles of country in which vein exposures and geological conditions are very similar to those on the Cariboo Gold Quartz property; the Red Gulch group, lying to the north and west of Jack of Clubs Lake, is reported to cover the extension of veins that are being developed by the larger operating companies on adjoining ground; the Gold Belt group, on Antler Mountain, adjoins the Premier Gold Mining Company's holdings, and the Devils Canyon group is said to cover some of the largest outcrops in the district and it is understood that work on these showings will be carried on throughout the coming winter. Other holdings of this company are located on Lightning Creek, Olally Creek, and Pinkerton Creek. Cariboo Amalgamated Gold Mines is capitalized at 10,000,000 shares of no par value, of which 4,500,000 shares are held in escrow as purchase consideration. Several other operations are in progress in

this field ; among these the development on the Foster Ledge property, on Burns Mountain, by interests identified with the B.R.X. company at Bridge River is meeting with encouraging results. Two quartz veins showing coarse gold have been encountered in the tunnel workings.

Nelson.—Development at the Reno mine, at Sheep Creek, is proceeding rapidly. Footage for the month of July amounted to 251·5 ft., for August 335 ft., and for September 340 ft. The vein maintains an average width of 2 ft., with average content of about 1·5 oz. gold per ton both on the No. 5 level and on the sub-level driven from a winze 100 ft. below. It has now been decided to sink a three-compartment shaft below the No. 5 level, from which depth development on the vein will be attacked on a major scale. The mill worked 27·5 days during the month of September, treating approximately 1,800 tons of ore of a gross average value of $15 per ton. The outlook at the Gold Belt property, which has been somewhat obscured owing to the failure to encounter the main "C" vein in the low-level cross-cut, has been changed by recent results of diamond drilling work. This exploration showed that the direction of the dip of the vein was reversed, throwing it beyond the point at which its intersection by the cross-cut was calculated. A series of five diamond drill holes has proved the continuity of this vein over a distance of 600 ft. and it is understood that it has now been intercepted in the tunnel workings, which were resumed following the information gained by the drilling. Work on the Vancouver-Midnight group has been discontinued pending arrangements for co-operation with the Queen property, whereby provision for more economic development might be secured. It is understood that an amalgamation of the two groups is under consideration. Regular car-load shipments of ore continue to be forwarded to the Trail Smelter from the Kootenay Belle mine, the gross value of the last consignment being valued at about $3,600. Preparations are almost completed for the driving of a new deep-level development tunnel on the Venus-Juno-Athabasca holdings of Noble Five Mines, Ltd. This work will be carried out with power supplied from the West Kootenay Power Company. Transmission lines carrying current at 2,200 volts for the supply of 150 h.p. have been constructed and a 1,000 cu. ft. compressor is being installed at the new site on the Athabasca ground. Exploratory work at the upper levels on the Juno vein which will be tapped by the new tunnel is said to have been highly encouraging.

Boundary.—On the recommendation of Arthur Lakes, who is acting as consulting engineer to Gold Mountain Mines, Ltd., a new development tunnel is to be driven to open up the Maple Leaf vein on the company's property at Hedley. The Maple Leaf vein, which shows a width of over 25 ft. at surface with heavy sulphide mineralization, has been encountered in a cross-cut tunnel at a depth of 70 ft. below surface and had been penetrated to a distance of 20 ft. when the last progress report was published. The better values are expected to be found on the hanging-wall side of the vein, which had not been reached. Values at surface are said to be around $25 per ton. The new tunnel is to be driven at a further depth of 200 ft. and it is calculated that the main vein should be reached in a distance of about 400 ft. There are other extensive showings on the property. The plan of development will be to drive on the Maple Leaf vein and to cross-cut at intervals ; it is anticipated that the property can be put on a self-supporting basis as a result of this work. In the Beaverdell camp it is reported that a vein 4 ft. wide was encountered in a cross-cut that has been driven on the Braemar Mines property, on Cranberry Mountain. This tunnel was driven to intersect a vein which has been traced at surface over a distance of 3,000 ft., at a depth of 160 ft. below open-cut workings. A drive is being carried on the vein, which shows greater width as this work is advanced. Work that was resumed at the property of Mak Siccar Mines, Ltd., in the Fairview camp, is said to have afforded encouragement, good gold values having been obtained in narrow veins that are being followed in driving work on the theory that they will lead to bigger bodies of low-grade ore, such as are characteristic of this field.

East Kootenay.—Expectations in regard to possibilities of profitable operation of the Monarch mine, at Field, despite low base-metal prices, are being fulfilled, according to recent advices. The energetic development of the mine, which was forecast in connexion with the recent amalgamation of interests, has been productive of good results and the mill capacity has been gradually stepped up. A first shipment of concentrates since resump-

tion of operations has been made to the London market. A considerable reduction in costs has been effected in all directions and largely in relation to improved facilities in hauling the ore from the mine.

Kamloops.—The intensive campaign of construction work at the Windpass mine, at Chu Chua, is expected to result in reaching the production stage in the near future. It has been matter fors urprise that this mine should have been dormant for the past few years in view of the established reserves that were blocked out and which are estimated to be more than sufficient to defray the capital expenditure on mill construction, while possibilities have been by no means exhausted for the discovery of further ore-bodies. The Vidette mine, at the head of Deadman Creek, is reported to be opening up well with development at greater depth. It is understood that the small pilot mill is to be enlarged and it is anticipated that the property will figure as a regular producer very shortly.

TORONTO

October 19.

Gold Production.—Ontario's gold production for September had a total value of $3,366,898, which was the lowest figure for any month of the year to date and $349,497 below August's total of $3,716,395. The decrease was largely due to the lower mill tonnage—a total of 454,875, as compared with 480,923 tons milled in August. Production of the Porcupine belt had a total value of $1,733,824 from 282,789 tons, while the Kirkland Lake area's output amounted to 145,566 tons, valued at $1,558,664. North-Western Ontario's production fell to $74,410 from $101,801 for the previous month, the ore milled totalling 26,520 tons, as compared with 35,243 for August.

Sudbury. — The Ontario Refining Company is now operating at 55% of capacity, as compared with a basis of less than 20% six months ago. Copper production is being carried on at the rate of about 5,500 tons a month, of which more than 60% is being shipped to England, while a considerable quantity is finding a market in France and other European countries. The ore is supplied largely by the Frood Mine. Development work on the property of Kenty Gold Mines, in the Swayze gold area, is progressing satisfactorily. A highly-mineralized zone has been encountered on the fourth level of the No. 2 shaft. Assay returns from two diamond drill holes located 450 ft. apart on the property of Lee Gold Mines, in the Swayze area, show encouraging values in gold over good widths on the No. 1 vein, which extends for over 1,000 ft. A second vein was revealed by drilling on the north side of the porphyry dyke. A report of J. G. MacGregor, mining engineer, on the McMillan Gold Mine records a gross indicated tonnage of 55,000 tons of ore averaging between $9 and $10 per ton, based on the results of a bulk sampling test conducted on 10 tons of samples taken from the roof of workings at the 325- and 525-ft. levels. Sinking is now being carried on preparatory to opening up another level at a depth of 650 ft. A complete mining plant will be moved to the property of Swayze-Huycke Gold Mines, Ltd., in the Swayze gold area, as soon as winter roads are ready. Sunorca Exploration Company, in the same area, has opened up more than sixty veins on surface. A group of eight claims adjoining its property to the east has been acquired by the company to protect its vein system.

Porcupine.—Bullion production of Dome Mines for September totalled $356,933, which was $10,388 lower than August's total of $367,721, but higher than the figure of $341,610 recorded for September, 1932. The decline was largely owing to the shorter month, as the tonnage treated and millheads were approximately the same as in August. Vipond Consolidated Mines had a total production of $124,947 exclusive of premium for the three months ending with September, a decline of $9,291 from the previous quarter's total of $134,238. Ore milled during the period totalled 26,533 tons. A development programme is being prepared by Arcadia Gold Mines, Ltd. About $200,000 has been spent by former managements in exploration and development of the property, which comprises 680 acres. The work planned includes diamond drilling, deepening of two shafts, and extension of cross-cuts to contact the large ore-body. At the property of Oliver Gold Mines Syndicate, in McNeil Township, a porphyry dyke containing a series of quartz stringers heavily mineralized with iron sulphides has been uncovered. The Turnbull Porcupine Gold Syndicate has been carrying out exploration work for several months on a number of recently acquired claims in the Turnbull section.

Kirkland Lake.—Macassa Mines, Ltd., has its new mill completed and ready for operation. Altogether there is enough ore in sight to keep the mill supplied for two or three years. Shaft sinking is being carried on at the Barry-Hollinger Gold Mines property, in the Boston Creek area, with the objective of 2,250 ft. nearly reached. It is planned to concentrate development work on the 2,125- and 2,250-ft. levels in order to build up ore reserves for mill requirements. It is intended to have the mill in operation by the first of December. An extensive programme of development is planned by Sylvanite Gold Mines, which is taking its shaft down from 3,000 to 3,500 ft. Enlargement of the mill is proceeding satisfactorily and it is expected that before the end of the year the company will be treating 325 tons of ore daily. The No. 1 shaft on the property of Lakeland Gold Mines, Ltd., has been carried to a depth of 850 ft. and five levels are being developed, with the main ore body intersected on each level. A high-grade vein has been encountered in the south wall of the shaft of Kirkland Lake Consolidated Mines. When the 250-ft. level has been reached driving will be started at that and the 125-ft. levels. A heavy development programme is being planned by the Four Nations Consolidated Gold Mines on its property south-west of Macassa Mines. The shaft will be unwatered and work resumed on three veins from the shaft.

Quebec.—Production of Siscoe Gold Mines for September was $101,719 exclusive of premium, as compared with $94,713 for August and $69,112 for September, 1932. A total of 9,445 tons of ore was treated during the month, with an average value of $11·05 per ton, as against 9,263 tons averaging $10·51 per ton in August. Noranda Mines will increase its concentrator capacity by 1,000 tons, bringing the rate to 3,000 tons effective in the second quarter of next year. It is also planned to install equipment for re-treating tailings, as experiments have indicated that metals recovered from this operation would yield a profitable return. For the quarter ending with September, production of Vipond Consolidated Mines had a total value of $124,947 exclusive of premium, a decline of $9,291 from the previous quarter's total of $134,238. Ore milled amounted to 26,533 tons. The mill of Granada Gold Mines, which has been placed on regular production, is drawing feed from the high-grade section on the 1,075-ft. level and treating slightly more than 100 tons per day with a good operating profit. A campaign of deep development is being carried forward by Canadian Pandora Gold Mines. After reaching the objective of 500 ft. and cutting a station and putting in a sump below 500 ft., a cross-cut will be driven to the north to encounter the downward extensions of the No. 5 and the Bell veins, where high gold values have been indicated. The mill at Greene Stabell Mines is almost completed and will be placed in operation very soon.

Manitoba.—Smelter Gold Mines, Ltd., in the God's Lake district, has commenced a programme of diamond drilling. On the Garry Gold Mines property a number of shallow holes put down to 100 ft. on the break yielded core assays averaging about $20 per ton in gold. The No. 41 diamond drill-hole put down on the property of God's Lake Gold Mines encountered the vein at a depth of 500 ft. and cores confirmed the features revealed at shallower depths. At the Little Long Lac Gold Mine a length of 35 ft. of ore averaging $25 per ton across a width of from 6 to 12 ft. has been opened up by driving east and west at the 200-ft. level. Shaft sinking has been resumed. The new mill at Oro Grande Mines is now in operation and running satisfactorily. Five new veins which have been opened in underground development at the San Antonio Gold Mines property, in the Rice Lake section, have an average width of 5 feet and values in excess of $15 in gold per ton.

North-Western Ontario.—Howey Gold Mines, in the Red Lake district, has built an addition to its mill which will increase capacity to 1,100 tons per day. It wasexpected to be ready for operation about October 1. Good results are being obtained from underground development and two new levels at 1,175 and 1,315 ft. are expected to be producing early in November. Indications are that the whole block of ore to the west of the shaft can be milled at a profit and it is believed that the ore reserves above the 1,000-ft. level will be practically doubled. Production at Parkhill Gold Mines was resumed on a regular basis on October 1, the mill addition now being finished. Development work is being carried on on a large scale, the shaft, which will be carried to an objective of 1,000 ft., having reached a depth of 900 ft. Six levels down to the bottom level at 720 ft. have been opened up

and, with the completion of sinking, work will be started on new levels down to 1,000 ft. Vein widths and values show improvement. Parkhill milled 1,335 tons of ore from June 20 to July 21, producing bullion to the value of $32,142 or an average of $24 per ton exclusive of premium. Net profit exclusive of premium was $19,292 for the period, the premium bringing it to approximately $33,150. Encouraging finds on the Springer group of Central Patricia Gold Mines have led the company to undertake increased operations and plans call for an immediate start on about 2,000 ft. of diamond drilling. This group is situated some three miles from the main property, where mill installation is proceeding. At the property of MacKenzie Red Lake Mines, in the Red Lake district, where shaft-sinking was begun early in August, the three-compartment shaft has attained a depth of 200 ft. and one station has been cut at the 150-ft. level. The next level will be established at 250 ft. A vein showing good mineralization was encountered at a depth of 125 ft. It is planned to carry out lateral exploration work at the 250-ft. level. A mill with a capacity of 100 tons is being installed on the Beardmore Gold Mines property, east of Port Arthur, operated by Northern Empire Mines, Ltd., and there is enough ore available, averaging about $10 grade, to keep the mill working several months. The shaft is down to 300 ft. and considerable lateral exploration has been done to this depth. Maple Leaf Mines, Ltd., has taken an option on control of Casey Summit Gold Mines, in the Patricia district. There is a considerable tonnage of $18 ore on the property and a programme of sinking and driving will be undertaken to block out this ore-body. The shaft is now down 100 ft., with an objective of 325 ft. It is anticipated that it will intersect the No. 2 vein at 175 ft. depth and that a level will be established at that point. A large programme of underground development is in prospect. Ore with an average grade of $16·53 per ton is being developed on the 375-ft. level on the property of Ashley Gold Mines Corporation, while the 625-ft. level is yielding ore with an average of $12·15 per ton. Jackson-Manion Consolidated Mines, Ltd., a merger of Jackson-Manion and Mint-Ore Mines, has resumed work on the Jackson-Manion property in the Patricia district. It is planned to install a mill of 50 to 60 tons capacity and begin production as soon as possible. Ore reserves are estimated at approximately $300,000 and an extensive programme of underground development will be carried out to open up further reserves. New equipment, including a 125-ton cyanide mill, is being installed by St. Anthony Gold Mines, Ltd., on its property at Sturgeon Lake, in the Thunder Bay district, with a view to early production.

Great Bear Lake.—Plans are being made to speed up development work on the B.E.A.R. property by the new management. Work will be concentrated on the completion of the tunnel and its system of winzes. It is expected that tunnelling operations will proceed at the rate of about 150 ft. per month. Diamond drilling will be continued as long as the weather permits, but all other surface exploration work will be abandoned for the time being. The tunnel now extends inwards for about 450 ft., with the vein showing all the way. Silver ores run as high as $35.

PERSONAL

A. C. J. Anderson has returned to Nigeria.
L. H. Bartlett has returned to India.
J. L. Beach has left Northern Rhodesia for New York.
Bernard Beringer has left for South Africa.
James P. Best has gone to Nigeria.
A. W. Blanford has left for Venezuela.
Thomas Breakell has left for Venezuela.
Stanley W. Carpenter is returning from Nigeria.
A. J. Clark is home from Northern Rhodesia.
A. H. Cretch is coming home from Malaya.
W. H. Eplett is now in Johannesburg.
Donald F. Foster is home from Victoria.
A. J. Gilbert has returned to Uganda.
W. C. Grummitt has left for Nigeria.
Austin E. Janes is leaving for Nigeria.
J. V. Lake has returned to Victoria from New Zealand.
J. G. Lawn is returning from South Africa.
Charles Leach has returned from Canada.
Thomas Pryor has left for India.
P. E. Raine has left for Sierra Leone.
R. W. Scott has left for the Gold Coast.
J. F. Thorn has returned to Western Australia.
G. W. Eaton Turner has returned to the Gold Coast.

Arthur D. Miles, president of Central Manitoba Mines and formerly managing director of the International Nickel Co., who died on October 17, aged 60, was for many years Canadian representative of John Taylor and Sons. A graduate of Yale University, he acted until 1905 as instructor there in chemistry, geology, and mineralogy.

Richard Eshott Carr died on October 10, at his home in Upper Norwood, aged 77. Mr. Carr spent a good many years in Spain, being associated

with the Rio Tinto in its early days and subsequently with the Bede Metal and Chemical Company, of which he was a director at the time of his death.

EDMOND JEFFREY, who has died in the Transvaal, was one of the first mineralogists to visit the Rand, where he arrived in 1886. Later he went to the Mysore and Champion Reef mines, in India. He was also engaged in the Sudan, in New South Wales, and in Southern Rhodesia and returned to Cornwall in 1920—to the South Crofty. In 1922 he again went to the Rand and was for eight years assistant assayer at Consolidated Main Reef.

TRADE PARAGRAPHS

G. A. Harvey and Co. (London), Ltd., of Woolwich Road, London, S.E. 7, issue particulars of the "Harco" extractor ventilators for workshops, offices, etc.

Head, Wrightson, and Co., Ltd., of Stockton-on-Tees, issue their booklet on crushing rolls. This gives detailed particulars of the following types: Improved standard, standard, Portland, and laboratory.

Sentinel Waggon Works, Ltd., of Shrewsbury, announce that they have acquired the business of Garner Motors, Ltd., and that the Garner range of light petrol vehicles will become complementary to the Sentinel range of steam road vehicles.

General Electric Company, Ltd., of Magnet House, Kingsway, London, W.C. 2, have received an order from the Johannesburg municipality for a 10,000-k.w. high-pressure turbo-alternator, together with the necessary condensing plant.

George Cohen, Sons, and Co., Ltd., of 600, Commercial Road, London, E. 14, issue their catalogue relating to electrical plant they have for disposal. This includes details of arc welding plant, circuit breakers, generating sets, and transformers.

Arthur R. Brown, Ltd., of 54, New Broad Street, London, E.C. 2, announce that, in consequence of their having acquired the business of the Wivenhoe Shipyard and Drydock, Essex, they are now in a position to answer inquiries for alluvial dredges for the recovery of gold, platinum, and tin, and a variety of light draft, small cargo, and passenger vessels.

Murex Welding Processes, Ltd., of Ferry Lane Works, Forest Road, Walthamstow, London, E. 17, in the October issue of the *Welder* publish an interesting article on weld decay. In the course of this article the author deals with the cause of decay, test for decay, relationship between time and temperature, explanation of time-temperature susceptibility curves, and practical aspects.

François Cementation Co., Ltd., of Bentley Works, Doncaster, have prepared a fully-illustrated booklet describing the services they offer to mining engineers in shaft sinking and other problems arising from encounters with flow of water. The cementation process enables the sealing of walls by means of grouting. Other services offered include bore-hole sinking and well-drilling and dam construction or repair.

Sir Isaac Pitman and Sons, Ltd., of Parker Street, Kingsway, London, W.C. 2, have published parts 27 and 28 of their *Engineering Educator*. The subject of Diesel engines, which was introduced in part 26, is continued in part 27. Then follows the first chapter on the outlines of automobile engineering and this section is completed in part 28, which also contains the opening chapters on the testing of prime movers.

