# The Mining 

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## CONTENTS

EditorialPAGENotesAppointment of Silicosis Medical Board; Malaria Controlin Northern Rhodesia; Institute of Metals' NewJournal; Standardization Conference Report ;Mining Fellowships in America; St. Jobn del ReyCentenary Medal; Tin Research; Exhibition ofImperial Mineral Resources; Frontino Gold Mines,Ltd.
Mining Hazards and Losses67
The papers presented at the January meeting of the Institution are here outlined
The Silver Problem68
The urgent need for standardization of silver values is discussed in the light of two recent proposals for its rehabilitation
East African Communications69
The opening of the Victoria Nile bridge at Jinja is made the occasion for a review of existing and projected railway routes in East Africa.
Review of Mining ..... 70
Articles
The Gold Mines of the Frontino andBolivia and Associated CompaniesW. H. RundallThe author describes the activities on these cld-established Colombian properties.
Aerial Ropeway Calculations G. Brillo
In this article the author, having previously described the mechanics of aerial ropeways, gives certain formula necessary for the design of such plant.
The Recovery of Vanadium Pentoxide at the Rhodesia Broken Hill
The process here described for the recovery of vanadium as pentoxide at the lead-zinc mines of the Rhodesia Broken Hill Development Company is Compiled from a report issued by the company.
Book Reviews
Milner's "Sedimentary Petrography " Dr. A. Brammall
Gowland's "The Metallurgy of the NonFerrous Metals" ...... C. W. Dannatt
Kraus and Hunt's "Tables for the Determination of Minerals " . Dr, W. R. Jones Maerks' "Bergbaumechanik"

$$
\text { Dr. S. J. Truscolt } 91
$$

Hanton's " Metalliferous Mine Surveying "
F. W. Armstrong,
Longwell's " Outlines of Physical Geology "
H. B. Milner

## News Letters

Johannesburg90919192New Kleinfontein's New Reef; Discovery of Banket inRhodesia ; Platinum Disappointments; Oil-ShaleDeposits in Natal.
Vancouver939288
Ontario Gold Production in 1930 ; Porcupine; Kirk- land Lake ; Sudbury; Patricia District; Manitoba Brisbane ..... 97
Mount Isa Operations; The Drilling Campaign; Oueens land Mining Concessions; Now Mining Legislation Shale-Oil Industry; The Briseis Tin Mine.
Perth ..... 99
A Mining Revival; Lake View and Star; Enterprise Syndicate: North Kalgurli; Sons of Gwalia;Wiluna Mines ; Prospecting Activity; WestAustralian Gold Yield.Ipoh100
International Tin Restriction Scheme; Dredges; Statistics.
Camborne ..... 101
The Outlosk; Some Efects of the Tin Slump.102
Trade Paragraphs ..... 102
The Morgon Drill Sharpener ..... 103
The Rexman Mill ..... 104
A Producer Gas Lorry ..... 104
Quasi-Arc Welding. ..... 105
Metropolitan-Vickers Winding Engines ..... 105
Metal Markets ..... 107
Statistics of Production ..... 109
Prices of Chemicals ..... 111
Share Quotations ..... 112
Mining Digest
Copper Recovery from Fine Ores and Dump Materials J.D. Sullivan and A. P. Towne ..... 113
Fan Testing ..... 115 ..... 115
Smelting of Potash and Phosphate Minerals
S. L. Madorsky, T. P. Hignett, and
P. H. Royster ..... 119
Tantalum E. P. Youngman ..... 123
Extraction of Tantalum and Columbium
C. G. Fink and L. G. Jenness ..... 124
Montreal Mine, Montreal, Wisconsin
Montreal Mine, Montreal, Wisconsin ..... 125
Molybdenum Analysis ..... 125
Concentration of Manganiferous Iron Ores F. D. DeVaney and J. B. Clemmer ..... 125
Short Notices ..... 125
Recent Patents Published ..... 126
New Books, Pamphlets, etc. ..... 126
Company Reports ..... 127
Apex (Trinidad) Oilfields; Broken Hill Proprietary Block 14 Jos Tin Area (Nigeria) : McCreedy Tins: Penawat (Malaya) TinDredging : Rambutan ; San Francisco Mines of Mexico.
Dividends Declared ..... 128
New Companies Registered ..... 128

## EDITORIAL

THE Home Secretary has given notice of the preparation of a scheme to provide for the appointment of a medical board which can issue the necessary certificates in all cases where compensation is claimed for silicosis or asbestosis. The board will also carry out periodical medical examinations of workers employed in certain specified processes involving exposure to silica or asbestos dust.

T'HE measures for the control of malaria introduced into Northern Rhodesia by the Ross Institute are evidently meeting with success. Mr. Nicolaus, of the Selection Trust, speaking at a meeting of the Ross Institute Industrial Anti-Malarial Advisory Committee last December, stated that since the expedition of the Institute to Northern Rhodesia the incidence of malaria had dropped enormously.

LAST month the Institute of Metals issued the first number of its new monthly journal, which contains original articles, Institute news, and many abstracts from the world's literature. By the issue of this new publication the Institute will speed up the issue of the abstracts and the half-yearly volumes will in future contain only " Proceedings " and will therefore be less difficult to handle.

IN connexion with the Imperial Conference of 1930, a conference on standardization was held and its report has just been issued. The report is a useful summary of the work done or proposed in reference to standardization in various parts of the Empire and it is pleasing to note that as a result of the conference the work of the British Engineering Standards Association is to receive more adequate help from the government.

FOUR fellowships in mining or metallurgy, tenable at the School of Mines and Metallurgy, University of Missouri, are to be awarded for the session 1931-32. They are of the value of $\$ 800$ per year and are open to graduates of all nationalities who have had the proper training in mining,
metallurgy, or chemistry and who are qualified to undertake research work. Applications should be addressed to the Director, School of Mines and Metallurgy, Rolla, Missouri.

IN connexion with the centenary last year of the St. John del Rey a gold medal was struck, presentations being made to the President and a few highly-placed ministers in Brazil, one also being presented to the British Museum. A limited number of bronze medals were also struck. The medal was designed by Lady Harris, wife of the chairman of the company, the obverse showing a Brazilian at work in the mine, the inscription, with a view of Morro Velho, being on the reverse.

THE 1930 programme of the Tin Research and Industrial Applications Committee of the Tin Producers' Association has recently been outlined. The most important lines of research have been on tin coatings, ternary alloys, white metal bearings, corrosion, and the tinning of cast iron. The expansion of the tin-plating industry by the cheapening of manufacturing costs is receiving particular attention. The actual research work was undertaken by the British Non-Ferrous Metals Research Association.

IN continuation of the series of special exhibitions designed to draw attention to the Empire's resources of raw materials which have been held at the Imperial Institute, an exhibition illustrating the mineral resources of the Empire has been arranged. It will be opened by Mr. Amery this month and among the exhibits from newly-developed areas the copper ores of Northern Rhodesia will be fully represented, together with representative samples from many other recently developed or discovered deposits.

ELSEWHERE in this issue will be found an article on the gold mines of the Frontino and Bolivia and associated companies by Mr. W. H. Rundall, partner in the firm of Messrs. Pellew-Harvey and Co., who have been the companies' consulting
engineers for nearly 21 years. As mentioned in the Magazine for December, the Frontino and Bolivia and the Marmajito companies have now been amalgamated under the title of the Frontino Gold Mines, Ltd., the chairman of the two companies occupying a similar position in the amalgamated undertaking.

## Mining Hazards and Losses

Members who attended the January meeting of the Institution had a most interesting evening, the two papers down for introduction and discussion treating widely different aspects of mining. The first, by P. J. Crowle, was " Notes on Ground Movements and Methods of Support in Deep Mines (The Kolar Gold Field) ' and the second, by G. W. Eaton Turner "Losses in Extracting Ore from Mines." In the absence of the authors abroad, the first paper was introduced by Mr. T. Pryor and the second by Mr. J. S. Watkins.

The dangers of deep mining-a problem becoming increasingly important as the shallower depths of our present mines become exhausted and one which, as Professor Lawn pointed out in the discussion, had not confronted miners of other days-were plainly shown by the first paper. The author explains that his notes on ground movements are the results of observations made during a long period of close contact with deep mining operations. His experience goes to show that the movements observed on the Kolar field do not conform to any law, although it might be observed that they are ruled by the various conditions brought out in the paper and cannot by any means be regarded as haphazard. For those unacquainted with the Kolar field it should be stated that the gold-bearing quartz reefs that are being worked are located in a belt of schists and that the plane of the lode is parallel to the foliation of the country. Although the rock is apparently massive, it embodies three distinct planes of weakness, the more prominent being the foliation planes, which are intersected at right angles by horizontal joint planes, while a third set of planes appear to run parallel to the ore shoots. The lode system is complicated by numerous faults and it is in the neighbourhood of some of these that movements most frequently occur, owing possibly to the fact that the ground is already in an unstable state. The problem of supporting the working places as the ore is removed becomes
increasingly important with depth. The early method of support by ordinary timber stulls was replaced by compressible packwalls and pigstys, but as some of the larger excavations were extended to still greater depths it was finally decided to replace the pack-walls by granite packs. An abundant supply of granite was available at the surface and this could be quarried by fire-setting methods and broken into blocks at a reasonable cost. The supports now in use consist of granite pack-walls built up from pigsty foundations, the latter constructed of round poles, filled with granite blocks. Since the system has been introduced there has been a marked diminution in the number of face-bursts. To those used only to shallow mines the author's notes on movements at these depths are amazing. He shows that an initial spring or expansion of the reef walls towards the excavations occurs simultaneously with the removal of each portion of reef and this happens before any support can be placed in position. Hanging-wall sag follows immediately and a considerable amount of closure therefore takes place before any support can resist the movement and until such resistance becomes effective face bursting is likely to occur. One might echo the opinion of Mr. Brodigan, who, during the discussion revealed that his ideas on safe mining had been rudely shocked by the author's revelations, and, with him, congratulate those concerned on the magnificent way in which such a difficult problem had been tackled. Other contributions to the discussion were made by Messrs. S. Taylor and J. Norman Wynne. Mr. Pryor's introduction of the paper was admirable and his reminder that it dealt rather with the prevention of rock-bursts on this field than on their causes was timely.