Metropolitan-Vickers Electrical Co., Ltd., of Trafford Park, Manchester, have prepared a special issue of their *Gazette* which deals entirely with the activities of the company in South Africa. This traces the development of their steam turbine from 1903 to the present day, going on to deal with specific turbine installations in the Union. A chapter on winding engines follows, together with one on electric winders in.

Mond Nickel Co., Ltd., of Thames House, Millbank, London, S.W.1, in their latest technical publications on nickel cast-iron, deal with the influence of nickel in improving cast-iron, reference being made to newly-developed methods of obtaining irons of high strength and hardness. Illustrations are given of air-compressor and air-turbine rotors, jaw breaker castings, and tractor hubs, in the manufacture of which nickel cast-iron has been used.

John Rolland and Co., Ltd., is the title under which the business formerly carried on by Mr. John Rolland will be continued, the office remaining at Abbey House, Victoria Street, London, S.W. 1. The company represent in this country the firm of Fried. Krupp Grusonwerk, A.-G., of Magdeburg, Germany, manufacturing ore-dressing and mining machinery, and also the Lurgi Gesellschaft für Wärmetechnik, m.b.H., of Frankfurt-am-Main, specialists in certain classes of chemical engineering plant.

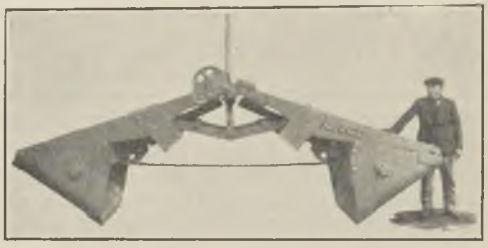
Rhodes, Brydon, and Youett, Ltd., of Gorsey Mount Street, Stockport, issue a number of leaflets describing their "Mopump" for a wide variety of pumping duties. This is a new form of unit which the makers claim is superseding the method of coupling a centrifugal pump and an electric motor on a common bedplate. Coupling and bedplate are abolished and the complete unit may be handled as though it were a motor only. In a single cylindrical casing the motor armature or rotor revolves and is connected to the impeller of a centrifugal type of pump by a special method. The range covers from $\frac{1}{2}$ in. to 5 in., suitable for heads up to 120 ft.

Lincoln Electric Co., of Cleveland, Ohio (London office: Bush House, W.C. 2), have published "Procedure Handbook of Arc Welding Design and Practice." It covers 434 pages, with about 500 illustrations, and is divided into eight sections, comprising welding methods and equipment, technique of welding, procedure, speeds, and costs, structure and properties of weld metal, weldability of metals, design for arc-welded steel construction of machinery, design for arc-welded fabrication of steel structures, and typical applications of arc welding in manufacturing construction and maintenance.

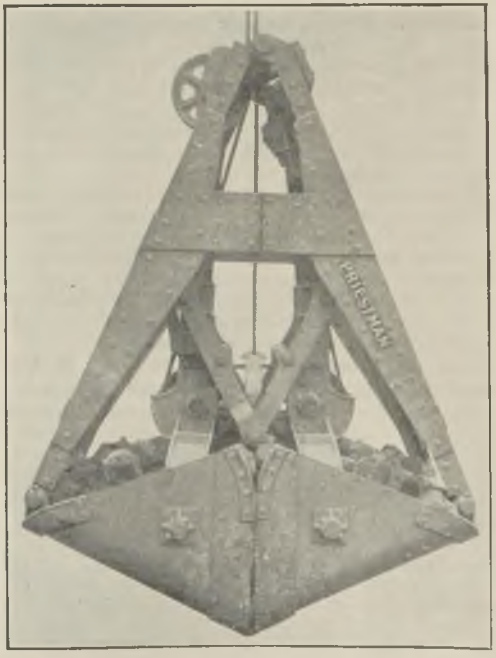
Demag, A.-G., of Duisburg, Germany, in their *Demag News* for September, publish an article describing the installation of the third 7,000 k.w. turbo-compressor having a suction capacity of 47,000 cu. ft. per minute recently completed for the Canada Dam Compressor Station of the Victoria Falls and Transvaal Power Co. This compressor works in 9 stages. The delivery pressure is 117 lb. per sq. in., the atmospheric pressure at the site being 12 lb. per sq. in. In addition to internal cooling, there are two external intercoolers. The total output capacity of this station will now be 130,000 to 145,000 cu. ft. per min.

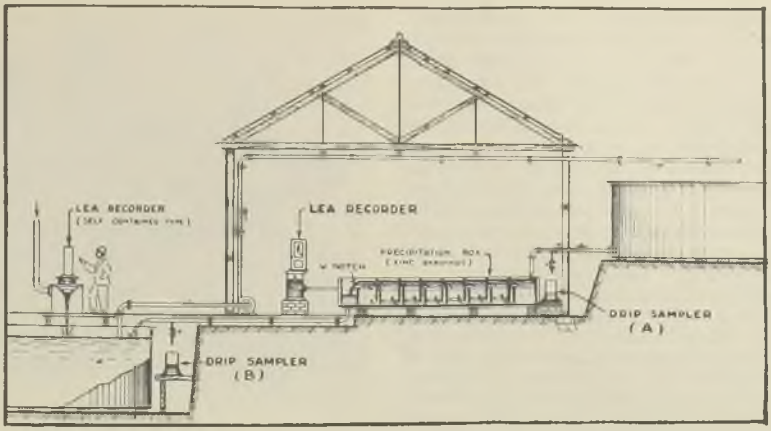
Victaulic Co., Ltd., of King's Buildings, Dean Stanley Street, London, S.W. 1, announce the Victaulic toggle joint. This is a new design of housing which has been produced for pipes in sizes from 1 to 6 in. in diameter and embodies all the features of the Victaulic joint, which has for some years been known as a self-sealing, quickly made, flexible joint and has been adopted extensively for pipe-lines in all parts of the world. In the new design the housing is placed over the self-sealing ring on the pipe ends and snapped into position immediately, as is shown in the illustration. Thus a sound joint in small-diameter pipes can be made in a few seconds, which suggests its utility for compressed-air mains underground, and these may henceforth be of metal tubing instead of flexible hose. The joint is recommended for all temporary and emergency work, but not for use with steam.

Priestman Bros., Ltd., of Holderness Foundry, Hull, have published information with regard to their Level-Cut grab suitable for handling ore, coal, etc. Unlike the clamshell type, which tends to scrape at the start and only just descends to take its load when the jaws are half closed, the jaws of the Level-Cut grab do not scrape over the surface, but enter the material with a true shovelling motion



and continue in this manner to gather the load. The jaws of this grab are maintained at the required angle by being connected on their inner sides to the open arms, thus giving to the cutting edges an approximately parallel motion. The grab requires a double-drum crane or hoist for its operation, one for hoisting and closing and the other for





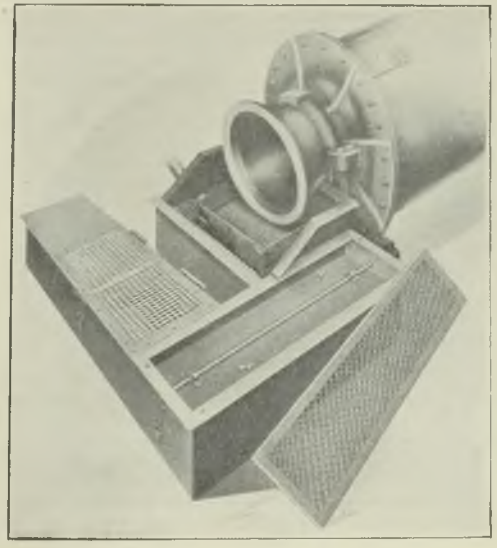
CYANIDE PLANT LAYOUT, SHOWING POSITION OF LEA RECORDERS.

holding and discharging. The usual method of working is to allow the grab to sink to the depth for a full load and no more and then to hold it on the brake of the holding drum during the completion of the action of closing, discharge taking place while the main arms of the grab are closed, so that the contents are emptied into a small space. Although the action is rapid it is without shock. Comparative results with this grab against the clamshell type are given as follows :—In 8 in. to 10 in. sandstone and with plain lips, 25 cu. ft., as against 5 cu. ft., with teeth, 28 cu. ft., against 10 cu. ft., and in excavating clay, 40 cu. ft., against 8 to 10 cu. ft.

International Combustion, Ltd., in association with Mining and Industrial Equipment, Ltd., of 11, Southampton Row, London, W.C.1., report having received the following orders :—For England : One 6 ft. by 36 in. Hardinge ball-mill for sulphur, one 2 ft. by 4 ft. 2-surface type 27 Hum-mer electric screen, one 5 ft. 2 in. diam. Raymond separator for coal, one Ro-Tap testing sieve shaker for laboratory work, together with a sample splitter for small scale testing. For Belgium : Two 4 ft. by 8 ft. type 72 Hum-mer electric screens and four 4 ft. by 8 ft. type 400 Hum-mer electric screens for screening coal. For Cyprus : Two 8 ft. by 5 ft. type 39 Hum-mer electric screens for screening pyrites ore and three 50 ft. by 10 ft. Hardinge thickeners for heavy sulphide ore. For India : Ro-tap testing sieve shakers for laboratory work. For Italy : Two 3 ft. by 5 ft. 1-surface type 38 Hum-mer electric screens for wet screening lead-zinc ore. For West Africa : Ro-Tap testing sieve shakers for laboratory use.

Lea Recorder Co., Ltd., of Cornbrook Park Road, Manchester, issue a leaflet describing their instrument for automatically recording the flow of cyanide solutions and thereby checking the gold content. A typical layout is shown in the accompanying section. The drip samplers A and B indicate the quality of the solution passing through the zinc boxes from the cyanide tank shown on the right, while the Lea recorder shows the quantity of liquid passing. Two possible arrangements are shown : (1) A recorder connected with a V-notch in the last compartment of the zinc box and (2) a self-contained recorder increasing the total solution from a number of boxes. For example, if 1,000 tons of solution has passed through the boxes, the gold content of which is 5 dwt. per ton (ascertained by analysis of samples from A), and if the gold content ascertained from the samples taken at B is 0·5 dwt. it follows that the weight of gold deposited in the zinc boxes is $1{,}000 \times (5{\cdot}0 - 0{\cdot}5)$, or 4,500 dwt., or 225 oz. The use of this recorder is exemplified in the treatment plant of the Lake View and Star Mine, described in the last issue of the MAGAZINE. The recorder consists essentially of a rate of flow indicator, a chart recorder (autographic), and a disc integrator. Many such installations have been supplied to mines throughout the world.

Mine and Smelter Supply Co., Marcy Mill Division, Denver, Col., U.S.A., are sending out a pamphlet describing the Clark-Todd amalgamator, which is designed for the recovery of free or uncombined gold. It provides new means of increasing the catch of amalgam by causing the pulp to change direction several times, each change resulting in a retarded velocity of flow and affording opportunities for amalgam to build up on the plate. In the apparatus the launders are fitted with amalgamated trays, which facilitate the attachment of amalgam



particles. The illustration shows the amalgamator placed immediately below the discharge trunnion of the grinding mill. The screen immediately under the discharge head traps iron and flint fragments and is easily removed for cleaning. The guard screen below, however, is not removable. Under these screens the whole lower space of the discharge box is lined with a copper amalgamated tray which opens into the second launder—that in the foreground of the illustration. Additional water supplied just above the tray through a hole in the left end-wall causes the pulp to flow through the second launder with a second change of direction and, with a third change of direction, through the third launder. The second launder is lined with a removable amalgamated copper box and the bottom of the third launder is covered with an amalgamated silver-plated copper plate. This plate is also removable and should be taken out and cleaned more than is necessary for the trays. As may be seen, the various trays are easily dismantled for cleaning up and are provided with locks.

Holman Bros., Ltd., of Camborne, Cornwall, have prepared two new publications—one devoted to their portable electric hoist and the other to their double-spindle hot mill. The hoist is mounted on a bedplate provided with holes for bolting to a floor or foundation. It is also capable of being clamped to a column or stretcher bar. At one end of the bedplate is a gearbox and at the other a pedestal. These are fitted with ball-bearings and carry the drum shaft, on which the bushed drum is mounted free to rotate. When the electric motor is started it drives the drum shaft through the double-reduction gearing at a constant but low speed. With the clutch band released the clutch race revolves freely, while the drum is held stationary by the brake. When, however, the brake is released and the clutch band is tightened the clutch race is prevented from rotating and a positive drive is transmitted to the drum. Thus the motor is started without load and it is maintained running at a constant speed in one direction, irrespective of the starting and stopping of the drum. Brake and clutch are both operated without effort, are gradual in application, and will remain " on " without being held. This is illustrated in Fig. 1. The double-spindle hot mill contains, as may be seen in Fig. 2, two milling cutters mounted on a common shaft,

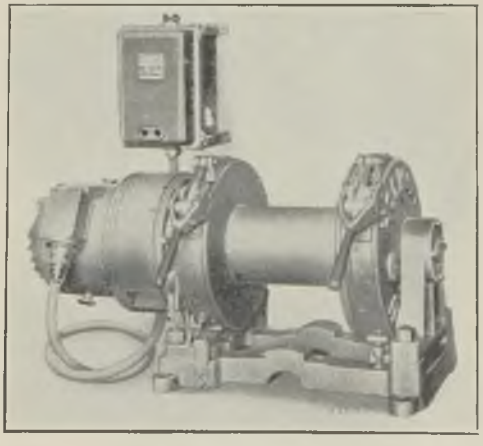


Fig. 1.

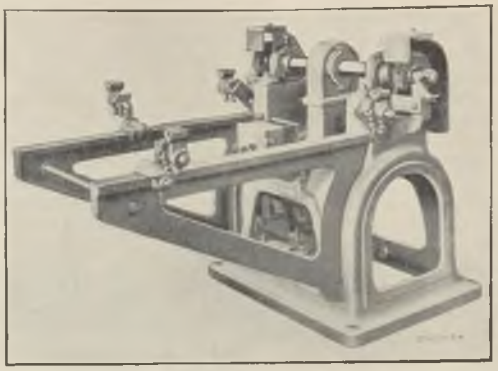
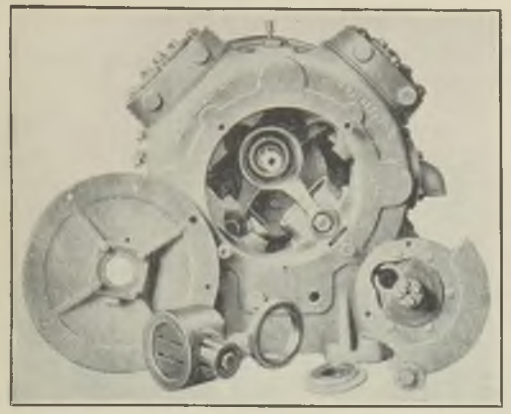


Fig. 2.

but in other respects is not greatly different from their Rotomill described in the Magazine for May of this year. In an introduction to the description of this machine they point out that hot milling does not replace ordinary sharpening practice, but is a valuable aid for the production of better bits. Thus the preliminary work is done on a machine such as the " Twingrip," of their manufacture, and is finished in the hot mill. The double-spindle mill is supplied with a self-contained drive, either an electric motor or an air motor being mounted on the platform with the main frame, the power being transmitted to the spindle shaft by " Vee " belts. The horse-power of the motor is given as four and the speed of rotation of the cutters as 3,000 r.p.m.

Reavell and Co., Ltd., of Ipswich, publish a pamphlet describing their Quadruplex air-compressors of the single-stage type. This is a radial reciprocating machine having special characteristics and is a modification of the original machine suitable for running at considerably higher speeds. The figure shows the machine partly dismantled and it will be seen that it has four cylinders arranged in a circular casing. Each cylinder is fitted with a trunk piston and the four connecting rods are all driven by a common crankpin. The casing contains an annular space forming a water jacket, through which the cylinders pass. Each cylinder forms as it were a separate single-acting compressor, delivering air into a common delivery passage, and, as the compressor is designed to run at high speed, a practically uniform stream of air is given out. The compressor has no suction valves, air being admitted to the cylinders by means of ports in the piston, which coincide with similar ports in the top of the connecting rod during the suction stroke, and at the end of the suction stroke the piston uncovers ports cut through the cylinder wall, thus making direct communication between the cylinder and the inside of the casing, which is arranged to form a suction chamber. This feature alone, it is claimed, results in a gain of at least 5% in volumetric efficiency as compared with compressors having spring-loaded suction valves, because the cylinders are filled with air at atmospheric pressure at each stroke, instead of at a reduced pressure due to the resistance of the valve springs. Delivery valves are fitted at the outer end of each cylinder and they open during the compressing stroke as soon as the air has reached the required delivery pressure and through them the air passes to the delivery belt or passage, from which it may pass away through either of the openings provided at the sides of the casing. The



valves, which are of the plate type made from special steel, are extremely light and the lift is reduced to a minimum to ensure silence in working and freedom from undue wear. The Quadruplex compressor is one of the few machines that can be perfectly balanced and in this type balancing is carried out very effectively by means of suitably proportioned balance weights which are formed on the crank-shaft. These machines are supplied with fast and loose pulleys for driving from line shafting, or with a single pulley for driving by an electric motor. The arrangement of the cylinders makes them particularly suitable for electric driving, as the torque on the shaft is practically constant, which enables the motor to work efficiently and without sparking. Owing to the relatively high speed at which they run they can be directly coupled to motors running at the same speed. They can also be coupled direct to high-speed steam or internal combustion engines, thus making extremely compact and efficient sets. The compressors are made in three sizes—*viz.*, 6 by 4, 7½ by 5, and 9 by 6. The first may be run at speeds ranging from 400 to 800 r.p.m., the corresponding air displacements ranging from 102 to 203 cu. ft. per minute. At 100 lb. pressure the h.p. ranges from 17 to 38. The next size, at speeds from 400 to 700 r.p.m., gives displacements ranging from 199 to 348 cu. ft. per minute the h.p. required being from 34 to 63 at 100 lb. The third size, at speeds of from 400 to 600, gives displacements of 347 to 520 cu. ft. per minute and the h.p. required ranges from 61 to 93.

METAL MARKETS

Copper.—Prices of standard copper in London lost ground last month, mainly owing to stagnation in copper business consequent on the uncertain economic and political outlook. During October the price of electrolytic copper in the United States fell from 9 cents to 7 5 cents per lb. delivered, reacting to 8 25 cents on the subsequent monetary developments. If American inflation takes place higher cent prices for copper may be seen. The export quotation fluctuated considerably owing to exchange movements. Unofficial statistics indicate that the copper position has improved substantially in recent months, but the tendency for output to expand outside America is ominous.

Average price of Cash Standard Copper : October, 1933, £33 13s. 10d. ; September, 1933, £33 3s. 7d. ; October, 1932, £31 18s. 7d. ; September, 1932, £35 0s. 7d.

Tin.—Fairly steady conditions ruled during October, industrial demand being dull. The statistical position is still improving and it is by no means certain whether the higher output now authorized by the International Tin Committee as from January 1, 1934, will entirely stop the present steady shrinkage in world stocks. The future of prices must also depend, as usual, very much on American developments.

Average price of Cash Standard Tin : October, 1933, £223 10s. 7d. ; September, 1933, £216 19s. 3d.; October, 1932, £151 7s. 6d. ; September, 1932, £152 16s. 3d.

Lead.—The undertone of the market during October was barely steady. Industrial demand in the United Kingdom is quite well maintained, but, owing to the big world stocks, the position of sellers is not particularly strong. The suggestion has been put forward in Canada that producers should arrange a fresh curtailment agreement in order to raise prices to a profitable level.

Average mean price of soft foreign lead : October, 1933, £11 19s. ; September, 1933, £12 1s. 7d. ; October, 1932, £12 1s. 3d. ; September, 1932, £13 4s. 8d.

Spelter.—Prices had a downward trend during October, although a rally occurred from the worst levels seen. The knowledge that the Cartel stocks are now increasing has not been a favourable factor, whilst apparently general consumption has been shrinking of late. Alarmed by the present statistical tendency, a meeting of the International Zinc Cartel has been called to discuss the problem with a view of taking steps to redress the situation. Some British consumers are dissatisfied with the present arrangements whereby they are being called on to pay premiums for " debased " Empire electrolytic zinc and they are endeavouring to alter this state of affairs.

Average mean price of spelter : October, 1933, £16 9s. 1d. ; September, 1933, £16 18s. 6d. ; October, 1932, £15 0s. 1d. ; September, 1932, £15 10s. 8d.

Iron and Steel.—The British pig-iron market continued to develop favourably last month and Cleveland producers reported deliveries as being the heaviest for quite six months. Output of foundry material is being increased. Foundry and forge prices are unaltered, No. 3 foundry g.m.b. remaining at 62s. 6d., delivered Middlesbrough area. There are no fixed prices for export. The principle of fixed prices to the home consumer has now been extended to the hematite market and the minimum price of East Coast mixed numbers has been laid down at 62s. 6d. f.o.t. British makers of semi-finished steel are busy, only small supplies of Continental material now coming forward. A certain amount of improvement is recorded by the finishing mills, although the continued lack of big shipyard orders is a handicap.

Iron Ore.—There has been a distinct improvement in the iron ore position during the past month, at any rate in this country. Sales have increased and prices are appreciably firmer in several directions. Best Bilbao rubio is quoted at about 16s. to 16s. 3d. per ton c.i.f. and good North African ores at 14s. to 14s. 6d. c.i.f.

Antimony.—This has been a dull market, but prices have not changed very much. Chinese

LONDON DAILY METAL PRICES.

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

	COPPER.									TIN.						ZINC (Spelter).			LEAD.						SILVER.		GOLD
	STANDARD.						ELECTRO-LYTIC			BEST SELECTED.									SOFT FOREIGN.			ENGLISH.			Cash.	For-ward.	
	Cash.			3 Months.									Cash.			3 Months.											
Oct.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	d.	d.	s. d.
10	33	18	9	34	1	10½	37	7	6	36	0	0	224	18	9	224	18	9	16	13	9	11	17	6	13	5	0	18 5/16	18 3/8	133 9
11	33	5	7½	33	9	4½	36	17	6		—		224	0	0	223	18	9	16	10	0	11	16	3	13	5	0	18 5/16	18 3/8	133 1½
12	33	3	1½	33	6	10½	36	10	0		—		223	17	6	223	16	3	16	10	0	11	17	6	13	5	0	18 5/16	18 7/16	133 5
13	33	6	10½	33	10	7½	36	15	0	35	10	0	223	18	9	223	17	6	16	10	0	11	17	6	13	5	0	18 5/16	18 3/8	132 10½
16	33	16	10½	33	19	4½	37	10	0		—		222	16	3	222	16	3	16	11	3	11	17	6	13	5	0	18 5/16	18 7/16	128 6
17	33	4	4½	33	6	10½	37	0	0	35	10	0	221	18	9	221	18	9	16	8	9	11	13	9	13	5	0	17 3/4	17 13/16	130 11½
18	33	4	4½	33	8	1½	37	0	0		—		224	1	3	223	18	9	16	6	3	11	13	9	13	5	0	18 5/16	18 3/8	132 0½
19	32	10	7½	32	14	4½	36	10	0		—		222	0	0	221	17	6	15	17	6	11	8	9	13	0	0	18	18 5/16	129 11
20	32	15	0	32	18	1½	36	10	0	35	0	0	221	16	3	221	16	3	15	16	3	11	7	6	13	0	0	18	18 3/8	129 0½
23	32	10	7½	32	14	4½	36	10	0		—		222	6	3	222	5	0	15	11	3	11	5	0	12	15	0	18 5/16	18 3/8	129 2
24	33	0	0	33	2	6	36	10	0	35	0	0	222	18	9	222	16	3	15	13	9	11	10	0	13	0	0	18 5/16	18 7/16	128 1
25	33	9	4½	33	11	10½	37	0	0		—		223	18	9	223	18	9	16	0	0	11	18	9	13	5	0	18 5/16	18 7/16	130 1
26	33	16	9	33	16	10½	37	5	0		—		225	1	3	224	18	9	16	0	0	12	1	3	13	10	0	18 5/16	18 7/16	130 9½
27	32	19	4½	33	1	10½	37	5	0	35	0	0	224	11	3	224	8	9	16	0	0	11	18	9	13	5	0	18 5/16	18 7/16	131 2
30	33	4	4½	33	6	10½	37	0	0		—		225	6	3	225	5	0	16	2	6	11	17	6	13	5	0	18 1/4	18 5/16	131 2½
31	32	16	10½	32	19	4½	37	0	0	35	0	0	224	12	6	224	7	6	15	17	6	11	12	6	13	0	0	18 1/4	18 5/16	130 7
Nov.																														
1	32	14	4½	32	16	10½	36	10	0		—		224	10	0	224	5	0	15	11	3	11	13	9	13	0	0	18 5/16	18 7/16	131 9
2	32	10	7½	32	13	1½	36	10	0		—		224	16	3	224	8	9	15	11	3	11	10	0	13	0	0	18 5/16	18 3/8	133 3
3	32	13	9	32	16	3	36	10	0	34	15	0	224	18	9	224	11	3	15	12	6	12	0	0	13	10	0	18 1/4	18 5/16	133 2
6	32	1	10½	32	4	4½	36	0	0		—		224	16	3	224	6	3	15	10	0	11	15	0	13	5	0	18 1/4	18 3/8	131 10
7	31	9	4½	31	11	10½	35	10	0	34	0	0	224	17	6	224	7	6	15	8	9	11	15	0	13	5	0	18 1/4	18 3/8	129 11½
8	31	18	1½	32	0	7½	35	10	0		—		226	16	3	226	6	3	15	15	0	11	17	6	13	5	0	18 1/4	18 3/8	131 10
9	31	16	10½	31	18	9	35	10	0		—		230	2	6	228	17	6	15	17	6	12	0	0	13	10	0	18 5/16	18 11/16	130 11
10	31	15	0	31	18	1½	35	10	0	34	5	0	229	7	6	228	8	9	15	13	9	11	17	6	13	5	0	18 1/4	18 5/16	129 8

regulus is quoted at about £23 to £23 5s. c.i.f. for forward shipment, with English steady at £37 10s. to £40 per ton, ex warehouse.

ARSENIC.—Mexican is still quoted at about £16 per ton c.i.f. but other foreign material has been offered at less. Cornish white remains at £16 to £16 5s. per ton f.o.r. mines.

BISMUTH.—The official price is unchanged at 5s. 3d. per lb. for 5 cwt. lots and over, at which level there is a fair demand.

CADMIUM.—A quiet business is passing at about 1s. 2d. to 1s. 2½d. per lb.

COBALT METAL.—There is a little more moving, but the price is unchanged officially at 5s. per lb. for cwt. lots.

COBALT OXIDES.—The market is not particularly active, but quotations are steady at 4s. 6d. to 4s. 8d. per lb. for black and 4s. 9d. to 4s. 11d. for grey.

CHROMIUM.—Platers are fair buyers, with the price steady at 2s. 8d. per lb.

TANTALUM.—The price is unchanged at about £15 per lb.

PLATINUM.—Although demand is rather better than during the early part of the year, it is by no means brisk. Prices are without change at £7 12s. 6d. to £7 15s. per oz. for refined metal.

PALLADIUM.—The market is quietly steady at £3 10s. to £4 5s. per oz.

OSMIUM.—The volume of sales is small, but prices are upheld at £12 to £13 per oz.

IRIDIUM.—Quiet conditions prevail here, but prices are unaltered at £9 to £10 per oz. for sponge and powder.

TELLURIUM.—A moderate demand is reported at around 15s. to 16s. per lb. for fair-sized parcels of ingots.

SELENIUM.—About 7s. 6d. to 7s. 8d. per lb. ex warehouse Liverpool is quoted, demand being steady.

MANGANESE ORE.—A rather better tone exists in this market, the Continent having bought moderately well at times. At the moment new business is rather slow again, but prices are firm at 9½d. per unit c.i.f. for best Indian and 9d. c.i.f. for good 48% Indian and washed Caucasian ores.

ALUMINIUM.—There have been no important developments, prices being unaltered at £100 for ingots and bars and £102 for rolling billets, both less 2% delivered, for the home trade.

SULPHATE OF COPPER.—English is quoted at £16 to £16 10s. per ton, less 5%.

NICKEL.—Business has continued to improve, but prices are without change at £225 to £230 per ton, according to quantity.

CHROME ORE.—Only a limited demand is in evidence at the moment, but prices are steady at 80s. to 85s. per ton c.i.f. for first quality 48% Rhodesian ore and 100s. to 105s. c.i.f. for 55 to to 57% New Caledonian.

QUICKSILVER.—The Italo-Spanish combine has been renewed until the end of 1934 and prices have firmed up to about £9 15s. to £10 per bottle, net, for spot material as a result of a rather better demand.

TUNGSTEN ORE.—The position of this commodity has been rather difficult to follow, since prices have risen meteorically, despite the fact that the export monopoly has not been imposed. China is now asking about 28s. 6d. to 29s. 6d. per unit c.i.f. for forward shipment, with buyers' ideas in the region of 25s. to 26s. c.i.f.

MOLYBDENUM ORE.—There is no change to report, good 80 to 85% concentrates being quoted at 40s. to 42s. 6d. per unit c.i.f.

GRAPHITE.—The battery trade is quite a good buyer, but otherwise demand is not impressive. Madagascar flake, 85 to 90% is quoted at £19 to £21 duty paid and 90% Ceylon lumps at £15 to £17 per ton c.i.f.

SILVER.—Few features of interest were apparent in the silver market during October. Spot bars, which were 18½d. on October 2, declined to 18⅛d. on October 16, as the result of some Continental selling, which was incompletely offset by American and Chinese purchases. During the latter half of the month the market was rather featureless. On October 31 spot bars closed at 18¼d.

STATISTICS

PRODUCTION OF GOLD IN THE TRANSVAAL.

	Rand.	Elsewhere.	Total.
	Oz.	Oz.	Oz.
October, 1932	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	924,671
August	882,587	52,127	934,714
September	851,985	49,814	901,799
October	859,724	52,164	908,888

TRANSVAAL GOLD OUTPUTS.

	September.		October.	
	Treated Tons.	Yield Oz.	Treated Tons.	Yield Oz.
Brakpan	117,000	£232,360	117,000	£237,458
City Deep	109,000	22,017	111,000	22,024
Cons. Main Reef	82,000	22,990	84,000	23,513
Crown Mines	294,000	86,761	300,000	88,511
Daggafontein	58,000	£133,075	60,300	£138,895
D'rb'n Roodepoort Deep	52,000	13,896	53,600	13,844
East Geduld	77,000	25,835	79,000	26,480
East Rand P.M.	168,000	39,210	174,000	40,812
Geduld	91,000	26,878	91,800	26,984
Geldenhuis Deep	80,000	14,438	83,000	14,757
Glynn's Lydenburg	7,500	2,832	7,600	3,477
Government G.M. Areas	208,000	£537,692	208,000	£536,562
Kleinfontein	48,600	£60,084	48,700	9,113
Langlaagte Estate	79,000	£117,399	83,000	£116,089
Luipaard's Vlei	36,500	8,245	37,000	8,391
Modderfontein New	176,000	49,612	177,000	49,294
Modderfontein B	80,000	17,609	82,000	17,636
Modderfontein Deep	44,900	17,302	45,500	17,074
Modderfontein East	78,000	20,631	78,000	20,330
New State Areas	91,000	£254,825	91,000	£253,274
Nourse	71,500	17,573	72,000	17,719
Randfontein	270,000	£439,195	280,000	£441,309
Robinson Deep	100,000	£170,533	100,000	£172,553
Rose Deep	63,000	11,674	65,000	11,771
Simmer and Jack	87,000	£132,532	90,000	£132,801
Springs	84,500	£233,681	84,500	£233,156
Sub Nigel	41,000	£230,064	42,400	£231,744
Transvaal G.M. Estates	19,700	5,232	20,700	5,422
Van Ryn	53,000	£62,015	54,000	£60,933
Van Ryn Deep	77,000	£125,318	79,000	£126,533
West Rand Consolidated	95,000	£155,547	98,000	£154,846
West Springs	88,000	£102,699	87,500	£102,411
Witw'tersr'nd (Knights)	75,000	£77,635	76,000	£79,639
Witwatersrand Deep	50,500	£66,378	51,500	£67,612

[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.	£
July, 1932	2,993,600	27 5	19 3	8 6	1,260,744
August	3,027,700	27 6	19 0	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 1	8 5	1,263,274
November	2,949,050	27 8	19 0	8 5	1,256,717
December	2,972,000	27 10	19 2	8 6	1,255,797
January, 1933	3,029,000	37 10	19 5	8 5	2,802,754
February	2,802,600	37 0	19 4	18 6	2,414,758
March	3,087,860	36 1	19 9	17 3	2,549,179
April	2,922,200	36 1	19 7	16 6	2,381,971
May	3,144,000	35 8	19 9	16 4	2,556,066
June	3,093,500	35 4	19 5	16 3	2,453,205
July	3,182,600	35 5	19 6	15 10	2,568,899
August	3,221,850	35 9	19 3	16 2	2,651,880
September	—	—	—	—	2,684,772

NATIVES EMPLOYED IN THE TRANSVAAL MINES.

	Gold Mines.	Coal Mines.	Diamond Mines.	Total.
October 31, 1932	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
October 31	231,799	11,662	—	243,461

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	56,790
October	45,006	44,260	50,416	—
November	44,351	44,516	48,082	—
December	46,485	50,034	52,096	—

RHODESIAN GOLD OUTPUTS.

	September.		October.	
	Tons.	Oz.	Tons.	Oz.
Cam and Motor	25,400	9,128	25,800	8,916
Globe and Phœnix	6,088	5,433	6,090	5,430
Lonely Reef	14,000	1,861	14,000	1,855
Rezende	6,500	2,154	6,500	2,019
Sherwood Star	6,800	1,805	7,000	£12,358
Wanderer Consolidated	15,500	3,208	16,100	3,361

WEST AFRICAN GOLD OUTPUTS.

	September.		October.	
	Tons.	Oz.	Tons.	Oz.
Ariston Gold Mines	9,055	£26,087	9,278	£26,144
Ashanti Goldfields	13,711	14,902	13,622	14,829
Taquah and Abosso	10,576	3,554	12,107	4,105

AUSTRALIAN GOLD OUTPUTS BY STATES.

	Western Australia.	Victoria.	Queensland.
	Oz.	Oz.	Oz.
October, 1932	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	7,963	6,774
August	56,147	—	—
September	58,679	—	—
October	54,834	—	—

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

AUSTRALASIAN GOLD OUTPUTS.

	September.		October.	
	Tons.	Value £	Tons.	Value £
Associated G.M. (W.A.)	5,103	4,306	4,824	7,372
Blackwater (N.Z.)	4,020	1,710*	3,797	1,679*
Boulder Persev'ce (W.A.)	7,289	8,201*p	7,606	5,967*p
Grt. Boulder Pro. (W.A.)	6,247	5,216*	6,331	5,143*
Lake View & Star (W.A.)	30,998	64,773	41,744	86,368
Sons of Gwalia (W.A.)	11,958	14,924	12,260	15,070
South Kalgurli (W.A.)	9,780	12,726	10,226	12,671
Waihi (N.Z.)	17,393	4,770* 28,620†	16,355	4,744* 34,863†
Wiluna	40,511	10,824*	—	—

* Oz. gold. † Oz. silver. *p* Profit

GOLD OUTPUTS, KOLAR DISTRICT, INDIA.

	September.		October.	
	Tons Ore.	Total Oz.	Tons Ore.	Total Oz.
Champion Reef	9,160	4,855	10,200	5,307
Mysore	14,672	7,582	15,240	7,847
Nundydroog	18,052	10,262*	17,985	9,611†
Ooregum	12,500	4,506	12,504	4,329

* 1,538 oz. from 932 tons Balaghat ore.
† 906 oz. from 756 tons Balaghat ore.

MISCELLANEOUS GOLD, SILVER, AND PLATINUM OUTPUTS.

	September.		October.	
	Tons.	Value £	Tons.	Value £
Bulolo Gold	—	7,335*	—	8,100*
Chosen Corp. (Korea)	12,200	18,435	12,700	17,802
Frontino Gold (C'bia)	4,510	18,296	4,720	19,025
Fresnillo	79,855	65,863*d*	—	—
New Goldfields of Venezuela	12,829	3,166*	15,233	4,610*
Oriental Cons. (Korea)	—	88,710*d*	—	85,635*d*
St. John del Rey (Brazil)	—	37,000	—	32,500
Santa Gertrudis (Mexico)	12,566	29,882*d*†	—	—
Viborita	—	—	—	—
West Mexican Mines	2,210	24,600*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	2,436
May	1,917	November	—
June	1,092	December	—

OUTPUTS OF MALAYAN TIN COMPANIES.

In Long Tons of Concentrate.

	Aug.	Sept.	Oct.
Ayer Hitam	—	—	—
Batu Caves	—	—	—
Changkat	28	36	27
Gopeng	—	60½*	—
Hongkong Tin	—	74*	—
Idris Hydraulic	8⅔	—	10½
Ipoh	37½	15	40
Kampar Malaya	—	—	—
Kampong Lanjut	—	—	—
Kamunting	83½	75	110½
Kent (F.M.S.)	—	—	—
Killinghall	—	76½*	—
Kinta	—	28½*	—
Kinta Kellas	—	—	—
Kramat Tin	40	40	55
Kuala Kampar	33	46	44
Kundang	—	—	—
Lahat	12½	10⅔	—
Lower Perak	—	—	—
Malaya Consolidated	—	136	—
Malayan Tin	62½	27½	53½
Malim Nawar	26	23	20
Pahang	78	78	78
Penawat	43	32	37½
Pengkalen	—	55½*	—
Petaling	89	—	222
Rahman	—	—	—
Rambutan	—	—	—
Rantau	—	—	—
Rawang	30	60	45
Rawang Concessions	30	30	25
Renong	—	—	27
Selayang	—	—	—
Southern Kampar	—	—	116⅔
Southern Malayan	71½	71¼	62½
Southern Perak	—	—	32½
Southern Tronoh	—	—	—
Sungei Besi	—	—	—
Sungei Kinta	—	—	—
Sungei Way	—	—	—
Taiping	—	—	—
Tanjong	—	—	—
Tekka	18½	39*	—
Tekka Taiping	—	54½*	—
Temoh	22	13⅔	14½
Tronoh	—	—	—
Ulu Klang	—	—	—

* 3 months to September 30.