The paper of Mr. Eaton Turner, as already remarked, covers an entirely different subject. Dealing with ore losses during mining, the author considers that five causes are mainly responsible for them. First, a part of the ore, such as fines, does not leave the mine : secondly, valueless rock is mixed with the ore and sent to the mill ; thirdly, material detrimental to treatment is sent to the mill ; fourthly, a part of the ore is unsuitable for treatment; and fifthly, ore is lost by theft. Among the important points brought out in this paper attention should be drawn to its condemnation of that state of affairs, so often apparent in mines where
there is a continual struggle to keep pace with the mill, whereby a certain proportion of waste rock is included in the ore sent from the mine in order to swell tallies or lower cost-per-ton figures. In this connexion the author reminds us that shift-rivalry is also apt to modify ideas as to what is or is not ore. The paper undoubtedly contains suggestions worthy of consideration, although many may be in agreement with Professor Louis that the author has not apparently heard of the magnetic separation of tramp iron. Many useful points arose from the discussion, in which Professor Lawn, Dr. Cullen, and Messrs. Bensusan, Brodigan, Palmer, and Hutchinson also took part.

## The Silver Problem

The serious decline in the price of silver continues, the posting of new record lowest quotations becoming a frequent occurrence, and the difference in price between silver and gold is now greater than it has ever been. The reason for the continued fall in price and for the increasing disparity when compared with standard gold are not far to seek, there being a growing abundance of the one and an increasing scarcity of the other. Not only are the reasons for silver's decline obvious, but the results are equally so, the most important being the colossal depreciation in the wealth of those Eastern countries which have, in face of the scramble to adopt the gold standard, retained their silver currencies and have, in consequence, lost so much of their power to purchase. It is also evident that the efforts of the Indian Government to change from its gold exchange standard to a purely gold standard have constituted a major factor in the serious fall which has occurred in the last twelve months. The sale of large quantities of silver in order to purchase gold is to treat the former as a commodity and to treat as a commodity a metal which is the currency standard for a portion of the world is questionable policy.

The industrial progress of mankind has entailed several changes in standards of value and exchange. The metallic standards have been successively copper, silver, and gold, the movement in each case being up the scale of metals. The adoption of the gold standard by Germany after the Franco-Prussian war was followed by other countries and, although bi-metallism was strongly supported for a few years, the continued fall in silver influenced the Indian

Government to suspend its free coinage and ultimately to adopt the gold exchange standard based on sterling. Silver demonetized by the great powers has forced it into the commodity market, the nations wealthy enough to support the gold standard ignoring the need of their poorer neighbours for a lower standard. Nickel and copper coins, slowly and painfully acquired by the East African native and hoarded in his hut, are of no value after a fire, whereas with a silver currency and a fixed silver price his savings would still have a realizable value. The imposition of a gold standard on such people is somewhat premature.

So much for the present situation and the circumstances which have brought it about. What is of more concern, however, is what can be done to restore silver values. In an address on " The Rehabilitation of Silver," given recently at a luncheon of the Royal Empire Society, Mr. J. F. Darling endeavoured to show how the British Empire, by virtue of its position as the most important gold producer in the world, could bring about the restoration of silver values. Briefly it may be said that he suggested that the Empire's gold might be pooled or rationalized and the Empire itself become a buyer of gold and silver at minimum prices. Sufficient gold would be retained to cover the silver holding, the Empire, if necessary, raising the price of gold in order to do this. The mechanism of this scheme would lie in the formation of an Imperial super-bank, which would take over the Empire's resources of gold and silver, paying for them in its own currency, to be known as Rex. While not venturing to criticize Mr. Darling's farreaching scheme, it is difficult to understand what there is against the standardization of silver itself, unless it be what Mr. Darling, quoting an American banker, describes as "the gold mentality" which seems to rule the present economic world. It has been pointed out, however, that such an enormous business has been developed in silver dealing which would be destroyed by any fixation of price that the interests concerned would do all in their power to oppose any change in the present system. Be that as it may, notice might well be taken of the suggestion put forward by Mr. Brownell, of the American Smelting and Refining Co., that an international understanding was needed by which there would be an agreed price for silver, below which governments would buy, selling when the price rose a certain amount
above the agreed figure. Such a " gentleman's agreement " might meet with more approval than a suggestion for actual price fixation.

## East African Communications

The development of communications in East Africa was further advanced when the Governor of Uganda opened the new bridge over the Victoria Nile at Jinja on January 14. This marks the completion
extension by steamer service to Karonga, Fort Hill, and Fife. These last-named links are regarded in some quarters as a means of connecting Dar es Salaam with the Northern Rhodesian and Congo copper fields and their sponsors hope for the capture of much heavy mineral traffic in consequence, although it is difficult to see how the east coast route can hope to compete with that which will be available to the Atlantic when the Benguela railway reaches Tshilongo. Other developments indicated on the map,


East African Railway Communications.
of the direct rail route from Mombasa to Kampala. The occasion affords an opportunity for a brief survey of present and contemplated railway communications in this part of the continent.

In several recent issues of the Magazine short notes have been given which have drawn attention to specific extensions of the existing railway systems which have been suggested. It is now possible to co-ordinate these, and this has been done in the accompanying sketch map. Thus the proposed extension of the railway from Kampala to Kasindi with the subsequent connexion with Stanleyville is indicated, as are also the alternative proposals for lines southward from Dodoma to Iringa or from Kilosa to Ifakara, with an ultimate connexion with Manda, on Lake Nyasa, and a possible
and to which reference has been already made in these columns, are for the alternative links between the Central and Tanga railways, either from Kilosa to Mombo or from Dodoma to Arusha.

The dream of Rhodes was for the CapeCairo railway route and gradually links are being forged which may ultimately complete the desired chain. The configuration of the African continent is such, however, that all the natural railway routes are east-west rather than north-south and these short routes to the sea are more likely to be completed at an early date than the more ambitious line from the Cape to Cairo, which over so much of its central and northern route must cover enormous tracts of what will never be "white man's country."

## REVIEW OF MINING

Introduction. Although conditions show little sign of improvement, there is abroad a spirit of cautious optimism, possibly awakened by the feeling that as things cannot become much worse there is a prospect of them becoming better. At any rate, the evident intention of Malaya seriously to tackle the tin situation is in the direction of creating that confidence which is so badly needed at present.

Transvaal.- The output of gold on the Rand for January was 873,872 oz. and in outside districts $40,704 \mathrm{oz}$., making a total of $914,576 \mathrm{oz}$., as compared with $908,492 \mathrm{oz}$. in December. The number of natives employed on the gold mines at the end of the month totalled 209,442, as compared with 203,473 at the end of December.

The quarterly reports of the companies operating on the Rand have in many instances given encouraging advice with respect to ore reserves. In the case of the East Rand subsidiaries of the Anglo American Corporation increases are shown by all four mines, particularly in the Springs and the Daggafontein. The estimate for Daggafontein shows a growth of 200,000 tons since the interim estimate was made two months previously and now stands at $1,233,802$ tons, averaging 8.37 dwt. over a stoping width of $43-93$ in. The designs for the reduction plant at this mine, which will have an initial capacity of 50,000 tons per month, are nearing completion and some orders have already been placed. Large increases in ore reserves have also been reported by East Geduld Mines, where there are now developed $3,900,000$ tons of ore, averaging 7.0 dwt . over 58 in., and by the Durban Roodepoort Deep.
At an extraordinary general meeting of Village Deep, Ltd, to be held following the general meeting in April, it will be recommended that the capital be further reduced by the repayment of 4 s . 6 d . per share out of the proceeds of realization of assets, which is still proceeding.
The reduction in capital of the Ferreira Estate Company to $£ 154,212$ in 16 s . shares and the return of 4 s . per share in cash sanctioned by shareholders in November last has now been confirmed by the Supreme Court of the Union and the repayment has been made this month.
The board of Sub Nigel, Ltd., have found it necessary to deny a rumour that the company contemplated the issue of new shares for cash or for the acquisition of further properties.

Diamonds.-The report of De Beers Consolidated to June 30 last states that the accounts show no improvement in diamond sales. During the year no mining was done at the De Beers or Kimberley mines, but 4,862,173 loads of blue ground, averaging approximately 0.23 carat per load, was hoisted from the Wesselton, Bultfontein, and Dutoitspan mines. It is suggested that any improvement in the diamond situation is contingent upon a revival of general prosperity, coupled with the judicious control of output and sales. Meanwhile a five day working week is to be adopted from March 1.

During the year ended October 31 last the Premier (Transvaal) Diamond Mining Company mined $4,472,155$ loads of blue ground and produced 700,943 carats. The development of the 610 ft . level was completed early in the year and the quantity of blue ground in sight above that level is estimated to be $14,000,000$ loads. The profit for the year was $£ 13,102$.

Owing to the state of the diamond market, Namaqua Diamonds, Ltd., has decided to close down its properties.
Southern Rhodesia.-The output of gold from Southern Rhodesia during December last was $46,485 \mathrm{oz}$., as compared with $44,351 \mathrm{oz}$. for the previous month and 46,829 oz. for December, 1929. Other outputs for December were : Silver, 5,369 oz ; copper, 103 tons ; coal, 70,349 tons ; chrome ore, 8,709 tons; asbestos, 2,323 tons; mica, 13 tons ; tin, 1 ton.

Northern Rhodesia.-Recent boring on the property of the Rhodesia-Katanga Company has established the occurrence of payable ore $1 \frac{1}{4}$ mile south of Kansanshi hill. Bore-hole G. 1 at this point cut a series of highly sulphidic beds, with pyrrhotite and chalcopyrite, which from 193 to 202 feet in depth assayed $3.52 \%$ copper. The hole is, however, south of the gabbro dyke and 920 yards from the nearest bore-hole, so that further work is necessary to establish connexion with the known mine mineralization.

The curtailment of development on the Northern Rhodesian copper mines in view of the present low price of the metal is having a serious effect on the employment situation. The Bwana M'Kubwa mine has been closed down, 250 white employees being paid off, and it is expected that the N'Changa mine will discharge 100 men. The authorities have been warned of the position and it is
announced that the Governor of Northern Rhodesia has notified his intention of visiting the copper belt and desires to meet a deputation of the miners.

The Rhodesian Broken Hill Development Company has announced that their vanadium plant is now in operation and producing hydrated vanadic oxide. The output during January amounted to 10 tons of $90 \% \mathrm{~V}_{2} \mathrm{O}_{5}$.
Uganda.-An extraordinary general meeting of Kagera (Uganda) Tinfields, held last month, resolved that the capital be increased by the creation of $£ 25,0006 \%$ cumulative convertible preference shares of 5 s . each and these new shares have since been issued. A progress report also issued last month stated that the output of tin concentrates had been maintained at 28 tons per month for the last four months of 1930, bringing the total output for the $11 \frac{1}{2}$ months' working to 328 tons, as compared with 312 tons in 1929. The opening of a new port on the Kagera River is being rapidly advanced by the administrative authorities and this will reduce the road transport from the Mwirasandu mine from 173 miles to 73 miles. The new plant, preparations for the erection of which are proceeding, will enter by this new port.