OUTPUTS OF NIGERIAN TIN MINING COMPANIES.

In Long Tons of Concentrate.

	Aug.	Sept.	Oct.
Anglo-Nigerian	16	16	16
Associated Tin Mines	100	100	105
Baba River	6	8	10
Batura Monguna	—	—	—
Bisichi	18	17	—
Daffo	—	—	—
Ex-Lands	21	23	22
Filani	—	—	—
Jantar	10	8½	10
Jos	7	8	—
Juga Valley	5½	5½	5½
Kaduna Syndicate	10	10	—
Kaduna Prospectors	7	7	—
Kassa	4	4	4
London Tin	73	76	70
Lower Bisichi	—	3	—
Naraguta Extended	—	—	—
Nigerian Consolidated	5	5	5
Offin River	—	—	—
Ribon Valley	7	6	—
Tin Fields	—	—	—
United Tin Areas	7	6	5
Yarde Kerri	—	—	—

OUTPUTS OF OTHER TIN MINING COMPANIES.

In Long Tons of Concentrate.

	Aug.	Sept.	Oct.
Anglo-Burma (Burma)	42	41	—
Aramayo Mines (Bolivia)	110	118	101
Bangrin (Siam)	87⅔	44½	52½
Beralt	27*	34*	40*
Consolidated Tin Mines (Burma)	118	100	80
East Pool (Cornwall)	46	49½	49½
Fabulosa (Bolivia)	25	25	21
Geevor	61	59½	55
Kagera (Uganda)	28	25	—
Kamra	26	17½	23½
Malaysiam Tin	14½	14½	14½
Mawchi	240½*	264¾	—
Patino	—	—	—
Pattani	68	66½	125½
San Finx (Spain)	—	—	—
Siamese Tin (Siam)	219	130	117
South Crofty	54¼	53¼	53½
Tavoy Tin (Burma)	65	86	95
Tongkah Harbour (Siam)	39	32	45
Toyo (Japan)	68	62	81½
Zaaiplaats	12⅓	12½	—

* Tin and Wolfram.

COPPER, LEAD, AND ZINC OUTPUTS.

		Sept.	Oct.
Britannia Lead	Tons refined lead	6,471	—
	Oz. refined silver	260,395	—
Broken Hill South	Tons lead conc.	5,968‡	2,762‡‡
	Tons zinc conc.	6,222‡	3,125‡‡
Burma Corporation	Tons refined lead	5,880	5,880
	Oz. refined silver	495,400	470,627
Electrolytic Zinc	Tons zinc	—	—
Indian Copper	Tons copper	370	400
	Tons yellow metal	474	489
Messina	Tons copper	688	754
Mount Isa	Tons lead bullion	4,200	—
Mount Lyell	Tons concentrates	6,999*	3,946
North Broken Hill	Tons lead conc.	6,060	5,630
	Tons zinc conc.	5,430	4,770
Rhodesia Broken Hill	Tons Zinc	1,620	1,680
	Tons V_2O_5 conc.	—	—
Roan Antelope	Tons blister copper	—	—
Sulphide Corporation	Tons lead conc.	1,702‡	—
	Tons zinc conc.	2,509‡	—
Trepca	Tons lead conc.	5,246	5,284
	Tons zinc conc.	7,585	7,629
Zinc Corporation	Tons lead conc.	5,784†	—
	Tons zinc conc.	4,933†	—

* To Oct. 4. † To Oct. 14. ‡ To Oct. 7. ‡‡ To Nov. 4.

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

		Aug.	Sept.
Iron Ore	Tons	227,527	226,606
Manganese Ore	Tons	15,181	9,496
Iron and Steel	Tons	79,710	80,342
Copper and Iron Pyrites	Tons	29,203	22,236
Copper Ore, Matte, and Prec.	Tons	63	4,369
Copper Metal	Tons	13,694	11,493
Tin Concentrate	Tons	2,929	943
Tin Metal	Tons	235	185
Lead Pig and Sheet	Tons	22,695	21,469
Zinc (Spelter)	Tons	7,280	5,802
Zinc Sheets, etc.	Tons	2,048	1,771
Zinc Oxide	Tons	59	66
Zinc Ore and Conc.	Tons	16,706	22,240
Aluminium	Cwt.	12,961	16,106
Mercury	Lb.	116,150	46,270
White Lead	Cwt.	5,851	7,462
Barytes, ground	Cwt.	26,525	20,975
Asbestos	Tons	2,250	2,155
Boron Minerals	Tons	846	744
Borax	Cwt.	8,440	15,500
Basic Slag	Tons	—	—
Superphosphates	Tons	—	550
Phosphate of Lime	Tons	35,009	30,495
Mica	Tons	142	176
Tungsten Ores	Tons	306	436
Sulphur	Tons	1,708	3,805
Nitrate of Soda	Cwt.	1 622	—
Potash Salts	Cwt.	454,116	425,579
Petroleum: Crude	Gallons	27,268,277	32,051,008
Lamp Oil	Gallons	12,509,352	13,114,300
Motor Spirit	Gallons	95,169,032	98,730,827
Lubricating Oil	Gallons	6,493,551	11,071,837
Gas Oil	Gallons	11,208,254	7,917,118
Fuel Oil	Gallons	42,226,108	55,722,866
Asphalt and Bitumen	Tons	8,818	4,627
Paraffin Wax	Cwt.	127,518	69,641

OUTPUTS REPORTED BY OIL-PRODUCING COMPANIES.

In Tons.

	August.	Sept.	Oct.
Anglo-Ecuadorian	18,208	17,099	17,416
Anglo-Persian	667,000	587,000	—
Apex Trinidad	44,120	41,280	44,370
Attock	1,113	1,035	1,118
British Burmah	4,513	—	3,948
British Controlled	27,191	25,841	—
Kern Mex.	856	551	758
Kern River (Cal.)	2,248	2,232	2,377
Kern Romana	222	168	312
Kern Trinidad	3,571	3,468	3,874
Lobitos	22,208	21,518	21,824
Phœnix	60,484	57,144	52,646
St. Helen's Petroleum	4,756	4,020	4,128
Steaua Romana	104,393	100,357	105,044
Tampico	2,312	1,616	1,981
Tocuyo	1,108	968	872
Trinidad Leaseholds	33,700	32,550	33,850

QUOTATIONS OF OIL COMPANIES' SHARES.

Denomination of Shares £1 unless otherwise noted.

	Oct. 10, 1933.	Nov. 10, 1933.
	£ s. d.	£ s. d.
Anglo-Ecuadorian	15 9	16 6
Anglo-Egyptian B	1 12 6	1 13 0
Anglo-Persian 1st Pref.	1 11 0	1 12 6
" " Ord.	2 10 0	2 11 9
Apex Trinidad (5s.)	1 8 6	1 9 3
Attock	12 6	13 0
British Burmah (8s.)	4 6	4 3
British Controlled ($5)	5 9	5 9
Burmah Oil	4 6 9	4 10 6
Kern River Cal. (10s.)	5 3	5 3
Lobitos, Peru	2 9 3	2 9 3
Mexican Eagle, Ord. (4 pesos)	11 6	12 0
" " 8% Pref. (4 pesos)	11 0	12 0
Phœnix, Roumanian	12 6	13 6
Royal Dutch (100 fl.)	22 7 6	22 0 0
Shell Transport, Ord.	—	2 14 3
" " 5% Pref. (£10)	12 0 0	12 0 0
Steaua Romana	13 0	12 9
Trinidad Leaseholds	3 8 9	3 13 9
United British of Trinidad (6s. 8d.)	5 3	6 3
V.O.C. Holding	1 17 6	1 14 3

PRICES OF CHEMICALS. Nov. 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	17	6
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	6
" " crystallized, 40°	per lb.			9
Carbon Disulphide	per ton	30	0	0
Citric Acid	per lb.			9½
Copper Sulphate	per ton	15	15	0
Creosote Oil (f.o.b. in Bulk)	per gal.			4½
Cresylic Acid, 99-100%	"		1	5
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	17	6
Lead, Acetate, white	"	34	0	0
" Nitrate (ton lots)	"	27	10	0
" Oxide, Litharge	"	27	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	0	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	0	0
" Nitrate	"	30	0	0
" Permanganate	per lb.			8½
" Prussiate, Yellow	per ton	75	0	0
" " Red	per lb.		2	0
" Sulphate, 90%	per ton	10	10	0
Sodium Acetate	"	22	10	0
" Arsenate, 45%	"	23	0	0
" Bicarbonate	"	10	10	0
" Bichromate	per lb.			4
" Carbonate (Soda Ash), 58%	per ton	6	0	0
" " (Crystals)	"	5	2	6
" Chlorate	"	32	0	0
" Cyanide, 100% NaCN basis	per lb.			8
" Ethyl Xanthate	per 100 kilos	7	0	6
" Hydrate, 76/77%	per ton	14	0	0
" Hyposulphite, comml.	"	9	2	6
" Nitrate (refined)	"	7	15	0
" Phosphate, comml.	"	11	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	6	6
" Roll	"	9	6	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.		1	0½
Turpentine	per ton	46	10	0
Tin Crystals	per lb.		1	0
Titanous Sulphate (Stabilized)	"			9
Zinc Chloride	per ton	9	10	0
" Dust, 90/92%	"	20	0	0
" Oxide (White Seal)	"	30	0	0
" Sulphate	"	9	0	0

SHARE QUOTATIONS

Shares are £1 par value except where otherwise noted.

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

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

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.

GOLD WORKINGS IN GOLD COAST COLONY

The report of the Geological Survey Department of the Gold Coast Colony for the year 1932–3 states that owing to the stimulating effect of the gold premium an active interest is being taken in the gold resources of the Gold Coast. In anticipation of this a comprehensive survey of these resources was commenced at the beginning of the period under review. This work was not completed at the end of the year, but practically the whole of the Western Province and portions of the Central and Eastern Provinces of the Colony and the Eastern Province of Ashanti were covered. Nearly two hundred banket and reef prospects and a large number of alluvial prospects were examined. During the course of this work the geological mapping of the country was continued and several reconnoitring traverses were made in thinly inhabited and uninhabited areas not previously examined by the Survey. In addition the Prestea gold belt and the underground workings of the Ariston mine were geologically mapped in detail and the plans and sections to accompany the memoir on the goldfield were prepared for publication.

One of the most important economic results of the survey of the gold resources is the proof that the auriferous quartz-reefs and lodes are constantly associated with Upper Birrimian greenstones (lavas, pyroclastic and hypabyssal rocks) where they are intruded by granite and porphyry of the Dixcove type. The manganese deposits also occur in these Birrimian greenstones and phyllites and many, if not most, of the diamondiferous occurrences are associated with the same rocks. As the auriferous conglomerates (banket) occur in the lower beds of the Tarkwaian System, which directly succeeds Upper Birrimian rocks, it is clear that with the help of geological maps, prospecting for these minerals will be greatly facilitated. In many districts old workings for gold were examined and notes on some of these prospects are reproduced here.

In Eastern Ashanti and Western Akim, gold occurs both in the Birrimian rocks and in the conglomerates of the Tarkwaian System. Fair to good prospects of alluvial gold were obtained from streams draining the Birrimian greenstones and phyllites near Ntranang, Adausena, Mamangsu, and Babochau, but no auriferous lodes or quartz-reefs were found. To the south-west of Banka the conglomerates of the Banket Series appear to be poorly developed and to be only weakly auriferous. From Banka the conglomerates and pebbly grits can be traced with a few breaks to near Akoasi, 24 miles to the east-north-east, from there 12 miles in a westerly direction to Kumeso, and thence to the south-west for some 10 miles. In the time available it was not possible to prospect the whole of the banket outcrop. It was tested in several places near Banka, Atokwai, Kokoben, Ntranang, Akoasi, Noyem, Nyafomang, Bintempi, Aseni Akrofunso, Damponkwanta, Kumeso, and Chempaw. Fair to very fair prospects of gold were obtained from some of the banket near Banka, Ntranang, Bintempi, and Noyem, but elsewhere it yielded only a little gold. Speaking generally it may be said that the best values are in the south-eastern and northern limb of the syncline east of the Pra. Only traces of gold were found in the conglomerates in the north-western limb of the syncline. In the Tarkwa goldfield a similar relation exists, the south-eastern limb of the banket being the richest.

Ntranang Mine.—The mine is situated on the east bank of the Pra about one mile north-west of Ntranang village. It was developed between 1909 and 1918. The main shaft was sunk to a depth of about 450 ft. (350 ft. vertical) on an inclination of 40° to No. 2 level and 60° below this random four levels were driven. At the surface the banket is about 8 ft. thick, strikes N.60° E. and dips to the S.S.E. at 50°. The banket is much faulted and considerable difficulty arose in picking it up at the various levels. The effect of the faults is to throw the banket back into the foot-wall so that between Nos. 3–4 levels it is almost vertically below its position at No. 2 level. Ultimately, owing to the fact that the beds are overturned and the structure synclinal, the banket will turn up again towards the surface on the north-north-west side of the mine. Some 400 ft. were driven on the reef at both No. 2 and No. 3 levels. When the mine was closed down in 1918 the ore reserves were, according to the manager, 74,598 tons of an average value of 8·06 dwt.

In the Anibil, Kanyankaw, Simpa area nearly all the gold deposits are in Birrimian greenstones in the contact aureole of Dixcove granite and diorite.

Akoko Mine.—The workings' at Cheriaman, Abeaba, Akoko, and Akramia stretch for more than one mile in a north-east–south-west direction. The reefs at Aboison, Essasika, Sarnie, and Bankurayo to the north-east near Simpa are apparently on the same line. The Akoko reef occurs in chlorite-schists, which, near the reef, are impregnated with pyrite and carbonate. The reef has an average dip of about 60° N.W. It consists of lenticular masses of quartz averaging about 4 ft. in width. Pyrite and chalcopyrite accompany the gold, which is usually concentrated in the foot-wall side of the reef. The mine was opened up to the No. 8 level 750 ft. from the surface, but No. 6 is the deepest fully-developed level. The ore shoot averaged between 200–300 ft. in length. From 1912 to 1928, 35,646 tons of ore were crushed and 29,041 oz. of fine gold, valued at £123,370 were obtained, being an average recovery of 16·2 dwt. per ton.

The Akanko auriferous belt, in Eastern and Western Nzima, consists of schistose basic lavas, ashes, and phyllites of Birrimian age intruded by small masses of Dixcove porphyry. Most of the

reefs occur in phylites or lavas, but some of them are in dykes of porphyry. On the main line the quartz reefs usually contain black tourmaline (schorl) and some pyrite and rarely arsenopyrite. The gold is normally coarse and patchy. At Aboaji and Mamponso pyrite and arsenopyrite occur in the quartz, but no tourmaline was seen.

Akanko Mine.—The mine is situated within 0·3 m. of the Ankobra river. The ore-body is a quartz reef, which outcrops strongly on the crest of a ridge about 100 ft. in height. The reef has been tested over a length of 500–600 ft. At the northern end of the ridge it is 10–12 ft. thick and dips E.S.E. at 55°. At the southern end of the ridge near Cox's shaft the reef contacts to a width of 1½ ft. and dips to the east at 70°. The country rocks are decayed Birrimian greenstones (lavas and ashes) with bands of phyllite and small intrusions of porphyry. The gold is rather coarse and patchy and much of it is visible to the naked eye. It is closely associated with schorl in saccharoidal quartz, which is penetrated by hard grey-white quartz carrying very little gold. The mine has been worked at intervals since 1881. The workings consist of shallow shafts and two adits. From an old shaft, which is now caved, sunk at the foot of the ridge in the hanging-wall of the reef, two levels were driven and the ore partly stoped from above No. 1 level to No. 2 level. No official records are available of the amount of gold extracted, but it is said that some thousands of ounces of gold were won.

The Tokosea auriferous belt occurs in the Enchi and Sefwi districts, and from Tanoso to near Tokosea a wide belt of Birrimian phyllites was crossed. Near Tokosea these rocks give place to Birrimian greenstones which stretch for nearly 25 miles to the north-west. Along the contact of these belts, from the Anglo-French boundary near Siwum through Tokosea to beyond Achimfu on the motor road east-south-east of Enchi, there are a number of auriferous occurrences aligned in a N.E.–S.W. direction. Quartz reefs were worked at Achimfu and near Tokosea and Siwum and alluvial deposits at many places in this belt. The Siwum-Tokosea locality is noted for the nuggety gold formerly won from the alluvial workings.

Tokosea Mine.—The original African workings, consisting of open-cuts and pits sunk to a depth of 50 ft. or less, are said to have been excavated mainly by the Appollonians. Between 1911 and 1918 a European company developed and worked the ore-body to a depth of about 100 ft. These workings are now full of water. The reef occurs in phyllites and basic igneous rocks striking about N. 30° E. and dipping at 60–90° on either side of vertical. The reef seen in the surface workings trends N. 30° E. It dips nearly vertically and varies from 1 to 4 ft. in width. The quartz contains partings of phyllite and flakes of a bright green micaceous mineral. During the period 1911–17 3,584 tons of ore were crushed for a yield of 1,557 oz. of fine gold, being an average extraction of about 8·7 dwt. per ton.

The workings at *Siwum Mine* (*Adjaye Birim*), 2 miles south-west of Tokosea, consist of shallow shafts and adits. Apart from one adit all the other workings have caved. Phyllites and decayed igneous rocks, striking N.30°E. and dipping steeply, are exposed in this adit. The main reef was not seen in situ. From the material on the dump of a caved adit the reef appears to occur in black phyllites. A sample of this quartz assayed 11·2 dwt. per ton. The mine was worked by Europeans at intervals between 1911 and 1925, but, so far as is known, no ore was crushed.

A few reconnoitring traverses were made across the country between the Anglo-French boundary and the road from Dadiaso to Debiso via Amoya and Aluakru. South-east of a line from Mafia to the frontier west of Dadiaso the rocks are essentially Birrimian with intrusions of various types of granite. North-west of this line to near Debiso exposures of rock are few and far between. Those seen suggest that the rocks in this area are chiefly Tarkwaian sediments. Typical hæmatitic quartzites and pebbly grits of the Banket Series outcrop near Yafurikrom, 6 m. due north-west of Dadiaso, carbonate-bearing sandstones and grits at 6–7 m. north-north-east of Yafurikrom and buff phyllites containing porphyroblasts of magnetite (Tarkwa phyllites ?) at Ajufia, Dominabo, and the Bia river between Mafia and Aluakru. Biotite-muscovite-granite with veins of pegmatite outcrops near the frontier west of Debiso.

Akwantambra Mine is situated on the bank of the Akwantambra Su, ¾ m. south-south-west of Akwantambra. The workings consist of three European shafts and a number of native pits.

In the vicinity of a line north-north-east from Dadiaso to the Akasu Mine, 2 m. due east of Mafia, there are a number of native alluvial and reef prospects. At Dadiaso veinlets of quartz in Dixcove granite carry a little gold and the material shed from these reefs has been worked by the natives. Along the Bia river near Kojotinikrom and the Sui river upstream from the confluence with the Bia and also in the Tawya at Pokokrom there are extensive old alluvial gold workings.