Gold Coast.-The report of the Ashanti Goldficlds Corporation for the year ended September 30 last shows that ore reserves have increased by 17,400 tons to 607,600 tons, the grade decreasing 0.5 dwt . to 24.7 dwt . The milling of 124,200 tons of ore yielded $144,470 \mathrm{oz}$. gold and $8,509 \mathrm{Oz}$. silver. The net profit for the period under review was $£ 320,561$. Particulars of dividends paid by the company and of the intention to capitalize a portion of the reserves were given here last month. At the annual meeting held this month a summary was given of Dr. Maclaren's report on the property, in which he has expressed the opinion that so long as geological conditions remain unaltered the ore may be expected to persist downward" at any rate to the comparatively shallow depths attainable by mining."

During the year ended June 30 last Morkwa, Ltd., succeeded in establishing its rights to the Mansu properties and since September, 1929, the areas have been revalued and further prospected. A plant is to be erected on the most promising part of the property when funds are available, but the time is not yet considered opportune for a capital issue. Expenditure during the period under review absorbed $£ 5,815$.

The report of the Geological Survey for the
year 1929-30 announces the discovery of a large deposit of bauxite capping the hills to the north-east of Asempanaiye in the northwest Sefwi district. The quantity of good quality bauxite is estimated at some 20 million tons.

Australia.-The report of Mount Isa Mines, Ltd., for the eighteen months ended June 30 last estimates the ore reserves available at $30,554,000$ tons of lead-zinc-silver ore. Since the last report the main ore shaft, the man and supply shaft, and the Rio Grande shaft have been sunk to the main haulage level and the Davidson and man shafts have been connected. The progress of the connexion of the other shafts by the main haulage has been delayed by water troubles. The construction of the treatment plant is rapidly approaching completion.

Western New South Wales Electric Power Proprietary, Ltd., was registered in Victoria on August 25 last and has since been registered as a foreign company in New South Wales, the capital being $£ 750,000$ in $£ 1$ shares, of which 500,000 have been taken up by North Broken Hill, Ltd., Broken Hill South, Ltd., and the Zinc Corporation, Itd. The company was formed for the purpose of erecting a central power station operated by crude-oil Diesel engines, which would supersede the existing system of separate stations for the supply of power and compressed air to the Broken Hill mines. The issue is now announced by the power company of $£ 700,000 \quad 8 \%$ debentures, of which $£ 250,000$ have been taken up by the three companies named, these having underwritten the issue.

After a period of doubt, it was announced last month that the miners on the Broken Hill field had decided conditionally to accept the terms offered by the companies and productive operations have been re-started. Meanwhile the Electrolytic Zinc Company of Australasia and the Broken Hill South Company have both decided to postpone the payment of the customary half-yearly dividend.

Prospecting activities in the Larkinville alluvial field, near Widgiemooltha, on the Coolgardie-Norseman railway, resulted last month in the discovery of a nugget weighing $1,135 \frac{3}{4}$ oz., which has since been bought by the Western Australian Government and is to be sent to London for exhibition. Reports that gold-bearing veins had also been discovered on the field have so far not been confirmed.

An announcement made last month stated that the Broken Hill Proprietary Company had asked the government whether technical assistance would be available if the company extended its operations into Western Australia. The reply was in the affirmative.

The firm of A. Victor Leggo and Co., of Victoria, which has chemical works at Yarraville and metallurgical plant at Bendigo, has announced that it will erect an arsenic condensation plant near the Wiluna mine, to utilize waste gases of the Wiluna roaster.
New Guinea.-The report of New Guinea Goldfields, Ltd., for the period ended September 30 last shows that work has so far been confined to proving the extension of the main mineralized zone. Two valuable lodes have been discovered and diamond drilling is in progress to test them at depth. On the lower area two other ore-bodies have been discovered and the erection of plant is now under consideration.

India.-A rock-burst of some severity occurred on the Ooregum mine last month in a stoping section between the 63rd and 69 th levels. The accident resulted in the death of 11 men, 56 more being injured. The shaft was not damaged, but, several levels being blocked, output was temporarily affected.

Burma.-The report of Mawchi Mines, Ltd., for the year ended December 31, 1929, shows that operations at the mine were mainly concentrated on development and the installation of the new plant and machinery. No mining or milling of ore was done during the year, but $629 \frac{1}{2}$ tons of concentrates was purchased from native workers. Milling was resumed in February last and up to the end of October 33,581 tons of ore was treated, producing 1,587 tons of concentrates. No. 2 main cross-cut was completed in July last and the second hydro-electric power station in December. In view of the present state of the metal markets no attempt has been made to develop new ore or to expand the scale of operations.

Malaya. - The crisis in the tin-mining industry has had a disastrous effect on the affairs of the Perak River Hydro-Electric Power Co., Ltd., but a scheme has been approved whereby a partial moratorium as regards certain fixed charges will come into operation. This scheme has also received the approval of the Treasury and of the Government of the F.M.S. On the mining fields it has been stated that while the
practical advantages of electric power are becoming better understood, the company's scale and method of charging are open to very serious objections as applied to conditions prevalent in open-cast mining and may lead to some mines abandoning use of the company's power. It is pointed out that the only satisfactory basis on which costs can be charged to most of the mines on the field, excluding dredges, is on the actual units of power consumed and that the power company would do well to give this subject the most urgent consideration.

Venezuela.-A progress report issued by New Goldfields of Venezuela, Ltd., states that during the period December 7 to January 18 5,316 tons of ore was milled and $1,991 \mathrm{oz}$. of gold recovered. It is stated that the transfer of the Bolivar Venezuela property of the company should be completed this month.

Panama.-Shareholders of Panama Corporation have been informed on the return of Mr. V. F. Stanley Low, the consulting engineer, of important developments on the company's properties. The new reef at Penon, north of the Mina Blanca lode, is considered important, bulk samples assaying 22 dwt . gold per ton. This lode has been traced for $1,500 \mathrm{ft}$. On the latest concession granted to the corporation a lode has been discovered on the main road from Panama to Santiago, the vein, which at the point of intersection assays 17.2 dwt. per ton, having been traced over 3 miles.

Mexico.-At an extraordinary meeting of Buena Tierra Mining held last month it was resolved that the date of repayment of the $£ 66,00010 \% 5$-year notes, previously postponed to February 1, 1931, should be further extended to February 1, 1936.

Yukon.-At the request of a number of shareholders of the Yukon Consolidated the Canadian Government has appointed an inspector to investigate its affairs.

Germany.-Following the exchange of shares which took place last August between the Amalgamated Metal Corporation, Metallgesellschaft, and the Société Génerale des Minerais, it is announced that Messrs. O. Lyttelton and W. Gardner have been elected to the advisory board of Metallgesellschaft.

Turner and Newall.-During the year ended September 30 last the profits of Turner and Newall were $£ 829,768$, of which $f 645,643$ was distributed as dividends, equal to $11 \frac{1}{4} \%$ on the ordinary shares.

# THE GOLD MINES OF THE FRONTINO \& BOLIVIA AND ASSOCIATED COMPANIES. 

By W. H. RUNDALL, M.I.M.M., A.M.I.C.E.

The author describes the activities on these old-established Colombian properties.

In the Magazine for last September Mr. R. S. Botsford gave an interesting account of conditions in the Republic of Colombia generally and of hydraulic mining in the State of Antioquia. The gold-bearing alluvials of that State occur along the course of the Porce River, as it is called in its upper reaches, and the Nechi River, as it is called further down, just before its junction with the Cauca, a tributary of the great Magdalena River. The Magdalena, which flows almost due north, is navigable for steamers of small draught for some 500 miles from Barranquilla, the principal port and distributing centre of the Republic, and is the main channel of communication between the northern coast and the principal centres of business and industry such as Medellin and Bogota, the capital.

The main watershed between the Magdalena and its tributary the Cauca is known as the Cordillera Central, which may be considered the northern limit of the great mountain chain of the Andes, and it is along this Cordillera Central, in the States of Antioquia and Tolima, that the mineral wealth of gold, silver, copper, iron, and coal is distributed. Owing to the difficult nature of the country, lack of means of communication, and the high cost of transport, only the precious metals offer any attraction from an economic standpoint. These latter, particularly gold, were utilized by the Indians long before the Spanish Conquest and a wealth of gold was abstracted from the graves of old Indian chieftains by the Spaniards, as well as from the alluvial gravels.

One of the oldest gold mining companies in the City of London is the Frontino \& Bolivia, which holds a large mineral bearing area granted in perpetuity by the Colombian Government. The location is shown on the accompanying map (Fig. 1), under the name of La Salada. It lies some 300 miles south of Barranquilla and about 100 miles northeast of Medellin, the capital of the State of Antioquia. The small towns of Remedios and Segovia are located mainly within this area. The first joint stock company to work the mines was formed in London in 1852 under the name of La Nueva

Granada. This company held areas at 'Frontino and at Remedios, about 130 miles distant one from the other. In 1866 the name of the company was changed to Frontino and Bolivia and, although there have been various reconstructions and the Frontino property was relinquished many years ago, the company has retained this name up to the present day. The last reconstruction took place in 1911 and in 1920 a subsidiary company was formed to re-open one of the old abandoned mines on the company's area under the name of the Marmajito Mines, Ltd.

During the Frontino Company's history many mines have been worked at different points within the large area held and very primitive methods were employed for the first fifty years of the company's existence, that is to say until the beginning of the present century. The lodes were opened up by adits and worked to such depths only as natural drainage by this means could be readily obtained. For the reduction of the ore native-made stamp mills with wooden camshafts, wooden stems, and cast iron heads and dies, driven by water-wheels, were used. The gold and the sulphide minerals, caught on blanket strakes, were panned with mercury to collect the gold and the sulphides were passed to " arrastras " for fine grinding and the amalgamation of the very finely-divided gold they contained. At one time as many as twenty of these small native mills are said to have been in operation, each contributing its quota to the company's output. Adequate supervision of these many small units by a limited European staff must have been almost impossible.

This, however, is ancient history and work for many years has been confined to two or three mines only, fully equipped with pumping and hoisting machinery and up-todate reduction and cyanide plants. At the date of writing two mines only are being worked, the Silencio, owned by the Frontino \& Bolivia Company, and the Marmajito, owned by the Marmajito Mines, Ltd., half the issued capital of which is owned by the former company. The mines lie at an elevation averaging about $2,500 \mathrm{ft}$.


Fig. 1.-Sketch Map showing Location of Frontino Properties.
in the heart of the tropics. Nevertheless, the climate is quite agreeable, the nights being cool-so cool that two blankets are often necessary during the early part of the rainy season. The locality is well watered and two mountain streams, the Pocune and the Dona Teresa, furnish the power for the company's hydro-electric plants.

The rock formation is almost entirely granite, as the overlying schists and limestones have been eroded away over much the greater part of the area. The gold-bearing veins so far worked lie entirely in the granite.

There are three main lode or fissure systems: (1) With strike approximately
N.-S. and dip flat to the East, (2) with strike N.W.-S.E. and dip flat to the N.E., and (3) with strike N.W.-S.E., but almost vertical dip. Work has been done in the past on all three of these lode systems. Of the deeper and more extensively worked mines, the Silencio, the La Salada, the San Nicolas, and the Cristales conform to system (1). The two latter, the Cristales and the San Nicolas, are not on the company's area, but are the property of a Belgian company.

Conforming to system (2) are the Marmajito and Tigrito, both the property of the Marmajito Mines, Ltd. Also several small lodes within the company's area which, according
to old records, were very profitably worked in the past down to water level.

System (3) is traceable for miles over the whole length of the Frontino \& Bolivia Company's area and a number of small mines have been opened in the past on this lode system down to water level, both by this company and also by the Sucre Mines, Ltd., a London company which after many years of prosperity suspended operations and with whom negotiations are now proceeding for the transfer of their areas to the Marmajito Mines, Ltd.

Small patches of alluvial and the easily worked outcrops of the numerous lodes were considerably exploited long before the company under reference was formed, since in fact the early days of the Spanish conquest. The town of Remedios was founded in 1560 by Capt. Francisco Martinez de Ospina, who gave it the name of Nuestra Senora de los Remedios. In a history of the State of Antioquia, published in Paris in 1885, reference to the Remedios district is made. The district is referred to in anything but cheerful terms ; translated from the original Spanish, it reads as follows: "The abundance of mineral, the introduction of large numbers of African slaves to work it, the swarms of snakes, jaguars, and other wild beasts, and also the prevalence of fever and other maladies has thrown over the region a cloak of horror and fearful superstition that has lasted nearly to the present day."

Whatever may have been the reputation of the Remedios district in the past, there is nothing wrong with it in these days. Without claiming that it is a health resort it may certainly be said to bear favourable comparison with most equatorial regions, exemplified by the fact that there are several European employees of the company who have spent over twenty years at the mines.

Prior to 1888 the Frontino and Bolivia Company's records are not complete, but since that date very complete records are available. From 1888 to the present day the Silencio mine has been worked continuously. The Salada mine, which was also working in 1888, was abandoned in 1915. During the same period, 1888 to 1915, the following mines were also worked intermittently :-The Cecilia, Cordoba, Tigrito, and Marmajito, the last mentioned being closed in 1911 until it was re-opened as a subsidiary company in 1920.

The tonnage milled and value of the bullion
realized by these mines from 1888 up to the date of the last annual reports has been :-

|  |  | Tons | Approximate |
| :--- | ---: | ---: | ---: |
| average |  |  |  |

The average yields are approximate only for the Silencio and Marmajito mines, as in both cases the total bullion realized includes the yield from certain old tailings dumps, and in the case of the Silencio mine the bullion produced by tributors and streamers is also included.


Fig. 2.-Silencio Mine-Main Incline Shaft. Head-frame built on the spot from iengths of old piping.
The "Other Mines" referred to in the above statement of output and grade were worked in the days of primitive treatment of the ore in native mills and without the cyanidation of the tailings and slimes. The average yield per ton of $£ 115 \mathrm{~s}$. can be taken therefore as representing not more than $60 \%$ of the gold content, which would make the actual assay value of the ore treated about $£^{2} 18 \mathrm{~s}$. per ton. Similarly at the Silencio and La Salada mines for the first fifteen years of their life very primitive reduction methods were employed and the


Fig. 3.-General View at Head of Silencio Mine Main Incline Shaft.
average assay value must have been considerably better than that shown.

The Silencio mine has been and still is the most extensively worked and the largest producer. It was for some years-after the suspension of operations at the Salada mine and before the re-opening of the Marmajito mine in 1920-the only mine worked by the
company. A brief description of this mine may be of interest.

The lode is a narrow one and, although widths up to 5 or 6 ft . occur, the average width is about 20 in . only. In spite of this the lode is very persistent both along the strike and in depth. The dip is about $30^{\circ}$ from the horizontal. There are numerous faults and cross-courses and, though the dislocation of the lode by these is often very considerable, in the sense that it is broken up, irregular, and of little value, the actual displacement or "throw" is not serious. The aggregate length along the strike exposed by the underground workings is some $3,300 \mathrm{ft}$. and the bottom level at present under development is $2,000 \mathrm{ft}$. in depth on the incline, equivalent to a vertical depth of about $1,000 \mathrm{ft}$. The last two levels opened up-namely, the 19 and 20 -have given improved results both as to width and value, particularly south of the shaft, where in the upper levels the lode, though of better width, was considerably under the average in grade. The lode contains considerable sulphide mineral, pyrites, galena, and blende, and the bulk of the gold is carried in the sulphides in a very finely divided state-free, not combined.

The main incline shaft (Figs. 2 and 3), which has now reached a depth of about $2,300 \mathrm{ft}$., has two hoisting compartments for the ore and rock and a third compartment for the service hoist. This also served for the


Fig. 4.-Silencio Mine-Mill and Cyanide Plant.
pump column, compressed-air main, electric cables, etc. The over-all length of the shaft is 20 ft . In view of recent excellent developments in depth and in order to increase materially the scale of operations a second shaft is shortly to be commenced.

Surface and outcrop water is drained off by an adit, which follows the lode. Originally the shaft was furnished with a Cornish pump, but for many years now all pumping has been done by direct-coupled, electricallydriven turbine pumps. These are driven by $200 \mathrm{~h} . \mathrm{p}$. motors running at 1,470 r.p.m. Two complete units are installed at main pumping stations, so that there is always one unit in reserve in case of breakdown or emergency.
considerable improvement in this respect in the future.

The ore offers no special difficulties in treatment. About $70 \%$ of the gold is recovered as amalgam and the remainder as precipitate from the cyanide plant. The tailings from the stamp mill are classified into sands and slimes for separate cyanide treatment. The sulphide minerals in the sands are concentrated for fine grinding and amalgamation by pan and settler and the sands after elimination of the sulphides go to the sand plant for cyanidation. The slimes plant consists of Dorr thickeners and agitators. Each ton of slime is agitated with 5 or 6 tons of weak cyanide solution by means of air under a pressure of from


Fig. 5.-Marmajito Mine-General View.

From the mine the ore goes to a sorting plant and some $20-25 \%$ of waste rock is sorted out by hand before the ore passes to the mill. This work is done by women, who sort out the waste on a revolving table.

The mill (Fig. 4) consists of 10 heads of heavy stamps ( $1,050 \mathrm{lb}$.) and 30 heads of light stamps ( 450 lb .). Crushing through 20mesh screens, the mill has a capacity of 2,600 to 2,800 tons per month. Owing, however, to shortage of water-power during the dry season and wash-outs and other troubles during the rains it has seldom been possible to run the mill continuously at its full capacity. The new hydro-electric scheme referred to later should, however, lead to a

6 to 9 lb . per sq. in. The bullion recovered varies between 600 and 630 fine in gold, and the recovery obtained by the reduction process is $93 \%$ to $94 \%$ of the gold contents of the ore milled.

Reference has been made to the Marmajito mine, belonging to the Marmajito Mines, Ltd., a subsidiary of the Frontino \& Bolivia Company. This company is under the same management as the parent company and is also dependent on the parent company for power, stores, etc. Here also the dip of the lode is about $30^{\circ}$ from the horizontal and the main characteristics of the lode are the same as at the Silencio mine, except that the average width of the gold-bearing quartz
is even less. This, however, is compensated by the very high average grade of the ore.

On this mine (Fig. 5) the main incline shaft has reached a depth of $1,020 \mathrm{ft}$. and in the No. 9 or lowest level the value of the ore is fully maintained, with a tendency to improved widths. One point of difference between this lode and that at Silencio is the tendency to split into foot and hanging wall branches, which complicates the stoping of the ore in certain stopes.

Reference has been made to the Cordoba and Tigrito mines, formerly worked by the company. These adjoin the Marmajito mine and are conveniently situated for the conveyance of the ore to the Marmajito mill.
proposal is to double the capacity of this mili should the re-opening of the Cordoba and Tigrito mines meet with the success anticipated.

Since the last reconstruction, which took place in 1911, the Frontino \& Bolivia Company has dealt with its profits as follows :


In addition a second hydro-electric scheme, referred to below, has been carried out. This


Fig. 6.-Marmajito Mine and Cyanide Plant.

Old records show that very good ore was opened up and milled from both these mines in the past, particularly the Tigrito, and they are to be re-opened shortly. The Tigrito will be developed by driving from the Marmajito shaft and the Cordoba will be explored by re-opening the old Cordoba adit for sampling and investigation, with a view to planning the development of the lode in depth.

The Marmajito mill (Fig. 6) consists of 20 head of light stamps ( 450 lb .) and has a capacity of 1,000 tons per month. Reduction methods are the same as at the Silencio mine, except that at present there is no slimes plant and the slimes are impounded. A slimes plant is now on order in England and should be in commission by the end of the year. The
has cost $£ 44,000$, the whole of which expenditure has been met out of revenue.

Hydro-Electric Power.-The company has now two hydro-electric plants, namely, the Pocune and the Dona Teresa. The Pocune plant, so named because it utilizes the water of the upper reaches of the Pocune River, a tributary of the Nechi, consists of a masonry dam and a ditch $1 \frac{1}{2}$ mile in length to the pressure box at the head of the power pipe. The power pipe is 24 in . in diameter at the top, reducing to 22 in . at the bottom, and the head of water is 360 ft . at the power house. The generating plant consists of three units-three 250 k.v.a. alternators direct-coupled to three $300 \mathrm{~h} . \mathrm{p}$. Pelton wheels running at 600 r.p.m. Three phase, 50 cycle, alternating current is generated


Fig. 7.-Doña Teresa Power-Scheme, showing Section of the Falls and the Power Pipe
at 550 volts and transformed to 11,000 it became necessary to instal the second volts for transmission to the mines, a distance of some six miles. This plant was completed in 1916 and replaced a smaller plant served by the same dam and ditch. During the dry season it is not possible to run more than two units and sometimes only one for a short period before the rains begin.