The *Akasu Mine* is situated in the hills 9 m. west-north-west by air line from Benchema, which is 93 miles from Dunkwa by motor-road. The mine is at an elevation of about 1,200 ft. above sea-level. About 1914 Mr. Yates sunk two shafts and one adit at the site of the old native workings. After the war Mr. Barbour worked here for about one year. The rocks of the locality are Birrimian lavas and intrusives and the wall rock of the reef appears to be a banded, fine-grained, acidic lava or dyke. Two types of quartz were seen on the adit dump: (*a*) white quartz containing black tourmaline, (*b*) quartz containing hydrated manganese oxides. Dollied samples of the quartz gave poor to very fair results.

Ntubia River.—The mine is 1½ m. east-north-east of Antubia and 8¼ m. in a direct line south-south-west of the motor-road at Benchema. The ore-body was discovered about 1908 by the people of Antubia, while they were working the gravels in the Bensupata. It was actively worked for about one year by some two thousand people from various parts of Sefwi. During this period an open-cut, about 1,200 ft. long and in places 40–50 ft. deep, was excavated. About 1909, while work was in progress, Mr. Yates obtained a concession on behalf of Sefwi Goldfields, Ltd. This company worked for about four years and developed the reef over a length of about 1,700 ft. and to a depth of 100 ft. and traced it for a further 800 ft. along the strike. The country rocks of the reef are deeply weathered, but appear to be mainy fine-grained igneous rocks with thin bands of phyllite. A metasomatically altered (carbonated and pyritized) albite-rich dyke rock of intermediate composition is prominent on the dump near the main shaft. The auriferous quartz reef trends about N.40°E. (N.30°E. near the Bensupata

and N.50°E. at the south-west end of the workings) and dips N.W. at 50–70°. Where fully exposed at one place in the open-cut it is 3 ft. thick. The quartz contains pyrite, arsenopyrite, and limonite in addition to gold. Three samples collected from (*a*) the reef exposed at the south-west end of the open cut, (*b*) the reef exposed near the Bensupata 0·15 m. north-east of (*a*), and (*c*) quartz rubble and debris from alongside the stamp battery assayed, respectively, 6·8 dwt., 19·8 dwt., and 6·0 dwt. of gold per ton. According to a report of the company the lode was proved on the 100-ft. level for 1,068 ft. having an average value of 77s. per ton over a width of 18·3 in. During 1912 and 1913, 7,409 tons of ore were crushed by a two-stamp pilot battery and yielded 4,344 oz. of fine gold giving an average recovery of about 11·8 dwt. per ton. When the mine was closed down in September, 1913, it was 100 miles from the nearest railway or motor-road. In view of the results obtained and the great improvement in transport facilities it is surprising that no work has been done since 1913.

A memoir on the Presta goldfield is in course of preparation. The country may be divided broadly into two areas consisting of Birrimian rocks to the west and mainly Tarkwaian rocks to the east, the contact between them lying roughly some 100 ft. east of the main reef channel. This and other branching channels were traced over a length of 30 miles. Repeated movements have taken place along the main reef channel, which does not quite conform to the strike of the country rocks, giving rise to breccia reefs of considerable thickness where it crosses hard lavas and dykes. These rocks have suffered considerable metamorphism and now consist mainly of albite, carbonate, and sericite. Phyllites are spotted both with carbonates and sulphides. The gold is closely associated with pyrite, chalcopyrite, pyrrhotite, arsenopyrite, and in places blende. One of the best indicators of high values is a compact green vanadium-bearing mica, which apparently represents a brecciated and metasomatically altered volcanic rock. Although the reef channel can be and has been traced through the greater part of the goldfield, it should be remembered that it is not filled with quartz throughout the length of 30 miles. The ore-bodies are lenses, from say 100 or 200 to over 1,000 ft. in length, and from a few up to 30 ft. in thickness. Where known the pitch is towards the south-west and the dip 60° to 80° towards the north-west. The strength of the channel, which shows movements repeated over considerable geological time, the uniform metamorphism of the wall rocks, and the fact that the channel cuts across the strike of the country rocks at a small angle, show that this has long been a well-marked line of crustal weakness which persists to considerable depth.

The *Bilpraw* Mine, near the Jetwi Su, in the midst of the Nkwanta hills, was visited during the year, and the reef line traced for some distance southwards and a shorter distance to the north. The reef contains sulphides, and occurs in Birrimian rocks close to the contact with a mass of porphyritic biotite-granite of the Wa type. It does not make much of a showing at the surface, although there are a few hundred feet of native workings above the mine. Samples from an old adit by the mill yielded a fair tail of gold on dollying. Native women were seen washing the bouldery scree gravel of the Jetwi Su below the mine and obtaining some nuggety gold. The mine was worked between 1907 and 1919. During this period 3,593 oz. of fine gold valued at £15,262 were recovered. The average yield was about 7½ dwt. per ton of ore crushed.

Cape Three Points gold belt is a term that may be conveniently applied to the narrow strip of auriferous country extending from Cape Three Points north-east to the Sekondi-Kumasi Railway near Mansu, a distance of 32 miles. The average width of the belt is about six miles and throughout its length gold prospects are abundant. The geological features are relatively simple. Greenstones, mainly lavas, and, to a lesser extent, phyllites of Birrimian age have been intruded by Dixcove granite, porphyry, and various modifications thereof. Fairly detailed mapping indicates that there are two main areas of granite separated by a belt of greenstones. The more easterly one occupies a strip of country having an average width of about four miles extending northward along the western side of the Butre Su, from Dixcove to Essuaso. There is a marked difference between the topography of the granite and greenstone country. The granite outcrops over comparatively low-lying, undulating country while the greenstone forms ranges of steep-sided hills. The western granite area lies to the north of Princes Town and its approximate eastern boundary is marked by the Nyan and Duabon rivers. It extends westward to a line Domun-Dajwin-Bamiankaw. The majority of the auriferous reefs are found in the belt of Birrimian greenstones separating the two granite areas and all of them occur within the intrusive aureole. The paucity of reliable information concerning the various prospects and the fact that most of the workings are now inaccessible imposes a severe limit on any attempt at appraisement. A study of old concession papers, a few of which are still preserved by the Chiefs, indicates that European activities along this belt cover a wide period of time. For example the agreement relating to the Aporphine prospect, near Agona, dates back to 1878. Of the 30 European prospects visited not one ever reached the production stage. The presence of a winch, one or more boilers, and a small pilot battery appears to indicate the most advanced stage. At the most promising prospects the machinery was heavy, immobile, and quite unsuitable for preliminary development work.

West and south-west of Agona there is an interesting group of old concessions and prospects. These are all situated in the greenstone-granite contact zone. The most promising prospects in the gold belt were found in this locality.

Entramor Bepo (*Aporiphine*).—This old mine lies 3·3 miles north-west of Agona, alongside the Faraba stream, which is a tributary of the Wasa. Here there is an old native open-cut working, in which there are numerous loose fragments of quartz. When crushed these were found to be rich in gold and a subsequent assay gave 1 oz. 19 dwt. of gold per ton. There is an old shaft, but this is full of water and mud. Another old European shaft was seen a few yards to the north-west. It had completely fallen in. There is a small dump of blue-grey quartz alongside, but this was found to be barren of gold.

Ancheyin.—An old prospect was visited in the concession of this name. It lies 2·0 miles north-west of Agona. Here there is a shallow European shaft and several old native pits. Samples from a small dump of pyritic quartz were assayed and gave 11½ dwt. of gold per ton.

To the east of the Butre granite, between Domenasi

and Amantin Dada, there are a number of gold prospects and workings. In this locality three main types of quartz reef were noted, (*a*) white, shiny quartz forming narrow ridges, which is nearly always barren, (*b*) tourmaline-bearing quartz containing a little gold, (*c*) markedly auriferous quartz often blue-grey in colour and usually pyritic.

Amantin Mine.—On the crest of a ridge 0·50 mile north-west of Amantin Dada there are two vertical shafts. One of these, sunk in the bottom of a big native open-cut, is 160 ft. deep. These shafts were sunk by the Dainso Syndicate and work was suspended in 1910. The quartz from the dumps is highly pyritic and country rock is pyritic greenstone. A sample from the dump was assayed and gave 4·2 dwt. of gold per ton.

Whinnia Eastifie.—This is a large prospect and lies 2·40 miles north-north-west of Manso. There are six shafts, one adit, and one trench. The property was worked by the Ebenezer Gold Mining Company. The deepest shaft is 60 ft. Samples of the reef exposed in the trench gave very fair results. The adit, which is in good condition, is driven at the foot of the hill on which the shafts are situated. Graphitic phyllites are exposed dipping to the west at 64°. No reef was seen in the adit. There is a very little quartz in the shaft dumps and work appears to have been suspended because no reef was found at depth.

Guadiam.—This is another large prospect situated on a hill 2·4 miles south-west of Amantin Dada. It was also worked by the Ebenezer Gold Mining Company. In and around the workings there are a large number of native gold pits. There is a shaft and an adit. The former was full of water and the latter had collapsed so that neither could be inspected. Samples of the ore from the dumps were crushed and yielded very good gold results. Another sample of the ore was assayed and gave only 1·2 dwt. of gold per ton. The reef is exposed on the surface near the shaft. It is semi-dull, medium-grey quartz.

About 8 miles south-east of Siwum there is a strip of country extending north-east from Mape to Efiena (6½ miles north-north-west of Asankrangwa) in which there are a number of gold prospects. The country rocks consist mainly of Birrimian phyllites striking north-east–south-west and in places markedly graphitic. There are also small intrusions of Dixcove granite.

FLOTATION OF GOLD ASSOCIATED WITH SULPHIDES

A description of the new flotation plant of the Hoge Development Company, situated near Nevada City, in California, is given by F. G. Moses in the *Engineering and Mining Journal* for October. The author says that the plant is of interest because it is small, modern, and efficient and treats a type of gold ore ignored in the past because it could not be economically dealt with.

During the last few years the Hoge company has been developing a new property under the direction of Otto E. Schiffner. Early in 1932 sufficient ore had been developed to justify erecting a small reduction plant. Experimental tests, made to determine the best method of treating the ore, showed that it responded most satisfactorily to flotation. A 50-ton flotation plant was accordingly built. At the Hoge mine the ores occur in veins partly filled with quartz and embedded in granodiorite. The only metal found in commercial quantities is gold, principally as native gold closely associated with and finely disseminated through the base-metal sulphides, which are iron, lead, and zinc, with pyrite predominating. It has been estimated that between 50 and 60% of the values could be recovered on amalgamation plates. Recently gold tellurides have been identified.

The Hoge mill is the first in the Nevada City-Grass Valley districts of California in which established practices were ignored and an all-flotation plant of modern design was built. The flow-sheet is simple. From the storage pocket on the headframe the ore is fed over a steel grizzly with 1½-in. openings to a 16 by 24-in. Blake crusher. Undersize from the grizzly and the crusher product are carried by a 16-in. belt conveyor to a 75-ton fine-ore bin. From here the material is fed by a 22-in. travelling belt feeder to a set of 10 by 30-in. Allis-Chalmers rolls, the product of the latter passing over a 12-in. conveyor to the mill feed box. Fine grinding is done in a 6 by 3½-ft. Marcy ball-mill operating in closed circuit with a 56-in. Model C duplex Dorr classifier. Sands are returned to the ball-mill and the classifier overflow goes direct to the flotation department. Here the equipment consists of a six-cell Kraut rougher and a two-cell Kraut cleaner machine. Tailing from the former goes to waste after passing over a Deister Plat-O concentrating table operated as a pilot to give a visual check on flotation operations. The overflow from the first four cells of the rougher machine flows by gravity to the cleaner machine. Cleaner concentrates are pumped by a Frenier pump to a 16-ft. Vandercook thickener, whence they pass to a 3 by 2-ft. Oliver filter, the filter cake being stored in a 20-ton storage bin prior to shipment by truck to the Selby smelter. The overflow of the last two cells of the rougher and tailing from the cleaner machine are returned by a Frenier pump to the classifier for re-treatment.

The rolls installed in the Hoge mill are probably the first used in northern California gold-mining districts and justify more attention than would otherwise be given them. For many years intermediate crushing of ores by gravity stamps has been standard practice in this district. This equipment is ideal for ores that carry their principal values as free gold requiring amalgamation. The ores now being developed, however, carry only a minor part of the values in a form that can either be amalgamated or freed at a size at which stamps can be operated efficiently. On ores on which intermediate crushing can be made a step in the recovery of coarse gold, stamps may have a decided value, but where this is not so, stamps can well be replaced by other crushing equipment. The rolls at the Hoge mill reduce the 2-in. crusher product to ½-in. ball-mill feed. Results attained after a year's operation are gratifying. Chief among the advantages offered is the lower initial cost of equipment. Other important items are: Ability to handle the various types of ore mined, including those that are received wet and contaminated with soft mud and gouge; and material reduction in maintenance, power, and labour costs.

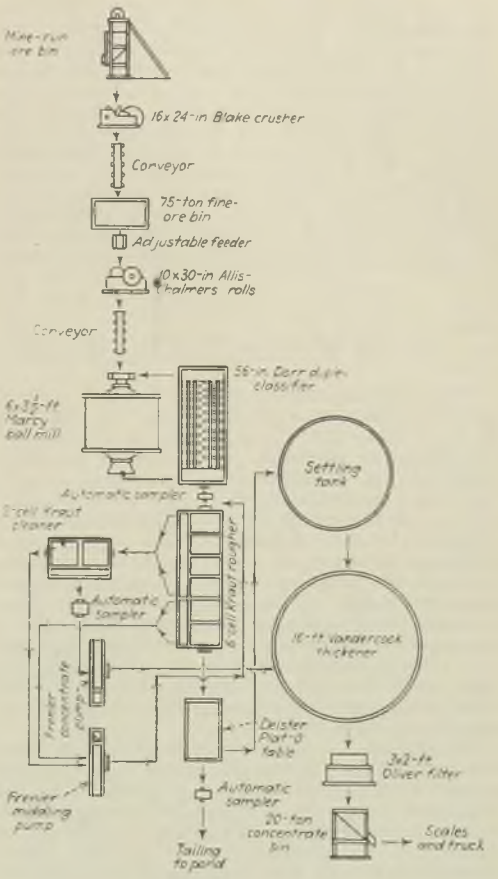
First tests made on Hoge ore indicated that very

fine grinding was necessary to obtain high recoveries by flotation. Data obtained by daily operation have continued to prove this fact. For this reason efficient operation of the grinding and classifier equipment is of utmost importance. The ball-mill used is a conventional grate-discharge type mill, the grates having ¼-in. openings. Feed to the mill varies from ½ in. to ¾ in., depending on the roll shells. Maximum ball load is about 8,000 lb. of steel balls. Both 3-in. and 4-in. balls have been used in the mill. The large balls were found to give better results both in tonnage and ball consumption. When the plant was first operated at a capacity of 50 tons a day, it was found that a finished product of a screen analysis of 3% on 80 mesh, 88% minus 200 mesh, and 70% minus 200 mesh would make possible an extraction of 95%. Mill capacity has been increased recently from 50 tons to 85 tons without decrease in extraction or change in screen analysis. This has been accomplished by increasing the speed of the classifier from 18 to 22 r.p.m. and the speed of the ball-mill from 24 to 28 r.p.m.

The gangue is a mixture of granodiorite and quartz. Felspar, clay, talc, and other altered gangue materials are also present in varying amounts. Sulphide content is about 5%. Small quantities of oxidized ore are found in certain stopes near the surface. The mill is run as a sulphide recovery plant because visual operation based on gold values is almost impossible, whereas the sulphide recovery process is based on the action of the sulphide content of the ore in the cells. Conditions favourable for recovering iron and lead sulphides are found also to give the best metallurgical results in terms of gold recovery and grade.

Respecting reagents, practice is simple. Reagents used are Pentasol xanthate, Minerec B, sodium sulphate, and pine oil. Xanthate is the principal promoter, as its action is so positive that all gold-bearing constituents of the ore are floated under rather widely varying pulp conditions. It is added at the head of the rougher machine at the rate of 0·02 lb. per ton of ore milled. A 1% solution of sodium sulphate is fed to the ball-mill and the rougher cells. Sulphate is added to the ball-mill to prevent oxidation of the iron sulphides during grinding and classifying. Addition of this reagent to the rougher cells steadies their operation. Pyrite flotation is very susceptible to slight variations in acidity or alkalinity of the pulp, the latter condition causing the iron pyrite to be depressed. The ore from the different levels in the mine varies, and it is believed that addition of sodium sulphate to the cells acts, as a buffer solution, to prevent wide variation in *pH* readings.

At first the variation in the amount of primary slime in the different ores treated was a source of tailing loss. The primary slime will carry such values that if a proportionate amount of them are not recovered, the tailings will contain an unsatisfactorily high percentage of valuable material. The time necessary for floating this fine mineral has been found to be much greater than for the recovery of the coarser sizes in the pulp. Likewise, the time required to prepare fine mineral for flotation is much longer than for the coarse values. Two methods can be used to obtain the necessary time for preparing the slime mineral: (1) Use of conditioning tanks; (2) addition of the promoter as far back in the circuit as possible. Conditioning tanks are less satisfactory when treating ores containing small or varying amounts of slime. In



FLOW-SHEET OF THE HOGE MILL.

the mill the second method was adopted—that is, the promoter is fed to the ball-mill. However, the xanthate was found to decompose in the mill, causing variation in cell operation. This difficulty has been overcome by adding to the ball-mill a small amount of a promoter stable enough to resist decomposition in the mill. Satisfactory results were obtained with Minerec B. It is an insoluble, very stable liquid of efficient flotation power and one that does not interfere with the xanthate and sodium sulphate added later in the circuit. Use of this reagent has steadied flotation operations and, on high slime ores, has reduced tailing values about 10 c. per tons. Consumption is 0·005 lb. per ton of ore milled. The fourth reagent, pine oil, is used as a frother and is added at the head of the rougher circuit. Consumption varies according to the type and grade of ore treated each day. During the nine months that the mill has been in operation the results attained have been most satisfactory.

The cleaner overflow, or final concentrate, is pumped by a Frenier pump to a 16-ft. Vandercook thickener. The thickened material flows by gravity to a 3 by 2-ft. Oliver filter and the thickener overflow to a small 6-ft. settling tank. Filter cake is stored in a 20-ton storage bin. A 1-ton bucket, operated by a chain block attached to an overhead

rail, is available to facilitate weighing and dumping the concentrates into 10-ton trucks. Overflow from the settling tank joins the rougher tailings at the head of the Deister table and a small flow taken from the bottom of the tank goes to the concentrate pump, whence it is returned to the thickener. No losses have been detected in the settling and filtering circuit. Automatic water-box samplers installed at strategic points sample periodically the flotation feed and tails and the concentrate produced by the cleaner machine. A tonnage sample is taken every hour by a manually-operated deflector from the conveyor carrying the mill feed during one revolution of the belt and weighted. The weight of each sample as well as any shutdown are recorded on a shift report to facilitate calculation of the number of tons treated per hour and per shift. This is done by multiplying the sample weights by a known factor.

The mill is operated in three 8-hour shifts with one man to a shift. A utility man who performs minor repairs and operates the crusher intermittently is employed during the day shift. During the night shift the latter duty is taken over by the waste trammer. The assay office is operated in the interest of both mine and mill with half of the charges being paid by the mill.