Owing to the shortage of power during the dry season and the increased demand due to the re-opening of the Marmajito mine
power scheme, known as the Dona Teresa (Figs. 7 and 8). This, which is distant some seven miles from the mines, was completed and put into commission in the spring of last year and is located on a stream known as the Dona Teresa. A section of this stream, with a very rapid fall-370 ft . in half a milegives an almost ideal site for a power scheme, as it has been possible to dispense altogether with a ditch to convey the water to the head


Fig. 8.-Doña Teresa Power-Scheme-Intake of Power Pipe.
of the pipe-line, thus obviating the continual expense, particularly during the rainy season, of maintaining a ditch in good condition and repairing the wash outs that are almost inevitable after heavy thunderstorms.

The photograph, Fig. 9, shows the very ample area of heavy punched plates provided at the intake of the pipe-line to prevent twigs, leaves, etc., from getting into the pipe. This is an essential precaution; all accumulation is raked off the screens every twelve hours and it is only necessary to see the extent of the accumulation each time this is done to realize how essential


Fig. 9.-Dona Teresa Power-Scheme, showing Screens at Intake of Power Pipe.
full and adequate screening is if trouble is to be avoided at the nozzles of the turbines.

The power pipe is 36 in . in diameter and $1,800 \mathrm{ft}$. long and without undue loss of head due to friction has sufficient capacity for $1,800 \mathrm{~h} . \mathrm{p}$. at the power house with an effective head of 350 ft . It is estimated that the above power will be available under conditions of minimum dry season flow of water in the stream.

A power house designed for four units, in the first instance has been erected, of which two units are installed and running. These consist of two Turgo impulse wheels each of 300 h.p. direct-coupled to two 250 k.v.a. alternators running at 750 r.p.m. and generating alternating current of the same
phase, cycle, and transmission voltage as at the Pocune plant. Two further units will be installed shortly. In addition to these two hydro-electric plants the company has a steam plant at the Silencio mine.

All hoisting is at present done by steam, but two electrically driven hoists are now in process of shipment to replace the steam hoists and when installed should bring about an important economy in the cost of hoisting. This steam plant consists of two Babcock and Wilcox boilers burning firewood brought in on mules at contract rates. In addition to furnishing the steam for the hoists this boiler plant can when necessary-during the latter part of the dry season, for instancebe used to generate electric power. For this there are two Belliss and Morcom high-speed engines direct coupled to alternators-one unit of $150 \mathrm{k} . \mathrm{v} . \mathrm{a}$. and one of $50 \mathrm{k} . \mathrm{v} . \mathrm{a}$.

The company has well-equipped workshops and a small foundry for both brass and iron castings, oxy-acetylene welding apparatus, etc., and in addition to all ordinary repair and maintenance work much is done in the way of reconditioning old plant, utilizing old scrap, etc.

Transport.-The remote situation of the mines and the high cost and difficulty of transport is a factor which greatly influences costs and makes difficult any comparison with the costs of other gold mines milling approximately similar tonnages.

From Barranquilla, the port on the Carribean Sea to which all machinery and supplies from Europe are shipped, there are 275 miles of river transport to Zaragoza and then 40 miles by pack mules across very mountainous and broken country to the mines. Any case or piece of machinery too heavy to be transported on mule back has to be man-handled from Zaragoza to the mines and the cost of doing this is very high. All machinery, therefore, has to be sectionalized as far as possible. Stores, explosives, etc., that can be kept down to convenient sizes and weights for mule transport cost about $£ 8$ per ton from Zaragoza to the mines. Machinery, rails, and all awkward and heavy cargo cost double this.

It is not only the cost of transport which is so high, but the consequent delay is also expensive. During the dry season, when conditions as to road transport are at their best, the reverse is the case with the river transport, and it is not at all unusual for the steam-driven flat-bottomed cargo boats coming up river to go aground and remain
aground for weeks until the rains start and the rivers rise.

Many people have expressed surprise that so old established a company has not built a properly-graded road fit for motor or at any rate wheeled transport from Zaragoza to the mines. The reply to this is twofold: (1) The company's only product is gold bullion. This does not go to Zaragoza, but to Medellin, and six to eight mules carry a month's output, and (2) in the very broken country through which the road would have to pass and taking into account the heavy rainfall of 120 in . per annum and upwards the annual maintenance only of a graded road would exceed the total annual cost of the freight from Zaragoza to the mines in a normal year.

It has been pointed out that the company is working only one or two of the many gold-bearing lodes comprised within their large property. The writer examined the mines in the spring of last year and, in view of the favourable report by the companies' consulting engineers which followed and the recommendations made, the directors have decided to enlarge the scope of the company's operations as financial considerations allow. The increased hydro-electric power now becoming available, together with an improvement in the supply of labour, are among the
favourable factors to be taken into account in connexion with the carrying out of such a policy.

In conclusion it should be emphasized that now for many years Colombia has been free from any serious political troubles and it is pleasing also to record that very friendly and harmonious relations exist between the companies' officials and the various government departments concerned. An important programme of road making and other public works has been planned and is being carried out, as government funds allow, with the object of improving communications and facilitating the development of the country's resources. Those who know the country do not hestiate to affirm that the Colombian Government will be found in the future, as in the past, willing to further to the fullest measure within its power the interests of those legitimate concerns prepared to develop the mineral and other resources of their country.

The writer desires to acknowledge very fully the assistance received from Mr. John Reed, the general superintendent at the mines, and also from Mr. J. J. Truran, the secretary of the Frontino \& Bolivia and associated companies in obtaining and co-ordinating the data and details embodied in this article.

# AERIAL ROPEWAY CALCULATIONS 

By G. BRILLO

In this article the author, having previously described the mechanics of aerial ropeways, gives certain formulæ necessary for the design of such plant.

In a previous article in the last issue of the Magazine a description was given of the parts composing an aerial ropeway and some idea of how to work out a rough price for a bi-cable plant and its operation. In the present article some particulars are given of all the necessary formulæ, so that when certain data have been arrived at, such as length and differences in level of the line, quality of material to be transported, and capacity per hour on the line, the various ropes, driving power, and everything else may be calculated to enable a small accurate project for an aerial ropeway for the transport of materials to be elaborated. Following the line of the first article all the formulæ relating to the bi-cable type of ropeway will be given.

Usually the elements that are needed for the calculations of an aerial ropeway for the transport of materials are the following :-
(1) Survey of the Line from Terminal to Terminal.-The survey should include the cross section of the line and the planimetrical route of it. As stated before, it would be much better, if possible, to have the route of the ropeway in an absolutely straight line, as angles increase the first cost and the working cost. It should be noted that usually at the terminals, and at the angles, enough space should be provided for the installation of stations. As a matter of fact it would be advisable to have small contour maps of the sites where the stations have to be erected. The profile of the line gives the complete altimetrical route of it with all the necessary levels. Usually these profiles are made to the following scale : $1 \mathrm{in} .=100 \mathrm{ft}$. ; $1 \mathrm{in} .=$ 150 ft ; or, $1 \mathrm{in} .=200 \mathrm{ft}$. In the profile as well as in the planimetry of the line, all the important crossings such as roads and
railways, etc., have to be shown, as they have to be protected.
(2) Capacity of the Plant-That is, the quantity of materials that has to be transported per working hour, and number of working hours in a day.
(3) Direction of Load.-That is, between terminals, whether upwards, downwards, or in both directions.
(4). Material.-The nature of it, and its weight per cubic foot in the state in which it would be carried.
(5) Power Available (if any is necessary).
(6) Requirements of the Two End Stations. -That is, how the material is to be loaded into the carriers and unloaded from them.

In possession of such details it is then possible to lay down the following working particulars, in which the symbols take the place of the actual figures :-

Working Particulars.-Horizontal length of the line, $D$.

Developed length of the line, L.
Difference in level between terminals, $H$. Quality of material to be transported.
Weight per cubic foot of the material to be transported.

Direction of load.
Carrying capacity per hour, Q.
Carrying capacity of one carrier, $q$.
Weight of empty carrier, p.
Weight of loaded carrier, P.
Speed of the line in feet per minute, $v$.
Number of carriers on the line.
Number of carriers at the stations.
Distance between two carriers, d .
The following table, which has been calculated by the Italian engineer G. Ceretti, gives the capacity of one carrier " $q$ " when the capacity per hour " $Q$ " of the line is known :-

| Table NO. 1 |  |
| :---: | :---: |
| Capacity | Capacity |
| per hour. | per Carrier. |
| Q | q |
| Tons. | Ciels. |
| 5 | 4 |
| 10 | 5 |
| 15 | $5 \cdot 5$ |
| 20 | 6 |
| 30 | 8 |
| 40 | 9 |
| 50 | $9 \cdot 5$ |
| 60 | 10 |
| 70 | 11 |
| 80 | 12 |
| 90 | 14 |
| 100 | 15 |
| 150 | 22 |
| 200 | 28 |
| 250 | 36 |
| 300 | 40 |

In order to obtain " $q$," that is, the weight of an empty carrier, the following data will assist. It is known that a carrier is composed of three parts, i.e. runner, hanger and bucket (or platform). The data for platforms are not given here because they vary from type to type and can be quickly estimated in each case. Instead there is given at this point the value of the weights of runners, hangers and buckets, of the types manufactured by Messrs. Ceretti and Tanfani Co., Ltd., of London. The runner may have two or four wheels. The twowheeled runner is for use up to 18 cwt . of load at the pin (including weight of load, hanger and bucket, and weight of portion of hauling rope between two carriers). Above that quantity and up to $1 \frac{1}{2}$ tons, a fourwheeled carrier is necessary. It may be assumed that the weight of a two-wheeled runner including the locking device is 140 lb ., whilst the four-wheeled carrier is 340 lb . The buckets normally vary from a capacity of $3 \cdot 5$ to $35 \mathrm{cu} . \mathrm{ft}$. Therefore their weights and the weight of the hangers vary accordingly. In the following table the weight is given of the type of buckets and hangers most used, both of light and heavy construction.

Table No. 2

| Capacity <br> of Bucket | Weight of |  | Weight of |  |
| :---: | :---: | :---: | :---: | :---: |
|  | light | pe of: |  | type: |
| in cu. ft. | Bucket. | Hanger. | Bucket. | Hanger |
|  | $l \mathrm{l}$. |  | $l \mathrm{lb}$. | $l b$. |
| 3-5 | 130 | 66 | 150 | 72 |
| 5-3 | 153 | 70 | 180 | 77 |
| 7 | 168 | 80 | 198 | 8S |
| 10.5 | 197 | 92 | 237 | 101 |
| 14 | 220 | 96 | 270 | 105 |
| $17 \cdot 5$ | 248 | 98 | 302 | 108 |
| 21 | 265 | 108 | 326 | 119 |
| 28 | 354 | 110 | 420 | 121 |
| 35 | 400 | 116 | 440 | 127 |

To obtain now the value of " $P$," add to the value " $P$ " (obtained from Table 2) the net load of the carrier.