EDGE-WATER ENCROACHMENT IN CALIFORNIAN OILFIELDS

The characteristics of edge-water encroachment in Californian oilfields are set out by V. H. Wilhelm, E. L. Davis, and W. A. Clark in *Mining and Metallurgy* for October. The authors say that mathematical formulas for the analysis of the behaviour of producing oil-wells can be devised which will be correct for the assumed conditions. However, in an oil-zone variables always exist which are unknown, or to which it is impracticable to assign mathematical values. It seems apparent that one should reason back from observed facts to an analysis of causes rather than start with a hypothetical reservoir with assumed properties and attempt to explain observed phenomena. In this paper the authors hope to throw additional light on factors influencing production, especially edge-water behaviour.

Oil and gas are contained in reservoirs of either the sealed type or the edge-water type. In the former all the recoverable oil is produced by gas expansion only. In this type of reservoir, edge-water is not effective. This may be because of faulting or overlapping strata or, more often, probably, the edge-water pressure is ineffective on account of resistance or lack of head. According to Herold, production ceases and edge-water is held in place when the capillary resistance (Jamin effect) overcomes the power of the gas to expand further. This type of production is referred to by Herold as "capillary control." Versluys refers to production during the gas expansion period as the "depletion stage." He infers that capillary resistance does not retard the advance of edge-water, but that edge-water is retarded by lack of permeability, due to cementation and also to crushing, because of compaction of the water-bearing sands subsequent to the deposition of the oil and gas.

In the open type of reservoir, edge-water is present and is the main factor in driving the gas-saturated oil up structure. Herold refers to this phase as "volumetric control." He believes that edge-water pressure is the fundamental factor in moving oil to the well in this type of control. In the preliminary stage of production the gas released from solution by the lowering of pressure moves the oil, the edge-water closing in behind and forcing the establishment of a new pressure gradient. Versluys recognizes the movement of the oil around the bore-hole by the breaking out of the occluded gas "depletion." He believes, however, that this occurs outward from the well to only a certain point, up to which the advancing edge-water moves the oil in which no gas had broken out. However, edge-water cannot move until pressure at the oil-water contact is reduced. This reduction of pressure undoubtedly means that some gas will be set free and tend to move the oil to the well even from a remote point.

Herold suggests a third control, known as "hydraulic control." This action is similar to that of a water tank delivering water with a head maintained at a constant level. Theoretically, the edge-water moves the oil forward at a constant rate. The volume of fluid and the head is maintained constant by the feeding of the edge-water sand at the outcrop or in some other place.

The usual virgin oil reservoir consists of a sand or series of sands and shales, usually the latter. The shale- and sand-bodies may or may not be continuous throughout the reservoir. The sands especially tend to be lenticular and in California show a considerable variation in fineness, degree of sorting, and continuity. The oil in the reservoir is commonly saturated with gas at the existing pressure. There may or may not be a "gas bubble" at the top of the structure. According to Lacey, such a gas bubble is due to the presence of exceedingly high pressures and temperatures. The pressure is uniform at any given depth throughout and is dependent on and equal to the pressure head of the edge-water in contact with the oil. The position of the edge-water line roughly parallels structure-contour lines, but tends to be somewhat lower on the plunge of structures.

(1) *Gas-Expansion Period.*—In a virgin reservoir the first oil and gas produced by a well should be in approximately the ratio in which they exist in the sand at that location. Reduction of pressure immediately causes gas to come out of solution near the hole, bringing with it some of the oil nearer the well. The expansion of gas has no immediate effect on the pressure at the edge-water line. With an increase in the radius of reduced pressure the well draws gas from a greater area and, due to bypassing the oil in the sand, shows an increasing gas-oil ratio. Normally in the newer California oilfields the gas-oil ratio increases for about a six months' period and then declines rapidly. The Ventura Avenue and Kettleman Hills fields, with some slight exceptions, show a constantly increasing gas-oil ratio for all wells. Both of these fields have a thick producing horizon, capped by a gas bubble. Edge-water encroachment has been slow.

(2) *Combination Period.*—When the pressure differential reaches the productive limits of a field the edge-water begins to move towards the well. The oil and gas may move more rapidly than the water

follows. In other words, the rate of withdrawal may be much more rapid than the advance of edge-water. This condition naturally causes considerable depletion in the centre of the field. Edge-wells under this condition have higher fluid levels and greater production than wells up structure. In 1923, after the intensive development of the Meyer zone in Santa Fe Springs, fluid levels were so low in the higher portion of the structure that it was impossible to pump wells after they ceased flowing. A year later, after edge-water had moved in, fluid levels were considerably higher and wells became profitable pumpers. In the Alamitos Heights field, where town-lot drilling obtained, fluid levels were low after wells stopped flowing, but a year later, due to encroachment of edge-water combined with a low production rate, fluid levels in some instances had risen about 1,000 ft. Theoretically, in a field of this type, withdrawal of oil and gas should be at a rate not greater than the advance of edge-water, but due to the great lag in the advance of edge-water this is not always feasible in economical operation. After edge-water begins to move in a field, the volume of the underground oil reservoir is contracted and a modified pressure gradient is established. Gas is an agent in the migration of oil as long as it is produced. Even in the latter part of this period, often called the settled production period, some oil is saturated at any pressure. A reduction of this pressure will cause gas to come out of solution and move toward the well.

(3) *Water-Drive Period.*—As the gas is exhausted, the pressure of edge-water moves the oil as the water seeks its head, owing to pressure from outcrop or some other source. It is believed that this period actually begins, or the combination period ends, for any given well on any contour of a structure, just before the wells show a considerable increase in the amount of water produced. It is often marked by a sudden increase in oil production. In other words, there is a short period of flush production caused by the large volume of oil floating on the edge-water suddenly entering the vicinity of the well. This body of oil is practically gas free and should be of greater volume than normally held in the formation. It consists of the final clean-up of any oil left adhering to the sand grains, swept ahead in a broad front by the incoming water. This phenomenon occurs in many fields. H. H. Wright has pointed out several fields in Texas in which a large increase of production was noted just prior to, or at the time, water entered the well. It is almost typical in the area near Fellows in the Midway field, as seen on old curves maintained since 1905. The water-drive period is a phase of the settled production period, which consists of that time during which the withdrawal volume is roughly equal to the encroachment volume of the edge-water. The Elwood field shows an effective water-drive maintaining formation pressure by following nearly as fast as oil is removed. This condition is resulting in a high theoretical recovery of oil per acre-foot, the largest in California. Wells in the north end of the Inglewood field show some seasonal increase of water from rainfall at the outcrop of producing sands in the Santa Monica hills.

Lompoc field, in the Santa Maria district, shows the true characteristics of an edge-water drive, the rate of fluid produced by the wells (oil and water) being a constant during the producing life of the well. The Kern River field shows conditions that indicate that migration of oil is due mainly to pressure of edge-water. The Mount Poso field lies in a horizontal water table, which causes a constant fluid production with some lag. The Kern River field, where the outcrop of the oil-sands is crossed by the river bed of the Kern River, shows seasonal effects of a water drive with considerable lag. Seasonal rains fill the river bed during the winter months but little rain falls after March. The wells show an increased fluid production during the fall.

(4) *Gravity Drive.*—Gravity is the main factor in the migration of oil in many fields in California. This stage often occurs in the later life of a field and results from several causes. The head of edge-water is sometimes reduced on account of the production of water by a large number of edge-wells. Such an effect is obtained in fields in an arid region, as in the west side of the San Joaquin Valley, California. This condition may be accentuated by the deposition of a chemically insoluble material due to release of carbon dioxide or to the chemical reaction between oil and salt water. Usually, during this stage, a marked difference naturally exists in head and volume between the encroached edge-water and the undisturbed or unproduced bottom waters, even though they had originally the same source and identical external head. Whenever, under producing conditions, the fluid head of the well is reduced to a point below the top of the sand, final gas expansion becomes operative. In the west San Joaquin Valley fields and in many Los Angeles Basin fields there is no possibility of the maintenance of an adequate edge-water head equal to that existing under the original conditions.

The east front area of the Buena Vista hills is itself a good example of gravity migration of oil. In this area the edge-water has remained stationary for years. Wells up structure become successively depleted by gravity migration of oil down structure towards the edge-water line. The line of depletion is rapidly approaching the edge-water line, so that now the only production obtained is from a narrow row of wells bordering this line. The Wheeler Ridge field shows some effect of lack of edge-water pressure, in that wells on top of the structure are rapidly becoming unprofitable. The Coalinga field in likewise an example of a gravity-drive field : Edge-waters have not moved appreciably since 1921, due to the fact that the head of the edge-water has been reduced to a static level by the withdrawal of large amounts of water by edge-wells ; also lack of rainfall along the outcrop precludes replacement of edge-water. In this field, during past shut-in periods, there was a readjustment of the edge-water line, which tended to become straight, so that many wells which previously produced water became oil wells, and vice versa.

In the Los Angeles Basin, the Montebello, East Coyote, Brea Olinda, and Richfield oilfields are mainly of the gravity-drive type. Between the East Coyote and Brea Olinda fields, the edge-water basin has a varying fluid level of 50 ft. between summer and winter. Otherwise the edge-water line is stationary.

Some fields, or zones in fields, in which migration of oil is mainly actuated by pressure of edge-water, tend to exhaust the entire head of water. For many years a large volume of water was produced with the oil in the McKittrick field, but in late years the water has almost disappeared and the wells produce by gravity migration. However, after shutting down a large portion of the field, the water began

increasing after a wet season. This field is probably fed continually from a small nearby catchment basin. A few wells on top of the structure in the Long Beach field, after producing large quantities of water for years, have recently had adnormal decreases in water content.

Exhaustion of the head of saline or connate waters, where not adequately replaced by fresh water, is as natural as the lowering of the head of the fresh-water strata in the Los Angeles Basin.

In eastern fields of the sealed type, artificial water drive has demonstrated its ability to produce oil after apparent exhaustion by natural or artificial gas drive, but in California the highest oil recovery for a given volume of oil-sand occurs where an effective and persistent edge-water drive is present. It is likely that, when California fields of arrested water drive are apparently exhausted under gravity drive, considerably more oil may be produced by allowing edge-water to advance uniformly. This may be done by replacing all produced water in wells outside the edge-water line. A carefully controlled water drive from the beginning of production will prevent "trapping" of oil in less permeable strata and increase ultimate recovery.

Conclusion.—The importance of an adequate and controlled edge-water drive is becoming most apparent and is beginning to receive attention. The authors have attempted to point out and correlate some of the better known facts.

A PORTABLE PLACER MILL

In Information Circular No. 2 of the Mines Information Bureau connected with the Washington School of Mines G. E. Ingersoll describes the W.S.C. placer mill. This mill was built with the idea of producing a portable plant at low cost that could be constructed by the placer miner. It was designed by A. E. Drucker to extract fine flake and flour gold from river gravels. The principle of the machine is simple. The feed is screened to pass 14 mesh before it reaches the table. By so doing only enough water need be used to carry away this fine material. The gold is caught on corrugated rubber and sponge rubber sheets on a vibrating table. It is believed that the vibration will keep the black sand in suspension and allow the fine gold to settle and be held by the rubber riffles. The slope of the table and the amount of water used can be varied to get the best results.

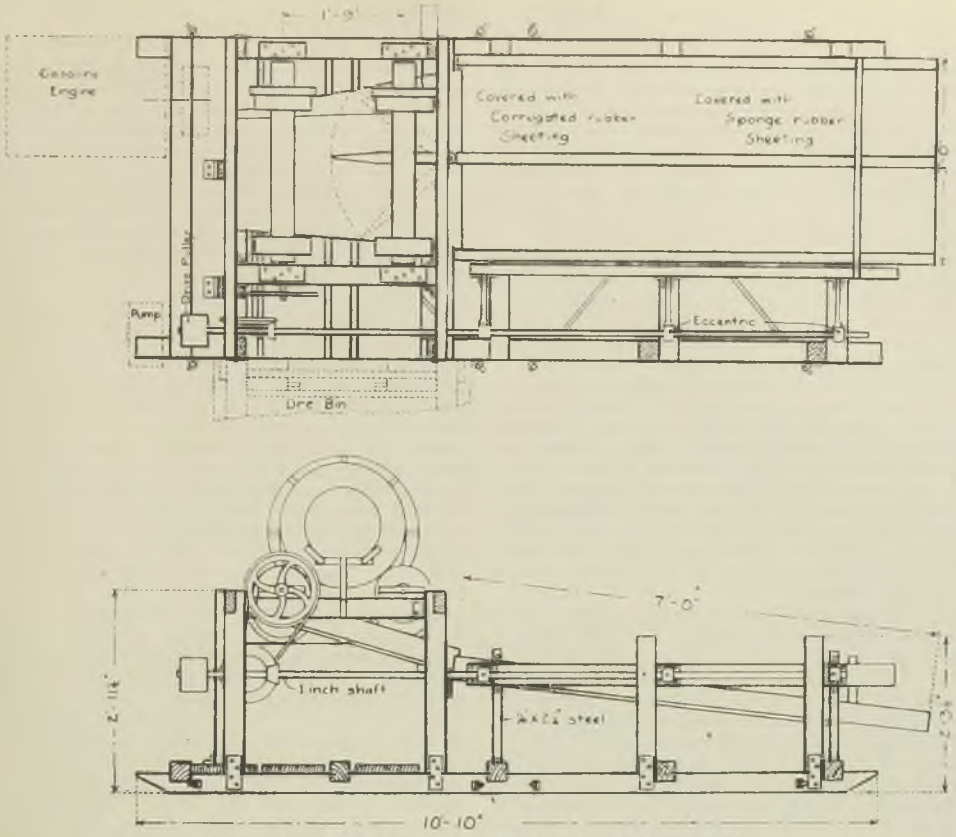
The mill consists of an ore bin, a concentration machine with a trommel and a clean-up amalgamating barrel, a centrifugal pump, and a petrol engine. In the discussion to follow when the term "machine" is used, it refers to the concentrating machine alone, which is shown in the accompanying sketch. The base is made up of two 4 by 4-in. stringers joined by cross-pieces of the same material and held together by four tie rods. Upright posts, bolted to the base, support the drive-shaft and form a base for the trommel. The table is supported by four pieces of flat, rolled steel of $\frac{1}{4}$ by $2\frac{1}{4}$-in. section. This allows the table to vibrate.

The trommel was made of a steel oil drum and a galvanized-iron wash-tub. Part of the drum is punched with $\frac{1}{2}$-in. holes and outside of this is 14 mesh wire screen bound on to handle-like steel fasteners which gives the wire screen 2-in. clearance outside of the drum. Small lengths of angle iron are bolted inside of the upper part of the drum to break up the gravel and disintegrate the clay. The wash tub, with the bottom cut out, is bolted on to the lower part of the drum for the discharge end of the trommel. The trommel has a slope of a little less than one inch per foot. It rests upon trunnions. These trunnions were made by rolling on and nailing belting on 4-in. wooden rollers and building them up to the desired diameter. The lower trunnions are built up higher on the lower side to form a flange to prevent the trommel from sliding. Power is transmitted to the trommel by means of a chain drive to one of the rollers from a jack shaft. This jack shaft is driven from the line shaft by bevel gears.

The clean-up amalgamating barrel is merely a 50-gallon oil drum which has been scoured out with lye to remove all traces of oil. If oil were left in the drum the mercury would not amalgamate the gold. When in use, it is placed upon the trunnions where the trommel sits. The opening in the drum is large enough to introduce the black sands and pebbles. The use of the clean-up barrel is described later.

Water is brought to the machine by a 1-in. centrifugal pump and carried by a pipe into the trommel, where it is perforated with small holes. Small streams of water spray the inside of the trommel and aid the screening and fall with the fine material to the sloping slide or distributor head and from there on to the shaking table. Water is also delivered to the sloping slide to carry away the screen oversize. This sloping slide has an adjustable gate which is pivoted on the lower end and can be swung to either side to divert the feed to the other side or left in the centre and allow the feed to go to both sides of the table. The slide is covered with galvanized iron.

The shaking table is 7 ft. long by 3 ft. wide with a strip dividing it in the centre so that it is really a double table. As stated above, the feed can be diverted from one side to make a clean-up or to make adjustments. The table is covered with rubber riffles. The upper parts of the table are covered with corrugated rubber sheeting of two kinds and the lower parts with sponge rubber sheeting. One kind of corrugated rubber sheeting used is similar to that used on the running-boards of automobiles. The rubber riffles extend down 6 ft. from the top of the table and the remaining foot of the table has a strip of corrugated iron at the bottom with the corrugations parallel to the end of the table. Mercury can be placed in the corrugations to catch any gold that might get by the riffles. As stated previously, the table is supported by four uprights of flat-rolled steel of $\frac{1}{4}$ by $2\frac{1}{4}$-in. section. The slope of the table can be adjusted by means of different holes in the uprights at the lower end of the table. By this means the lower part can be lowered or raised to get the desired slope. The vibrating motion of the table is accomplished by means of three eccentrics on the line shaft, which are $\frac{1}{8}$ in. off centre, which gives $\frac{1}{4}$-in. movement. Three connecting-rods transmit this movement to a horizontal timber which in turn transmits the movement to the table. The upper part of the table is connected directly



PLAN AND ELEVATION OF THE W.S.C. PLACER MILL.

to the horizontal timber but the lower end is connected to it by a 2 by 4 in., which extends from the horizontal timber to the opposite side of the table. With the present hook-up the table vibrates 400 times per minute. This vibration period can be varied by changing the size of the drive pulley on the line shaft.

It was thought advisable to use wheelbarrows to transport the gravel to the placer mill. A tugger hoist and scraper could be used if desired. An ore-bin, or gravel hopper, was built to receive this material and feed it to the machine. The framework of the ore-bin was made of 4 by 4-in. timber. It has a sloping bottom and an automatic feeding device. Under the chute lip of the bin is a feeder which extends into the trommel and is held up by a support on the machine. Under this feeder is a shaft driven by a belt from the line shaft of the machine. The feeder shaft has a cam on each side of the feeder which is in contact with steel projections on the feeder. The cams push the feeder ahead and springs pull it back. This combination shakes the feeder and causes the gravel to be fed uniformly into the trommel. Two large wire screens have been made which fit over the top of the bin. One of these has openings $1\frac{1}{3}$ in. square and the other has openings $\frac{5}{7}$ in. square. A wheelbarrow load can be dumped into these screens and the coarse material which will not go through them can be thrown out.

Power for the mill is furnished by a $1\frac{1}{2}$-h.p. petrol engine. This is connected by a belt to a pulley on the line shaft of the machine. Another belt drives the centrifugal pump.

It is possible to clean up one-half of the table while the other is in operation. To do this, the gate on the sloping side is swung to cover the side to be cleaned up. Clear water is run over the riffles while vibrating to remove the surplus material which has settled over the riffles. Some black sand will probably be found with the gold in the riffles. The rubber sheeting is then removed from the half of the table being cleaned and washed out in a tub of water. When enough of this concentrate accumulates in the tub it is put in the clean-up amalgamating barrel with some pebbles to scour off the oxide film of the rusty gold, if present. If there is any grease in the concentrate some lye should be added to cut it. Mercury is then added to the barrel and the opening is then closed tightly with the plug and the barrel is set on the trunnions in place of the trommel and the barrel revolved slowly until the gold has become amalgamated. If the barrel is made to revolve at too great a speed the mercury will be broken into very small globules or "floured", and it will be very difficult to separate it from the black sand. The plug is then taken out and the contents dumped into a tub and the amalgam is panned out of the black sand or is run through a special amalgamating trap. The amalgam is then cleaned and retorted.

AMALGAMATION

A few notes by G. Halcombe on amalgamation appear in the *Chemical Engineering and Mining Review* of Melbourne for September 5. The author says that the process for the recovery of gold by amalgamation with mercury is generally assumed to be a very simple one and to present very few problems. There are, however, a number of points which present themselves in the actual operation of the process and which are worthy of examination and discussion.

Type of Plate.—The first point which should be considered is the selection of the copper plates for the splash doors and lips of the mortar boxes and for the tables. Unfortunately silver-plated copper plate, which is undoubtedly the best and the easiest to keep clean and bright, is not always available, since it frequently happens that the silver-plating plants in the neighbourhood are not equipped to handle the large sizes that are best suited for the modern mortar box. Failing the silver-plated article, there remains three alternatives—the hard copper plate, the soft copper plate, and the Muntz metal plate. Copper plates vary considerably and even if sold as annealed should always be annealed afresh before being surfaced. This is important if it is desired to avoid stained and patchy surfaces.

Many operators deliberately choose a soft copper, but the writer's preference is for the hardest copper obtainable, and he has observed better results from a good homogenous Muntz metal than from any class of copper plate. Muntz metal plates, when properly surfaced, keep bright longer and stain less readily than copper plates. When worked side by side it has been found that the Muntz metal plates have given far less trouble. In the same mill and treating the same class of ore a set of soft copper plates, although surfaced with the greatest care, could not be prevented from staining although swabbed at very frequent intervals, took many weeks to acquire a proper surface, and no doubt were responsible for undue losses. Regarding thickness, the absolute necessity for a dead flat surface renders the choice of any thickness less than $\frac{1}{8}$ in. unwise.

Preparation of Plates.—The method of preparation of the plates—*viz.*, annealing, scouring, and amalgamation—is well known. Experience has proved that repeated applications of mercury to the plate surface will repay the extra trouble involved. A good plan is anneal, scour, and amalgamate the surface of the plate and then immerse it in running water over night, repeating the process every night for a week or ten days. To ensure a good "body" to the amalgamated surface the mercury is best applied in the form of sodium amalgam. This amalgam is highly deliquescent and rapidly disintegrates in the presence of moisture, the action of cleansing the surface and depositing the mercury being simultaneous.

Staining.—In cases where staining of the plates happens, no matter what care is exercised, sodium amalgam is invaluable. Its preparation is simple, the correct proportions being 97 parts of mercury to three parts of metallic sodium by weight, and the temperature about 180° F. An old retort, with the outlet pipe removed so that the sodium can be dropped through the hole, makes a suitable vessel if a stout wire handle is affixed. When all the sodium has been absorbed the retort should be moved from the fire and the contents poured into a flat dish, when the amalgam will set in a thin sheet on cooling. The amalgam should then be ground and placed in a wide-mouthed glass jar, fitted with a tightly-fitting stopper. Staining will never be troublesome on the splash or lip plates on account of the cleansing action of the scouring pulp; the lower ends of the tables are usually the seat of the trouble. On account of their position they acquire the necessary gold coating far more slowly than the other plates in more favourable positions, unless they are dressed with gold amalgam, which should only be necessary in extremely obstinate cases and as a last resource.

Neutralization.—If it is desired to neutralize an acid pulp it is not always advisable to add lime, although this may be procurable very cheaply. In cases where the flowsheet includes a flotation unit for the recovery of a pyritic concentrate, the use of lime is precluded as it is a depressant for pyrite. Where lime is added it can very conveniently be added to the "heads" at the automatic feeders by some simple mechanical device. Ground lime being used, where the "Challenge" type of feeder is employed it can generally be worked by an attachment to the feeder arm and with the "Ross" type of feeder by belt drive from a suitable position.

Addition of Cyanide.—The addition of a cyanide solution to the mortar boxes, in cases where the cyanide process is not employed, is a much debated question. In cases where it is the practice to add mercury to the mortar box it has been found that the use of a 0·5% cyanide solution, added at the rate of, say, ten drops a minute to the mortar box, has had a marked effect in retarding the staining of the plates. The plates do not require dressing so frequently when cyanide is used. The conclusion arrived at by the writer is that the action of the cyanide in promoting efficient amalgamation is a benefit which outweighs any possible loss of gold in solution.

Treatment of Graphitic Ore.—When crushing ore containing free gold and about 2% of arsenical pyrite certain interesting phenomena have been observed. The ore alluded to consists of a mixture of quartz and graphitic schist, the quartz carrying the free gold and the schist containing the bulk of the pyrite. Owing to the sliming of the pulp considerable dilution was necessary, as much as nine to one, liquid to solid being used at times. Without the addition of any reagent, a certain amount of natural froth flotation occurred. This took the form of a dense black froth which was first noticed collecting behind the baffle boards in the mercury wells. Subsequently this froth was trapped and collected and found to contain mercury in a very fine state of division. It was possible to amalgamate a copper plate with the froth after plenty of hard rubbing. When the froth was dried and assayed the value was found to be very high. It was not actually determined whether the values were present in the form of finely divided amalgam or in the auriferous pyrite which had been naturally floated, the latter being suspected. The occurrence of this froth was not constant and it only made its appearance when the heads were particularly schisty, so that apparently it was formed primarily by the graphite in the schist. The froth was a deep black and had a greasy metallic appearance and as it floated down the launders in the form of a scum it was easily trapped and saved.

UNDERGROUND PIPE-LINE PROTECTION

For many years the United States Bureau of Standards has been conducting an investigation of the relation of soils to corrosion and some tentative conclusions as to the nature and mechanism of underground corrosion are presented by K. H. Logan in *Chemical and Metallurgical Engineering* for October. The author states that corrosion is probably always an electro-chemical phenomenon and that, as differences in local conditions along the pipe surface appear to be the primary cause of corrosion, it seems probable that a coating which serves only to maintain uniform conditions with respect to the pipe surface might be satisfactory. Thus the coating might absorb moisture and permit the diffusion of oxygen, provided the absorption or diffusion were uniform. The rate at which either oxygen or moisture penetrates a coating, however, depends upon the supply just outside the coating. For this reason the specified uniform condition is likely to be obtained only where the soil is constantly wet. Nevertheless, it seems probable that a uniform continuous coating would reduce the potentials which cause corrosion and thus decrease the number of deep, isolated pits. Obviously without a continuous coating uniform conditions at the pipe surface cannot be maintained.

If in addition to reducing potentials the galvanic currents can be further reduced by increasing the resistance of the path over which they flow, a further reduction of corrosion may be effected. Bituminous coatings furnish this increased resistance to a very considerable degree.

A quite different method of preventing corrosion is to maintain the pipe cathodic with respect to the adjacent ground. This may be accomplished in several ways.

All of the principles mentioned above have been applied to a greater or less extent in the construction of protective coatings. One way to reduce corrosion is to use a metal, the natural corrosion products of which inhibit further attack. Outstanding examples of such metals are copper-bearing steel, which resists atmospheric corrosion, and the so-called stainless steels, which also resist some other forms of corrosion. Copper-bearing steel, however, does not appear superior when buried in soil, perhaps on account of the limited supply of oxygen. Stainless steel has not been seriously considered for underground pipes, except under unusual conditions, on account of its relatively high cost. Its behaviour in soils in which the oxygen supply is limited has not been fully determined. The United States Bureau of Standards has removed a number of specimens of iron containing above 26% chromium from different soils. For all of these the rate of penetration of the metal exposed to the soil was low.

Data collected by the Bureau on depths of pits for different periods indicate that in most soils the rate of pitting is greatest for the first year or two after the pipe is buried. This can be partly accounted for by the loose condition of the earth in the trench during the early period, a condition favourable to the downward movement of oxygen and water. In a large proportion of the soils under observation the curve for the penetration-time continues downward throughout the test. This may be accounted for by a film of corrosion products on the pipe surface, or in the adjacent soil, which tends to retard further corrosion.

In a number of localities where the soils are of limestone origin, a whitish deposit, probably calcium carbonate, has been observed on the pipes; where this deposit was observed the corrosion was negligible. This phenomenon might possibly be utilized to a greater extent by proper treatment of the soil. Increasing the self-protecting properties of a pipe-line appears to be a field for profitable research.

Specimens buried by the United States Bureau include coatings of lead, zinc, and aluminium. Unfortunately the number of specimens of the last-named coating is very small. The relative merits of zinc and lead differ in different soils, but, on the average, the galvanized pipe appears to be superior to the lead-coated pipe. At the end of eight years the galvanized specimens in most soils retained a large percentage of the original 2-oz. coating of zinc, although many of the specimens showed rust spots or pitting. The progress of the test is not yet sufficient to indicate the effect of the base metal, the relative merits of the pure zinc and the zinc-iron alloy layer, or the extent of the cathodic protection afforded by the zinc. The effectiveness of the coating depends on soil conditions. In neutral and nearly neutral soils a 2-oz. coating should not show signs of failing for at least eight years and the protection afforded would probably extend over a considerably longer period. In highly acid or alkali soils definite pitting of the base metal may be expected to begin within six years. Whether the zinc affords any cathodic protection after pitting begins and thereby decreases the normal rate of penetration cannot be determined from the data now available. On the average the lead-coated specimens showed considerably higher rates of loss of weight and of penetration than the galvanized specimens in the same soils. Although lead applied by a different process may possibly afford greater protection, the fact that specimens of sheet lead show appreciable losses of weight and in some cases considerable pitting makes it doubtful if lead is more satisfactory than zinc as a protection for buried metal.

Comparison of the rates of corrosion of the two kinds of metal-coated specimens with those of uncoated specimens shows that both coatings reduced the corrosion during the period of the test, but did not protect the bare metal completely under many soil conditions.

A test of a few specimens of wet and dry calorized pipe gives rates of loss of weight and of penetration of the same order of magnitude as found for lead-coated pipe.

Of the two types of inorganic non-metallic coatings now seriously advocated for pipe-line protection, only cement mortar has had extensive use and this use has been confined to applications so thick that the coating is rather expensive. Well-made and properly-applied cement mortar has proved effective. Within the last two years a coating has been developed which requires much less material and is more easily and economically applied. Recently a vitreous enamel has been offered for pipe-line protection. The material seems to have possibilities, but only exposure to a variety of soil conditions will tell definitely the extent of the protection such a coating can afford. In addition to withstanding soil action, the coating must resist considerable rough handling and be reasonable in cost.

The most extensively used pipe coatings have bituminous bases. Originally they took the form of cutbacks or paints. These proved ineffective under severe soil conditions and were followed by hot applications of coal tar or asphalt, in some cases modified by the addition of other materials, such as lime, clay, and volcanic ash. These in turn were found to be inadequate in territories where the soil contained stones or formed hard clods. To overcome the effects of so-called soil stress, it is now common to reinforce bituminous materials with felt or woven fabric. The reinforcement reduces the number of punctures of the coating due to rough handling and clod pressure. In many cases it also results in the use of a greater amount of bitumen and consequently in a more nearly moisture-proof coating. Successive measurements of the electrical resistance of protective coatings applied to short lengths of pipe indicate that most bitumen-base coatings absorb enough moisture to reduce their resistance materially. This absorption of moisture appears largely to take place through pinholes and pores, which may or may not be bridged over by a film of bitumen. The asphalt base coatings seem to absorb a certain amount of moisture through still more minute pores; when such coatings have been exposed to wet soils for considerable periods a thin film of rust is often found beneath the coating. Whether or not this film increases with time and whether it affects the value of the coating has not been very fully determined at this time.

It appears that, other things being equal, coatings with coal-tar base are, as a class, more nearly moisture-proof than those with petroleum asphalt base. On the other hand, the asphalts have some characteristics which tend to make them superior to coal tar for pipe coating. The protective value of bituminous coatings seems to lie in their ability to maintain uniform oxygen and moisture distribution at the pipe surface, thus minimizing the number and potentials of the concentration cells. The relatively high resistivity of a coating, even when it has absorbed moisture, reduces materially the galvanic currents, as the resistance of the paths of these currents lies largely in the region immediately adjacent to the pipe surface. An essential feature of a pipe coating is continuity. The bitumens are essentially fluids, yielding even to low pressure if applied for long periods and offering little resistance to the rough handling to which pipes are subjected during the construction of a line. Consequently it is difficult to maintain continuity in bituminous coatings.

Lack of resistance to applied forces is not the only weakness of bituminous coatings. Until recently most coatings were applied to all but small-dimensioned pipe in the field and the facilities for the work were necessarily rather crude. Under field conditions it is almost impossible to secure perfectly clean and moisture-free pipe, to maintain the melted bitumen at the optimum temperature, or to apply a continuous and uniformly-thick coating. This frequently results in an imperfectly protected pipe. As most of the corrosion loss of a bitumen-coated pipe is at points where the coating is defective and as the area of the defective spots is small compared with the area of the line it may prove more economical to apply supplementary protective measures to the defects than to produce a perfect coating. One way of stopping corrosion at defective points on a coated line is to maintain the line cathodic to the adjacent ground. This involves a continuous expense for electrical energy.

It might appear that cathodic protection of a bare pipe would offer a satisfactory solution to the corrosion problem. Cathodic protection for pipe-lines was proposed by scientists of the Bureau of Mines years ago and has been used to a very limited extent both in the laboratory and in the field. The resistance between the pipe and remote ground varies greatly from point to point along the pipe surface on account of variations in contact pressure, moisture, and soil characteristics. These variations have made it economically impractical to maintain all points on a bare pipe surface cathodic to the ground.

As a large part of the coating failures is the result of poor application, a test applicable to coatings prior to the laying of the protected pipe is needed. An apparatus to accomplish this has been developed. The present trends in pipe-line protection are the development of effective methods for determining where protection is needed, the construction of bituminous coatings to resist soil stress, and the design of apparatus for the detecting of flaws and failures in coatings.

Standard Bottom Tumbler for Dredges.—In a paper read before the Dredging Association of Southern Malaya on August 19 last, G. G. Wilkinson discusses the design of bottom tumblers for dredges. After reviewing the evolution of the types at present in use the author arrives at a standard specification, which is reproduced here.

BODY. (*a*) *Type*—round two-piece body with a tread diameter about twice the bucket pitch, pressed on to shaft and keyed, 2-in. gap between cheeks to allow lateral flow, tread grooves optional, cored holes at corners of webs to relieve casting strains.

(*b*) *Material*—cast manganese steel of carbon 1·0 to 1·1% and manganese 12 to 14%, toughened by heat treatment.

(*c*) *Machining*—ground in the bore and on face of bosses and in key seats.

SHAFT. (*a*) *Material, etc.*—mild steel or nickel steel forged and afterwards annealed, machined all over and with ample fillets in all shoulders.

(*b*) *Journals*—protected with sleeves of chrome steel or of cast steel (C., 35/40%, Mn., 70/80%) annealed and shrunk on.

(*c*) *Key stops*—formed by the journal sleeves or by the boss wearing rings.

(*d*) *Boss wearing rings*—cast steel as above machined annealed and shrunk on over key ends. The necessity for these renewable rings depends upon the method employed for packing the bearing.

(*e*) *Thrust device*—a type adjustable from the outside.

BEARINGS. (*a*) *Material*—a close-grained cast-iron or bronze.

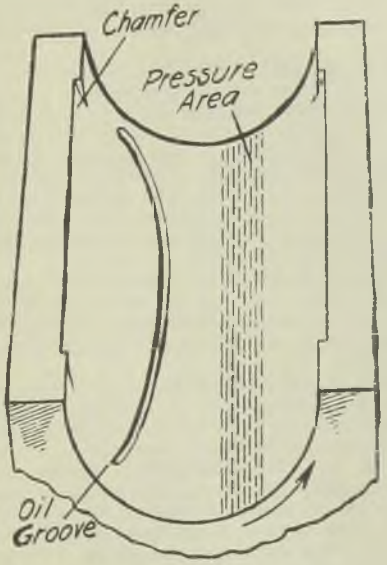
(*b*) *Oil groove*—The objects to be obtained by grooving a bearing are: (1) To facilitate access of the lubricant to the pressure area; and (2) to secure longitudinal distribution of the lubricant. In most bearings a groove formed by chamfering the edges of the bearing segments will serve both purposes. The reservoir formed in a normal clearance by such a chamfer will collect the lubricant along the length of the bearing. The chamfer should be cut at as steep an angle as is necessary to ensure

the lubricant being drawn from this reservoir into the pressure area. The chamfer should extend to within half an inch of the radius usually found at each end of a bearing. The higher the journal speed the greater is the force with which lubricant is drawn into the pressure area to maintain the lubricating film on the frictional surfaces. Pressure, on the other hand, tends to prevent the formation of the film by squeezing out the lubricant from between the surfaces. When sufficient speed is lacking and heavy bearing pressures are encountered it is necessary to cut grooves so that they will lead the lubricant to the pressure area. A sharp edge acts as a scraper.

The correct grooving for slow speed and heavy pressure as found in a bottom tumbler bearing is illustrated in the accompanying diagram. The arrow in this shows the direction of journal rotation. The grooves should be no larger than is necessary to hold the quantity of lubricant required by the bearing. A shallow groove with rounded edges is recommended. Deep grooves with vertical sides and sharp edges should be avoided. Grooves that are broad and shallow are inefficient as they deprive the bearing unnecessarily of effective surface. The "V"-shaped groove, although moderately efficient, is not advocated because of its tendency to start cracks or fractures, especially in thin bearing shells.

(*c*) *Grit exclusion*—No existing device seems wholly satisfactory, but, where a stuffing box can be fitted, it will give good service.

(*d*) *Lubrication*—Grease should always be delivered to the bearings through a non-return valve at a pressure slightly above the pressure of the paddock water at the greatest working depth. The following greases have proved very economical for bottom tumbler bearings:—1. Gargoyle Voco Grease B No. 4. Where a rubber ring is used to exclude grit as in the Lobnitz tumbler use Gargoyle product 2295 A, B, or D, as these do not effect rubber. 2. Black Bearing Grease (Wakefield Company).



CORRECT GROOVING FOR SLOW-SPEED BEARING AND HEAVY PRESSURE.

Three factors are at present unsatisfactory. One is the flow factor in manganese and the others are the present methods of excluding grit from and lubricating B.T. bearings. Progress will perhaps be mainly confined to overcoming these objectionable features, particularly the last two. With regard to the flow factor in manganese steel it may be said that the Billiton Co. has experimented with a high-alloy manganese chromium steel known as "Bohler Chronosteel." Special heat treatment has made it possible to give it a flow-limit of 67,500 lb./sq. in. and thus overcoming the danger of "flowing" which all have experienced with manganese steel. Bucket pins and bushes, it is claimed, have been kept in continuous service for 12–14 months by the Billiton Co., after which the pins were welded and used again. The author had not at the moment information as to whether this Dutch steel can be used in bottom tumblers. After all, the flow is not a serious proposition in bottom tumblers where it can be cared for by grooving. On the other hand if "Bolher Chronosteel" has the tough-hardness free from flow, as claimed, it would be invaluable for top tumbler slabs, bucket pins, bushes, and bottoms. Regarding methods of lubrication one mining company is now delivering grease to the bottom tumbler at pressures up to 200 lb. by means of a press situated near the top tumbler.