The spacing (distance in feet) between anv two carriers is obtained from the following formula :-

$$
\mathrm{d}=\frac{60 \mathrm{qv}}{\mathrm{Q}}
$$

in which " $q$ " and " $Q$ " are expressed in 1 b . The number of carriers on the line is obtained by dividing " $L$ " (developed length of the line) by "d," whilst the number of carriers at the stations is usually $\frac{1}{2}$ or $\frac{1}{10}$ of the former.

Having now obtained all the working particulars, it is possible to proceed with the
proper calculations of the ropeway. We will divide these into five different parts, viz. :-
(1) Calculation of the hauling rope.
(2) Calculation of the driving power (or power in excess to absorb).
(3) Calculation of the adherence on the driving pulley.
(4) Calculation of the carrying ropes.
(5) Design of the route of the carrying rope on the profile of the ground.

Calculation of the Hauling Rope.First of all the profile of the ground must be thoroughly examined. This will give at once an idea of the route that the ropes will take, and the profile may therefore be divided into several regular sections. The sketch (Fig. 1) will give an idea of what is meant.

These sections obtained, the following should be written :-

Horizontal lengths in feet of each section $=1$.

The difference in level in feet between the two terminals of each section $=h$.

The number of carriers on one carrying rope in each section $=n$.
component of loads is given by the following formulæ :-

> | $\Delta=\mathrm{nP} \sin \alpha$ (for side hauling loaded |
| :--- |
| $\Delta=\mathrm{np} \sin \begin{array}{c}\alpha \text { (fors side hauling empty } \\ \text { carriers) }\end{array}$ |

in which $\alpha=$ angle of inclination of the line in the section considered. It being desirable to obtain $\Delta$ in lb., " P " and " p " have to be expressed in lb . The component of the weight of the hauling rope is given by the formula :-

$$
\Delta_{1}=g_{t} \cdot h
$$

in which $g_{t}=$ weight per ft . of hauling rope in lb .

The friction is given by the formulx :$\Delta_{2}=\mathrm{a}\left(\mathrm{nP} \cos a+\mathrm{g}_{1}\right)$ (for side hauling loaded carriers)
$\Delta_{2}=\mathrm{a}\left(\mathrm{np} \cos a+\mathrm{g}_{\mathrm{t}}\right)$ (for side hauling empty carriers)
in which :-
$a=$ general co-efficient of friction. This is equal to :-
0.025 for carriers with brass bushes and when driving power is necessary,


Another assumption to be made is the weight of the hauling rope which is not yet known, but which of course has to be taken into consideration. This has to be guessed. for the time being, but it will be seen that with a little experience this will not be a very difficult job and that the guessing is not very far from accuracy. Anyway, the first calculations made will enable one to judge with accuracy the second time and then one can proceed to amend the calculations. Starting from the terminal in which the counter-weight of the hauling rope is placed, proceed towards the other, calculating for both sides of the line the various increments of tension which take place in the rope in each section, without taking into consideration for the time being the initial tension given by the counter-weight. These increments are: The vertical component of the loads, the vertical component of the weight of the rope itself, and friction. The vertical
0.01 for carriers with brass bushes and in the case of the line being self-propelled, or with power in excess,
0.006 for carriers fitted with ball or roller bearings, and when driving power is necessary,
$0 \cdot 0025$ for carriers fitted with ball or roller bearings, but with line self-propelling, or with power in excess.
" $p$ " and " $p$ " are expressed in lb.
When these three values for each section, and for both sides of each section have been obtained, it will be easy to find the increments of tension at the entrance and exit of the driving pulley in the following manner. Starting from the terminal in which is the counter-weight and working towards the other one, add or subtract - according to whether the gradient is against or in favour of the load-the various values of $\Delta$ and $\Delta_{1}$ obtained on both sides of the line. The values $\Delta_{2}$ have always to be added, however, in the direction of the loads and
always subtracted in the opposite one. To make this clear: Let us suppose we are considering a plant with loads running from the lower terminal to the upper one. Proceeding from the former to the latter, and for the loaded side of the hauling rope (by " loaded side of the hauling rope" is meant the one which hauls the loaded carriers) add or subtract subsequently according to their being in favour or against the loads, all the various items $\Delta$ and $\Delta_{1}$ previously obtained for each section, up to the entrance of the driving pulley, bearing in mind that all the $\Delta_{2}$ (friction figures) are to be added in here, being in favour of the load. Thus at the entrance of the driving pulley a certain value " $S$ " is obtained. Then the same is done for the unloaded side of the hauling rope, bearing in mind that in this case all the $\Delta_{2}$ figures have to be subtracted because they are against the load. At the exit of the driving pulley, another value is obtained which may be called " $\mathrm{S}_{1}$." To " S " and " $\mathrm{S}_{1}$ " must be added now the initial tension given to the hauling rope by the counter-weight, that is, half of its value for each side of the said rope. Calling " $\mathrm{C}_{\mathrm{t}}$ " the weight in lb . of the counterweight, add $\frac{C_{4}}{2}$ to both " $S$ " and " $S_{1}$," obtaining two new values, i.e. " T " and " $\mathrm{T}_{1}$ " respectively which correspond to the real tensions of the rope at the exit and entrance of the driving pulley.

At this stage, it may be mentioned that the weight of the counter-weight should be such that the ratio $\frac{\mathrm{T}}{\mathrm{T}_{1}}$ (or $\frac{\mathrm{T}_{1}}{\mathrm{~T}}$ ) should not exceed 8 , for reasons to be explained later. Anyway, " $C_{t}$ " is usiually not much less, or much more, than $2,200 \mathrm{lb}$.

To the greater of " $T$ " and " $T_{1}$," must be added, in order to obtain the maximum effort of the rope at the driving end, the supplementary tension due to the bending of the rope over the main sheave. This supplementary tension is given by the formula :-

$$
{ }_{8}^{3} E \frac{d}{\mathrm{D}} \Omega
$$

in which:-
$\frac{3}{8}=$ co-efficient of correction introduced by Bach into the formula of Rouleaux.
$\mathrm{E}=$ modulus of elasticity of steel $=$ $30,000,000 \mathrm{lb}$.
$\mathrm{d}=$ diameter of wire in in.
$\mathrm{D}=$ diameter of driving pulley in in.
$\Omega=$ sectional area of the rope in sq. in.
It is to be noted that the ratio $\frac{D}{d}$ should never be less than 1,000 .

Usually it is the case that the final tension so obtained is the maximum which takes place in the whole line, although sometimes it may be that the maximum tension occurs in some other part of the line, that is, at the culminating points.

It is now possible to calculate if the rope chosen is suitable by comparing its breaking strain to the maximum effort to which it is subjected, bearing in mind that the safety factor should be within 6 and 8 .

Calculation of Driving Power (or Power in Excess to Absorb).-The peripherical effort at the main sheave is given by subtracting " T " (tension of the rope at the entrance of the sheave) from " $\mathrm{T}_{1}$ " (tension of the rope at the exit of the sheave). If this is a positive number, then the effort is to be overcome by a motor; if a negative one, the power in excess is to be absorbed by brakes.

Let "Fm" be the positive value and " $F_{\mathrm{E}}$ " the negative one. The driving power, "Nm" expressed in h.p. is given by the formulæ :-

$$
\mathrm{Nm}=\frac{\mathrm{Fm} . \mathrm{v}}{33,000 . \mathrm{c}}
$$

in which:-
$\mathrm{v}=$ speed of line in ft . per min.
$\mathrm{c}=$ co-efficient of efficiency of driving gear $=0.7$ to 0.8 .
"Fm" to be expressed in lb.
To the "Nm" thus obtained, it will be necessary to add $2 \mathrm{~h} . \mathrm{p}$. for each intermediate or angle station.

Calculation of the Adherence on the Main Pulley.-The adherence or grip of the hauling rope on the groove of the main sheave should be such that when the sheave in question is in motion or stopped, the hauling rope should not slip. Dividing "T" by " $T_{1}$ " (or vice versa according to which of these is the greater, bearing in mind that the greater has to be divided by the lesser) we shall obtain a ratio $\tau$ which should never exceed 8 (the less the better).


Fig. 2.
For winding of the rope on the sheave and counter-sheave in "ring formation" as shown in Fig. 2, the following table will show how many grooves the sheave and countersheave should have in order to ensure a reliable grip for the various values of $\tau$.

For winding of the rope in "cross formation " as shown in Fig. 3, Table 4 must be consulted.

Table No. 3
$\left.\begin{array}{cccc}\tau & \begin{array}{c}\text { Number of } \\ \text { grooves on } \\ \text { up to } \\ \text { main sheave. }\end{array} & \begin{array}{c}\text { Number of } \\ \text { grooves on } \\ \text { counter-sheave. }\end{array} & \text { Remarks. } \\ 1.37 & 1 & 1 & -\end{array} \begin{array}{c}\text { Groove without } \\ \text { leather lining. } \\ \text { Groove with }\end{array}\right]$

Table No. 4
Number of Number of

| $\tau$ | grooves on <br> main sheave. counter-sheave. <br> main <br> 2.21 | 2 | 1 |
| :---: | :---: | :---: | :---: | | Rumber of |
| :---: |
| 3.86 |

The above tables have been worked out as follows: Main sheaves having 70 in ., 80 in ., and 90 in . in diameter and counter-sheaves having $60 \mathrm{in} ., 70 \mathrm{in}$., and 80 in . in diameter. The author would prefer to have the winding of the rope on sheave and counter-sheave as in the first example.


Fig. 3
Calculations of Carrying Ropes.-As was noted in the previous article there are three types of carrying ropes mainly used, i.e. the spiral type, the fully-locked type, and the semi-locked type. The circumference in inches of the carrying ropes is given by the following formulæ:-

$$
\begin{aligned}
& \mathrm{O}=\mathrm{a} \sqrt{(\mathrm{P}+\mathrm{g} \cdot \mathrm{~d}) \cdot \mathrm{b}} \begin{array}{l}
\text { (for loaded carrying } \\
\text { rope) }
\end{array} \\
& \quad \mathrm{O}=\mathrm{a} \sqrt{(\mathrm{p}+\mathrm{g} \cdot \mathrm{~d}) \cdot \mathrm{b}} \text { (for unloaded carry- } \\
& \text { ing rope) }
\end{aligned}
$$

$\mathrm{O}=$ circumference of carrying ropes in in.
$\mathrm{a}=$ co-efficient that varies with the type of rope, its breaking strain, and the factor of safety, i.e. :-

For spiral carrying rope having a breaking strain of 92 tons per sq. in.:-
For a safety factor 3
$3 \frac{1}{2}$
$3 \frac{3}{4}$
4. $a=0.0855$
$a=0.0913$
$a=0.0946$
For locked or semi-locked carrying ropes having breaking strain of 76 tons per sq. in. :For a safety factor $3 \frac{1}{2} \quad, \quad a=0.0913$ 3 . $\quad a=0.0962$ $4 \quad a=0 \cdot 1012$
$\mathrm{P}=$ weight of loaded carrier in lb .
$\mathrm{p}=\quad$ " empty carriers in lb.
$\mathrm{g}=\quad$., hauling rope in lb . per ft .
$\mathrm{d}=$ distance in ft . between two carriers.
$b=$ co-efficient that varies in accordance with the number of the wheels on a carrier, and if the carriers are coupled in tandem, i.e.:-
For 2 wheeled carrier
$b=1$
", 4 two 2 wheeled carriers
in tandem . $\quad \mathrm{b}=0.55$ to 0.6
, two 4 wheeled carriers
in tandem
b -0.35 to $0 \cdot 4$
The above is a formula dictated by G. Ceretti which the writer has modified to be suitable to English measurements. It would take too long here to give all the mathematics by which the formula has been obtained, for which the reader is directed to the standard text-books.

Having obtained the circumference of the carrying rope, the value of the counterweight must be fixed. This value in lb . is given by the following formula :-

$$
\mathrm{C}=\frac{\mathrm{R}}{\sigma+1 \cdot 5}
$$

in which:-
$\mathrm{R}=$ breaking strain of the ropes in lb .
$\sigma=$ total factor of safety that the rope should work.
Design of the Route of the Carrying Ropes on the Profile of the Ground.In the previous article it was explained where trestles and intermediate anchorage and tension devices are situated, and also some idea of their purpose was given. Therefore, it is known that in order to support the ropes along the line, it is necessary to have trestles, and that owing to the fact that it is not advisable to have a single length of carrying rope greater than 2 miles, intermediate anchorage and tension devices should be provided. In considering the profile of a site where an aerial ropeway is to be erected, and the length exceeds 2 miles, the spots
where the intermediate devices have to be placed must first be chosen. Preferably these should be on elevated points. Then the route of the carrying ropes for each section thus obtained must be laid out, bearing in mind that in a concave section the rope in question disposes itself in a catenary curve and that in a convex section a succession of trestles should be put in order that each trestle may bear a very light angle.

Practically, owing to the fact that the catenary curve is very similar to the parabolic curve, the latter is taken into consideration for calculation purposes. The formulæ which give the sag in the middle of a span are as follows :-
! - horizontal length of span in ft.
$\mathrm{L}=$ developed
$T=$ tension of carrying rope at the counterweight in lb.
In calculating the profile, it is better that in the concave section of the profile the socalled "safety parabolic curve" which is the ideal line that will connect the heads of the various trestles be worked out. The sag of this ideal curve is given by the formula :-

$$
\mathrm{f}=\frac{\mathrm{g} \cdot 1 \cdot \mathrm{~L}}{12 \mathrm{~T}}
$$

in which the symbols have the same meaning as described in this item. Also it may be the case that the sag is required not only


Fig. 4.

For unloaded carrying rope:-

$$
\mathrm{f}=\frac{\mathrm{E} \cdot 1 . \mathrm{I}}{8 \mathrm{~T}}
$$

For carrying rope loaded with a central load " P ":

$$
\mathrm{f}=\frac{\mathrm{l}}{4^{\prime} \mathrm{r}}\left(\mathrm{~g} \frac{\mathrm{I}}{2}+\mathrm{F}^{\prime}\right)
$$

For carrying rope with load uniformly distributed :-

$$
f-\frac{\left(g+g_{1}\right) \cdot 1 \cdot L}{8 T}
$$

in which :-
$\mathbf{f}=$ sag (measured on the vertical) in the middle of the span in ft .
$\mathrm{g}=$ weight of carrying rope in lb . per ft . of length.
$\mathrm{g}_{1}=$ weight in lb . per ft . of the combined load of carriers and hauling rope, presuming it is distributed uniformly along the whole carrying rope.
$\mathrm{P}=$ weight in lb . of the single load including carrier and length of hauling rope supported.
in the middle of the span, but at any point of the span, in order to see if the clearance from the ground will be sufficient, and the formula for this is the following :-

$$
\mathrm{f}_{1}=\frac{4 \mathrm{f}}{1^{2}} \cdot \mathrm{X} 1 \cdot \mathrm{X} 2
$$

in which:-
$\mathrm{f}_{1}=$ sag along the vertical at the desired point in ft .
$\mathrm{f}=\mathrm{sag}$ in the middle of the span as worked out with the help of the above said formulæ in ft.
X 1 and $\mathrm{X} 2=$ the horizontal distances in ft . from the two terminals of the span where the sag is being calculated.
In the convex section of the profile, however, it is desirable to erect a sufficient number of trestles to obtain a gradual change of gradient of the ropes without loading the said trestles too much. On each trestle, the carrying rope, either empty or loaded, should always effect a positive angle of pressure of which the value has to be contained within certain limits.

We will call " $\phi$ " the angle formed by the carrying rope only under the action of its own weight, and " $\psi$ " the one formed when fully loaded. From Fig. 4 it will be seen that there are four kinds of angles on the trestles, that is :-
$a=$ the angle formed by the cord of the two adjacent spans.
$\beta_{1}$ and $\beta_{2}=$ the additional angles formed by the tangent to the catenaries of the rope.
$\gamma_{1}$ and $\gamma_{2}=$ the additional angles formed by the tangent to the catenaries of the loaded rope, presuming the load to be uniformly distributed on the whole length of the line.
$\delta=$ the additional angle formed by the tangent to the catenary when a loaded carrier is approaching the trestle. Therefore, it can be written that-

$$
\begin{array}{l|l}
\beta=\beta_{1}+\beta_{2} & \phi=\alpha+\beta \\
\gamma=\gamma_{1}+\gamma_{2} & \psi=\tau+\gamma+\delta
\end{array}
$$

It will be much quicker and easier to obtain " $\alpha$ " (expressed in radians) graphically from the profile, whilst the formulæ which give the value of " $\beta$," " $\gamma$," and " $\delta$ " (expressed in radians) are the following:-

$$
\begin{aligned}
& \beta=\frac{g(A+B)}{2 T} \\
& \gamma=\frac{P(A+B)}{2 d . T} \\
& \delta=\frac{P}{T}
\end{aligned}
$$

in which:-
$\mathrm{g}=$ weight of rope in lb . per ft .
$A$ and $B=$ horizontal length of the two spans adjacent to the trestles (in ft .).
$T=$ tension of the carrying rope in lb.
$\mathrm{P}=$ weight of the loaded carrier including portion of hauling rope between two carriers in lb .
$\mathrm{d}=$ spacing (distance between) two carriers in ft .
To obtain " $\phi$ " and " $\psi$ " (also expressed in radians) it is necessary to add arithmetically the values obtained above. The accepted values are :-
$\phi$ equal to or less than 0.04 to 0.06 (for
important lines)
0.06 to $0.1 \quad$ (for
ordinary lines)
\% ". ., 0.36

At this stage the reader's attention must be called to the fact that sometimes the
angle formed by the two cords of the adjacent span of the trestles is concave. Therefore, in this case a should have a negative value, i.e. which should be subtracted instead of added.

Three different types of shoes are usually manufactured, i.e. short, medium and long. The short shoes (length of which is from 2 to $2 \frac{1}{2} \mathrm{ft}$.) take angle " $\psi$ " up to $0 \cdot 17$. The medium shoe has a length from $2 \frac{1}{2}$ to $3 \cdot 3 \mathrm{ft}$., and takes angle " $\psi$ " from $0-17$ to 0.26 . The long shoe has a length from $3 \cdot 6$ to 4 ft ., and takes " $\psi$ " from 0.26 to 0.36 . The writer thinks it may be added that the shoes on a trestle should have a slope equal to half the algebraic sum of the two slopes of the two adjacent spans, these if the said spans are approximately equal in length. If the spans are unequal, the gradient of the shoe will be half the above said sum plus the supplementary slope given by the following formula :-

in which the symbols have the meaning as explained before. Sometimes it happens that for a particular condition of the ground, in a certain spot, it is not possible to have on a trestle an angle " $\phi$ " (supposing empty carrying ropes) as small as $\mathbf{0 . 1}$. In such cases therefore special multiple trestles are considered, which are steel structures, of practically the same construction as an intermediate stretching device, in which the shoes are made of a long channel iron, specially shaped and duly curved. In here, the hauling rope is supported by batteries of rollers.

Before concluding this article a very useful formula for the calculation of the weight of the anchorage blocks of the carrying ropes should be given. Supposing from the Fig. 5 " T " is the tension on the carrying rope (in tons), and " O " the centre of gravity of the section of the concrete block, then if-
$\mathrm{l}=$ distance between the carrying rope and the rotating point of the section of the concrete block in ft . and
$\mathrm{L}=$ distance between " O " and the said point of rotation in ft ., then $\mathrm{PL}=1 \cdot 5+2 \mathrm{Tl}$
in which:-
$\mathrm{P}=$ the weight of the concrete block in tons.

The formulæ which have been given, of course, refer to a bi-cable plant, but the formulæ for the calculations of a mono-cable plant could be easily worked out with the help of those given.

## THE RECOVERY OF VANADIUM PENTOXIDE AT THE RHODESIA BROKEN HILL

The process here described for the recovery of vanadium as pentoxide at the lead-zinc mines of the Rhodesia Broken Hill Development Company is compiled from a report issued by the company.

Ore Deposits. - The ore deposits of Rhodesia Broken Hill occur in a dolomitic formation and have originated by the replacement of susceptible beds in the dolomite by cross-cutting mineralizing fissures. They take the form of successive lenses bearing slightly south of west by north of east and dipping steeply to the north, conformably to the strike and dip of the enclosing dolomite.

The mode of occurrence of the oxidized and primary ores is characteristic. The more important ore-bodies always consist of two parts: A central portion or core of massive sulphide ore-zinc blende and galena-enclosed within an envelope or "shell" of oxidized ore, principally zinc silicate.

Zinc silicate is the local designation for the bulk of the oxidized ore, which consists of quartz, iron oxides and zinc silicate, with lesser amounts of zinc carbonate, lead carbonate and vanadium minerals. It is very rich, assaying from $30 \%$ to $55 \%$ of zinc and lead combined.

The occurrence of vanadium in the oxidized ores is of special interest. The rich vanadium ores have a well-defined relation to the oxidized ores, being developed on the margins of the latter and largely in the broken ground between the massive oxidized ores and the dolomite as well as in open fissures and cavities. The whole of the oxidized ores also contain a small percentage of vanadium. Descloizite with lesser amounts of vanadinite constitute the vanadium bearing minerals.