Sphalerite Flotation.—In *Mining and Metallurgy* for October R. L. Kidd and W. A. Wall, of the Utah Engineering Experiment Station, Salt Lake City, discuss the effect of particle size on the flotation of sphalerite. They say that in present-day flotation practice grinding of the flotation feed is carried to extremely fine sizes, 70 to 80% minus 200 mesh being customary. The greatest flotation losses occur in the coarsest and finest sizes, but the losses in the very fine sizes are of course much the more important because of the large proportion of fines in the feed. These losses are particularly high in zinc ores, so a study of the effect of size on the flotation of sphalerite has been made. The mineral used in the experiments was a pure sphalerite, especially free from copper, from the Joplin district in Missouri. The sizes coarser than 200 mesh were separated by screening, the sized mineral then being deslimed on a Wilfley table. The sizes finer than 200 mesh were obtained by water elutriation. Particles finer then 6.5 microns could not be obtained with the apparatus used. In all the flotation tests the mineral was first treated with a one-normal solution of hydrochloric acid to remove any oxide film. The acid was then filtered off and the mineral washed with copper-free distilled water until the filtrate had the same pH as the distilled water. The tests were made in a 50-gram University of Utah type cell [Gates and Jacobson, *E. & M. J.*, 119, 771 (1925)]. Cresylic acid was used as the frother, potassium ethyl xanthate as the collector, and copper sulphate as the activator. The results obtained showed that:

1. The finer sizes of sphalerite require less cresylic acid to give the best froth character than do the larger sizes.

2. With cresylic acid alone, much better recoveries are obtained with the fine sizes than with the large. In general, the recoveries increase with increase in amount of the frother used, but more gangue would probably also be carried over.

3. The finer sizes of sphalerite require more copper sulphate and more potassium ethyl xanthate for the best recoveries. However, in the fine sizes better

recoveries are obtained with cresylic acid alone than when copper sulphate, or copper sulphate and xanthate, is present. The reverse is true in the larger sizes.

4. The recovery of the fine sizes can be considerably improved by increasing the length of the collecting period such as by using more flotation cells.

SHORT NOTICES

Aluminium Alloy Mine Cage.—A short description of an aluminium alloy mine cage recently installed in the Wright-Hargreaves Mines, Ltd., appears in the *Canadian Mining Journal* for October.

New Hoists for Homestake.—Particulars of winding engines recently supplied to the Homestake mine are given in the *Canadian Mining Journal* for October.

Overwind Prevention.—In a paper read before the North Staffordshire Institute of Mining Engineers on October 16 Arnold Ray describes modifications to overwind-prevention gear at the Sneyd collieries.

Rope Haulage.—Lucien Eaton discusses rope haulage in the *Engineering and Mining Journal* for October.

Rope Pressure in Hauling.—In *Colliery Engineering* for November W. Ferguson discusses the problem of rope pressure in heavy haulage.

Large-Scale Blasting Underground.—A description of what is believed to be a record underground blast at the Climax Molybdenum Company's mine at Climax, Colorado, is given by W. J. Coulter and W. E. Romig in the *Engineering and Mining Journal* for October.

Ventilation.—A note by E. Ower on the effect of changes of air density on the readings of a vane anemometer appears in *Colliery Engineering* for November.

Smelter Dust.—The recovery of smelter dust and oxide at a secondary metals plant in the United States is described by W. Romanoff and C. O. Thieme in *Mining and Metallurgy* for October.

Alaska Mine Flotation Plant.—In the *Bulletin* of the Institution of Mining and Metallurgy for October C. P. McMillin describes milling methods and costs at the Alaska mine flotation plant of the Southern Rhodesia Base Metals Corporation, Southern Rhodesia.

Asbestos Milling.—W. RuKeyser discusses present-day milling practice on the Urals asbestos mines in the *Engineering and Mining Journal* for October.

Power Plant.—Contribution No. 61 to the American Institute of Mining and Metallurgical Engineers for October, by H. M. Faust, discusses the effect of modern power-plant requirements on the production and preparation of coal.

Air Surveying.—D. R. Crone discusses some factors in determining heights from air photographs in the *Empire Survey Review* for October.

Magnetic Needle Surveys.—In the *Empire Survey Review* for October J. W. Macgillivray describes the use of the magnetic needle on surveys in Trinidad.

Echo Bay District.—A description of the geology of the Echo Bay district, Canadian North West Territories, is given by H. S. Robinson in the *Canadian Mining and Metallurgical Bulletin* for October.

Borax in California.—In *Mining and Metallurgy* for October R. G. Mead describes the Kramer borax deposit in California and discusses the development of other borate ores.

Pretoria Salt Pan.—A discussion of the origin of the Sternheim basin in Swabia, South Germany, and the Pretoria salt pan by Dr. H. P. T. Rohleder appears in the *Geological Magazine* for November.

Asbestos in Australia.—An article on Australian asbestos by H. S. Elford is published in the *Chemical Engineering and Mining Review* of Melbourne for September 5.

Burgenland Antimony Deposits.—In *Metall und Erz* for October Dr. G. Heissleitner describes the geology of the Kurt antimony mine in Burgenland, Austria.

Canada's Base Metals.—A discussion of Canada's position as a base metal producer by Dr. Charles Camsell appears in the *Canadian Mining and Metallurgical Bulletin* for October.

Blasting with Liquid Oxygen.—A digest of an article in the last issue of the MAGAZINE on blasting with liquid oxygen was ascribed to W. D. B. Molter. The author's name should be W. D. B. Motter.

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.*

5,714 of 1932 (397,540). ANGLO-PERSIAN OIL CO. and A. C. HARTLEY, London. In order to prevent foaming and the entrainment of oil in gas escaping from mineral oil in its rise in a well the oil is caused to flow along a series of small channels, the small gas bubbles merging into larger ones and escaping.

6,081 of 1932 (397,851). I. G. FARBENINDUSTRIE A.-G., Frankfort-on-Main, Germany. Roaster gases containing sulphuric acid fog are first cleaned by passing through a high tension plant and then cooled below 100° C., a second high tension plant being used for separation of the sulphuric acid vapour.

11,816 of 1932 (398,579). DORR CO., INC., New York. Improvements in classifiers.

2,783 of 1933 (398,394). SOC. IND. D'APPLICATIONS ELECTRIQUES, Paris. Improved electrodes designed for electrostatic dust-precipitating plants.

3,320 of 1933 (398,724). LODGE-COLTRELL, LTD., Birmingham. Changing the polarity of the electrodes of an electrostatic dust-precipitating plant at frequent intervals is found to increase the efficiency of the plant.

9,475 of 1933 (398,121). EISEN UND STAHLWAKE OCHLER UND CO. A.-G., Aaran, Switzerland. Crushing machines incorporating a cutting member rotating inside a conical casing provided with fixed knives.

10,500 of 1933 (398,759). ANACONDA COPPER MINING CO., New York. A method for the continuous deposition of metal on a travelling cathode and for shipping the metal therefrom.

12,079 of 1933 (398,770). FRIED. KRUPP GRUSONWERK A.-G., Magdeburg-Buckau, Germany. Retorts placed within a rotating furnace are used for the distillation of volatilizable metals, such as zinc or cadmium, the metal being collected on condensers placed parallel to the axis of rotation of the furnace.

NEW BOOKS, PAMPHLETS, Etc.

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

The Witwatersrand Goldfield : A Compendium for Investors. By DR. HANS SAUER. With an up-to-date coloured map of the mining properties covering the whole Witwatersrand goldfield, together with a geological sketch map. Paper boards, 30 pages. Price 3s. London : Walter E. Skinner.

Gemstones : Imperial Institute Handbook on the Mineral Industry of the British Empire and Foreign Countries. Paper covers, 137 pages. Price 2s. 6d. London : H.M. Stationery Office.

Quarries and Metalliferous Mines, 1932 : Annual Report of H.M. Chief Inspector of Mines. Paper covers. Price 9d. London : H.M. Stationery Office.

Routine Analysis of Coal and Coke : An Investigation of the Accuracy of the Routine Analytical Determinations on Coal and Coke. Fuel Research Survey Paper 29. By DR. H. V. A. BRISCOE, DR. J. H. JONES, and the late DR. C. B. MARSON. Paper covers. Price 9d. London : H.M. Stationery Office.

The Inflammation of Coal Dusts : Effect of the Nature of Added Incombustible Dust. Safety in Mines Research Board Paper No. 79. By T. N. MASON and R. V. WHEELER. Paper covers, 13 pages, illustrated. Price 6d. London : H.M. Stationery Office.

Colliery Explosions : Report on the Medical Treatment of Men Burned in Colliery Explosions. Mines Department. Paper covers, 25 pages, illustrated. Price 6d. London : H.M. Stationery Office.

Geological Survey : Summary of Progress, 1932, Part II. Paper covers, 142 pages, illustrated. Price 3s. London : H.M. Stationery Office.

Geological Maps of Great Britain : Glossop (Huddersfield). Sheet 86 (Solid and Drift). Scale : 1 mile to 1 in. Price 2s. each map. London : Geological Survey and Museum.

Gold Coast : Geological Survey Department, 1932–33. Paper covers, folio size. Price 2s. London : Crown Agents for the Colonies.

Nigeria : Geological Survey Department, 1932. Paper covers, folio size, 36 pages, with maps. Price 3s. London : Crown Agents for the Colonies.

British Columbia : Map No. 1H, Northern British Columbia, 1933. Scale : 1/1,000,000 or 15·78 miles to 1 in. Size : 42 in. by 28 in. Price 50 cents. Victoria : Department of Lands.

Guidebook of the Western United States : Part F, Southern Pacific Lines. United States Geological Survey Bulletin 845. Paper covers, 304 pages, illustrated, with maps. Price $1·00. Washington : Superintendent of Documents.

United States Minerals Yearbook, 1932–3. Cloth, octavo, 819 pages, illustrated. Price $1·25. Washington : Superintendent of Documents.

Quarry Accidents in the United States, 1931 : Bureau of Mines Bulletin 375. By W. W. ADAMS. Paper covers, 50 pages. Price 5 cents. Washington : Superintendent of Documents.

Coke-Oven Accidents in the United States, 1932 : Bureau of Mines Technical Paper 559. By W. W. ADAMS and L. CHENOWETH. Paper covers, 15 pages. Price 5 cents. Washington : Superintendent of Documents.

Mineral Resources of the United States, 1931. Part II, pp. 523–552, Cement, by B. W. BAGLEY ; pp. 553–675, Crude Petroleum and Petroleum Products, by G. R. HOPKINS and A. B. COONS. Each part in paper covers. Washington : Superintendent of Documents.

Static Electricity in Nature and Industry : United States Bureau of Mines Bulletin 368. Part 1.—General observations and experiments. Part 2.—Industrial hazards and safeguards. By P. G. GUEST. Paper covers, 98 pages, illustrated. Price 10 cents. Washington : Superintendent of Documents.

Brazil : A Provincia Magmatica do Brasil Meridional. Monographia 1, Departamento dos Serviços Geographico e Geologico. By DJALMA GUIMARÃES. Paper covers, 63 pages, illustrated. Bello Horizonte, Estado de Minas Geraes : Secretaria da Agricultura.

Kingston's Metric Equivalent Tables : Weights, Measures, and Thermometer Scales. Price 1s. 1d. London : Kingston's Translations Institute.

Alaska : Progress of Surveys of the Anthracite Ridge District. By R. W. RICHARDS and G. A. WARING. United States Geological Survey Bulletin 849-A. Paper covers, 27 pages, with map. Price 5 cents. Washington : Superintendent of Documents.

Mineral Resources of the United States, 1931. Part I, pp. 575–600. Copper (General Report), by C. E. JULIHN and H. M. MEYER. Part II, pp. 415–510, Coal (Part 1—Bituminous Coal, by W. H. YOUNG, L. MANN, and F. G. TRYON, Part 2—Pennsylvania Anthracite, by F. E. BERQUIST, H. L. BENNIT, and F. G. TRYON). Each part in paper covers. Washington : Superintendent of Documents.

COMPANY REPORTS

Glynn's Lydenburg.—This company was formed in 1895 and works gold-mining properties in the Pilgrim's Rest district of the Transvaal. The report for the year to July 31 last shows that a record of 88,860 tons of ore was milled, yielding 31,689 oz. of gold, worth £174,004. Working costs amounted to £123,175 and the working profit to £50,829, an improvement of £37,478 as compared with the results for the previous year. The ore reserves at the end of the year were estimated to be 394,220 tons, averaging 8·0 dwt. in value over a stoping width of 22 8 in., an increase of 63,250 tons in amount, 0·1 dwt. in value, and 1·3 in. in stoping width as compared with the previous year. These figures are calculated on standard conditions and are unaffected by the higher price now being obtained for gold.

Zaaiplaats Tin.—Formed in 1908, this company has tin-mining properties in the Waterberg district of the Transvaal. The report for the year to July 31 last shows that the mill was in operation for 174 days and crushed 16,091 short tons of ore. The concentrate produced totalled 165 long tons, while 1·2 long ton was purchased. The working profit for the year amounted to £8,858 before charging development expenditure, the amount carried to the balance sheet being £7,618.

Wanderer Consolidated.—This company was formed in 1928 and is working gold-mining properties in the Selukwe district, Southern Rhodesia. The report for the year to June 30 last shows that 185,900 tons of ore was treated, yielding 41,917 oz. of gold, worth, including premium, £254,564. Working costs amounted to £163,668,

leaving a working profit of £90,896. After making various allowances there was a profit of £76,484, which, added to the sum brought in, gave an available total of £141,332. Of this amount dividends equal to 10% absorbed £57,798, while £17,573 has been set aside for taxation purposes, the balance—£65,961—being carried forward. The ore reserves at the end of the year were estimated to be 506,000 tons, consisting of 307,000 tons of available ore, averaging 4·9 dwt. in value, and 199,000 tons at present unvalued, as compared with 225,000 tons of available ore, averaging 5 dwt., and 206,000 tons of unvalued ore at the end of the previous year.

Cam and Motor.—This company was formed in 1919 and works gold-mining properties in the Hartley mining district, Southern Rhodesia. The report for the year to June 30 last shows that 304,000 tons of ore was milled, against 295,000 tons in the previous year, the revenue being £492,212, against £515,585. Working costs amounted to £268,983 and, after payment of royalty, the working profit was £198,587. After making allowance for the gold premium and charging all expenses there was a balance for appropriation amounting to £291,935, increasing the sum brought in to £330,278. Of this amount £243,750 has been distributed as dividends, equal to 6s. 6d. per share, and, after making other allowances, a balance of £39,303 was carried forward. The ore reserves at the end of the year were estimated to be 1,110,000 tons, averaging 41s. per ton, as compared with 1,000,000, averaging 44s., at the end of the previous year. In calculating these figures gold has been taken at its standard value—85s. per oz.

Naraguta (Nigeria).—Formed in 1910, this company works alluvial-tin properties in the Bauchi province, Northern Nigeria. The report for the year to March 31 last shows that the company's quota production amounted to 159½ tons, as compared with 223 tons in the previous year. The average price realized was £86 18s. 1d. per ton, against £70 10s. 2d. The year's working shows a profit of £3,999, increasing the sum brought in to £41,527, and, after providing for income tax, there remains a balance of £40,828 to be carried forward.

Mount Isa.—This company was formed in 1924 in New South Wales and is working silver-lead deposits in the Mount Isa field, North Queensland. The accounts for the year to June 30, 1932, cover a period when part of the plant was put into operation for tuning up and for production of bullion on a limited scale and they show a loss of £37,818. During September last extraordinary meetings of the company were held in Sydney for the purpose of winding up the company in order that it might be taken over by a Queensland company of the same title.

El Oro.—This company was formed in 1899 to acquire the El Oro gold and silver mine in Mexico and the railway connecting it with the State system. Work on this property was suspended in 1926 and the company is now interested, through a Mexican subsidiary, in the La Noria silver mine, Zacatecas, Mexico, and adjacent properties. The report for the year to June 30 last shows that 193,896 tons of ore from the Noria mine, averaging 17·97 oz. silver and 11·72 grains of gold per ton, was milled, 6,160 tons of concentrates being produced, the company's share in the profits of this work amounting to $117,690. Operations at El Oro, including railway receipts, resulted in a profit of £11,407 and the net result of the company's operations for the year is a profit of £33,425, increasing the balance brought in to £46,300. From this a dividend equal to 6d. per share, free of tax, has been declared.

DIVIDENDS DECLARED

Broken Hill Proprietary.—1s., less tax, payable Nov. 15.

Broken Hill South.—1s. (Aust.), less tax, payable Dec. 15.

Bulolo Dredging.—60 cents, less tax, payable Dec. 16.

Central Mining.—6s., less tax.

Chosen Corporation.—7½d., less tax, payable Jan. 1.

El Oro.—6d., free of tax, payable Nov. 7.

Geevor.—4½d., less tax, payable Nov. 10.

Great Boulder.—3d., less tax, payable Nov. 20.

Kampar Malaya.—6d., less tax, payable Nov. 23.

Lake View and Star.—1s., less tax, payable Dec. 7.

Maroc.—1s. 1½d., less tax, payable Oct. 31.

Minerals Separation.—1s., less tax, payable Oct. 19.

North Broken Hill.—1s. 6d. (Aust.), less tax, payable Dec. 12.

Pahang Consolidated.—Pref. 3½%, less tax, payable Nov. 22.

Petaling.—7½%, less tax, payable Oct. 30.

Rawang Concessions.—1s., less tax, payable Nov. 23.

Rio Tinto.—Pref. 2s. 6d., less tax, payable Nov. 1.

St. John del Rey.—Pref. 1s., free of tax; Ord. 9d., less tax, payable Nov. 17.

Sungei Way.—2½%, less tax, payable Oct. 23.

Taquah and Abosso.—4½d., less tax, payable Dec. 7.

Union Corporation.—2s., less tax, payable Nov. 23.

Wanderer.—1s., less tax, payable Nov. 2.

Wankie Colliery.—1%, less tax.

NEW COMPANIES REGISTERED

Ampat Tin Dredging.—Capital: £100 in 4s. shares. Directors: John H. C. E. Howeson. Henry Waugh, Harry Vandervell, William H. Edwards, and Adolph A. Henggeler. Office: Lloyd's Bank Buildings, 55-61, Moorgate, E.C. 2.

Colrood Oilfields.—Capital: £10,000 in 5s. shares. Directors: Walter G. Collom and Wm. G. Trood. Office: 14, Lower Regent Street, S.W. 1.

Northern Smelting and Chemical Company.—Capital: £250,000 in £1 shares. Objects: To operate the recent acquisitions of the Imperial Smelting Corporation.

Porkellis Tin Mine.—Capital: £1,200 in 1s. shares. Objects: To acquire and turn to account mines, tin-bearing lands, etc. Directors: C. W. Parish, R. A. Thomas, and E. T. Janson.

San Finx Tin Mines (1933).—Capital: £18,750 in 500,000 shares of 9d. each. Objects: To adopt an agreement between San Finx Tin Mines (in liquidation), W. H. Bevan, W. R. Sharp, and W. E. Martin and E. B. Ridsdel and Co.

Selection Trust.—Capital: £2,000,020 in 10s shares. Directors: A. Chester Beatty (Chairman), Sir Henry Strakosch, J. A. Agnew, Sir Albert Bennett, A. D. Storke, W. Selkirk, A. Chester Beatty, Jnr., O. Hoare, C. T. Pott, and J. A. Dunn. Secretary and manager: R. D. Peters. Office: Selection Trust House, Mason's Avenue, E.C. 2.