Vanadium Recovery. - The following is a description of the process used for the recovery of vanadium pentoxide from zinc-iron vanadate as used in the works of the Rhodesia Broke. Hill Development Co., Ltd., Broken Hill, Northern Rhodesia. In the Magazine last month Dr. S. W. Smith
in the concluding instalment of his article describing metallurgy in South Africa, as observed during the recent tour of the Empire Mining and Metallurgical Congress, dealt briefly with the plant and operations at this mine, but not in any detail with the vanadium, an important and valuable by-product.

The ores of the Broken Hill zinc-lead deposit in Northern Rhodesia contain vanadium in the form of descloizite and vanadinite. In the extraction of the zinc from the ore for electrolytic recovery, the vanadium is dissolved and its recovery is now effected in the form of fused vanadium pentoxide.

The vanadium is precipitated from the zinc solution by the addition of dross, calcines, or milk of lime, as a zinc or iron vanadate, or a mixture thereof, which precipitate is subjected to retreatment for the recovery of the vanadium in a purified form. The precipitate is removed from the solution by filtration in pressure filter presses, the filtrate being returned to the zinc circuit, and the cake washed with water to remove most of the soluble zinc. When washing is complete, the precipitate is discharged from the press and transported to a storage bin, whence it is fed together with water to a grinding mill where the cake is converted to slurry. The mill discharge is pumped to storage tanks, in which agitation is maintained, and from which pulp is withdrawn as required to the first stage of purification, which is a solution of the vanadium values in caustic soda. The latter reagent is prepared on the plant by reaction between lime and sodium carbonate in the well-known manner, and is produced as a caustic liquor containing at least 75 g.p.l. NaOH .

Proportions of vanadate slurry and caustic solution depending on the relative density
and strength, are mixed in an iron tank provided with agitation and means of steam heating. The temperature is raised to nearly $100^{\circ} \mathrm{C}$. and agitation is continued until the reaction is complete, approximately 1 to 2 hours. The vanadium dissolves as a sodium vanadate and the zinc, iron, etc., mostly remain insoluble as hydroxides.

The pulp is then pumped to a filter press and the purified solution sent on to the next stage of treatment. The residue in the press is washed with water and then discharged and transported to a pug-mixing machine which delivers into an agitation tank where the residue is suspended in zinc solution and then pumped back to the zinc circuit for recovery of that metal and utilization of its basiscity for further precipitation purposes.

The sodium vanadate solution is then sent to the vanadic hydrate precipitation tanks, where sulphuric acid is added until free acidity is about 5 g.p.l. $\mathrm{H}_{2} \mathrm{SO}_{4}$. Steam is then turned on and the temperature allowed to rise to a maximum about $95^{\circ} \mathrm{C}$. The solution may be heated prior to addition of acid or acid added during heating, whichever of the three methods is most convenient. Acid is added from time to time as may be necessary to maintain at least 5 g.p.l. excess, though excess up to 25 g.p.l. can be added without detriment. As the temperature rises, the vanadic hydrate will be precipitated and maximum precipitation will be obtained at boiling point, the final temperature of the solution being such as to give an economic precipitation consistent with the cost of steam heating. Excess of acid generally lowers the precipitation efficiency, but may give a more pure product so the excess acid at which the precipitation is conducted is regulated
to be the amount required to produce maximum precipitation at the desired purity. The residual impurities in the solution remain dissolved and the vanadic hydrate is practically pure.

When precipitation has reached the desired standard, the pulp is filter pressed in a wooden framed press. The filtrate is either run to waste or is retreated for its vanadium content depending on the amount of the latter. Such retreatment may be simply returning to the zinc circuit at a suitable point if the content of other soluble salts permit, or may be a precipitation with lime, which precipitate would then be re-treated in the causticizing step and the vanadium recovered in the caustic solution during the use of the latter to dissolve the vanadium from the zinc vanadate.

The vanadic hydrate precipitate in the press is then washed until all soluble salts are removed, the wash being used in a counter-current manner, and the strong wash returned to the precipitation circuit, after which the cake is discharged to a bin and then fed to a gas-fired melting furnace, where first the moisture and combined water are drawn off, and then the dehydrated material fused. The fused oxide discharges more or less continually into moulds, from which it is discharged, crushed and bagged.

The grade of oxide produced is at least $90 \% \quad \mathrm{~V}_{2} \mathrm{O}_{5}$ and may be $95 \%$ or better. It is practically free from phosphorus and sulphur, the balance being made up of alkalies, with small amounts of silica and iron. The method of treatment has been developed by the General Manager, Mr. R. H. Stevens, who was responsible for the original zinc leaching process, which is now the principal interest of the company.

## BOOK REVIEWS

Sedimentary Petrography. By H. B. Milner. Second (Revised and Complete) Edition. Cloth, octavo, 514 pages, illustrated. Price 21s. London: Thomas Murby and Co.
Out of the modest "Introduction" to the study of detritals, which made its first appearance eight years ago, has evolved the substantial, well-printed, and very readable volume now under review, comprising nearly 500 pages of concise text-matter and 181 illustrations directed to the study and interpretation of sedimentaries in general. About
a hundred pages (constituting Ch. V, which is new) are devoted to the petrography (group characters, types, and modes of origin) of the sedimentary rocks, which are treated in relation to the problem of correlating types from sequence to sequence-under conditions, and by methods, which are fully described in earlier and later chapters.

In such an expansion of the original work, we expect to find not only a more detailed treatment of basic nrinciples, but also new ideas, new techniqud worthy of extended trial, and an adequate account of recent applications of the subject to academic and
industrial requirements. The reader is not disappointed. Although in respect of both treatment and outlook the author admits bias in the direction of oil-field routine and requirements, this bias is not likely to hinder a reader in search of principles elastic enough to meet requirements in some other " field" hardly less specialized--the study of soils, for instance ; if the reader be an agricultural chemist, or in any way concerned with the mineral composition of particular soils, the whole of Chapter XI (which is new) is " biassed " in his favour, while all the rest of the volume is his in common right. Chapter V (also new) is a useful epitome of the rules, conventions, etc., by which petrographical facts of various kinds are quantitatively assessed and recorded. Chapters IX and X are equally catholic in their appeal; they contain a wealth of descriptive detail and comment on methods applied and results obtained in various investigations at home and abroad. The student who cannot find in this volume what he wants in the form of hints and suggestions as to methods, etc., must have a weird problem in hand, or the problem is quite ordinary but rather beyond him.

No effort has been spared by the author to supplement text-description of mineral species by figures illustrating specific "habits" assumed by mineral grains according as they have been involved in one or more cycles of sedimentation, with varying degrees of attrition. Just as " Cæsar and Pompey were very much alike, especially Pompey," so also are figuved grains of magnetite and ilmenite, epidote and monazite, zoisite and clinozoisite, etc.: resemblances may involve three or even more species. The author, who appreciates this difficulty fully, does much in this volume to direct the beginner along the right lines in this most difficult field of determinative mineralogy.

## A. Brammall.

## The Metallurgy of the Non-Ferrous

 Metals. By William Gowland. Fourth Edition, revised by C. O. Bannister. Cloth, octavo, 633 pages, illustrated. Price 30 s . London: Charles Griffin and Co.The late Professor Gowland's well known textbook on the metallurgy of the nonferrous metals has gained such a secure position amongst the students of metallurgical engineering, that a cordial welcome
from all quarters is assured to a new edition. The arduous task of revision has been very ably carried out by Professor C. O. Bannister of the Liverpool University in a manner which would, certainly, have met with the approval of the original author, his former teacher.

The general arrangement of the book remains unchanged, the various sections dealing with each metal in turn, as in the previous edition. Professor Bannister has made considerable additions to the subject matter, but he has pruned the text so skilfully that the volume barely exceeds its former dimensions. At first glance it may seem regrettable that any of Professor Gowland's original material should be deleted, but the continual change in the practice of metallurgy makes this unavoidable if the book is to be brought up to date and is not to be expanded to an unwieldy size. It must be admitted that Professor Bannister might have been far more severe in this part of his task without diminishing the value of the book to any extent. In nearly every case where a portion of the original text has been removed, the omission is compensated by the inclusion of more recent information. In one or two isolated instances the reviser has overlooked the effect of his alterations on the adjoining text. Thus, referring to fireclays on page 6 , we read that "Alkalies are most injurious, seriously increasing the fusibility of clays. Two per cent should be the maximum permissible. Titanium compounds are frequently present in fireclays, but the amount (under 2 per cent) has little effect on the refractoriness. Mica is similar, but much less powerful in its effects." The added reference to the effect of titanium breaks the connection between the statements concerning alkalies and mica. Again, when speaking of the Cornish tin smelting furnaces on page 522 , it is stated that the hearth " cannot be dropped like that of the furnace just described " (i.e. the Pulo Brani reverberatory furnace). On referring back, however, we find that the description of the dropping of the hearth has been omitted from the new edition.

Amongst the more important additions to the subject matter of the text, the following should be mentioned. In the chapter on refractory materials, a summary of the properties of silica at different temperatures has been included. The section dealing with platinum has been consi derably
altered in order to include references to the treatment of the platinum deposits of South Africa. To the chapter on cadmium have been added two new paragraphs which describe the extraction of that metal, by wet methods, from flue dust and bag-house fume and from the precipitate obtained from clectrolytic zinc plants. Considerable alterations have been made in the final chapter on aluminium in order to include various items, such as brief references to the alloys of aluminium with manganese and with silicon, to the preparation of alumina by the Hall, Pedersen, and Haglund processes, and to the conditions which obtain during the "up" periods in electrolysing.

The book contains a vast quantity of fundamental information in abbreviated form, and it should find a place on the bookshelves of all those who are interested in the general study of non-ferrous metallurgy. Professor Bannister is to be warmly congratulated on the excellent manner in which he has completed his task, and it is to be hoped that his assistance will again be available when the production of a fifth edition is contemplated.

C. W. Dannatt.

Tables for the Determination of Minerals - by means of their physical properties, occurrences, and associates. By E. H. Kraus and W. F. Hunt. Cloth, octavo, 266 pages. Price 15 s. London: McGraw Hill.
Twenty years ago E. H. Kraus and W. F. Hunt, professors of mineralogy and petrology respectively at the University of Michigan, published the first edition of this book, in which they made lustre and colour the basis of their determinative tables, with further subdivisions based on the streak and hardness.

The authors rightly maintain that their tables have been used with marked success for two decades, which clearly demonstrates that their original arrangement was sound in principle, and practical in its application. They have good reason, therefore, in this second edition for keeping the original tables essentially unchanged. They have, however, taken the opportunity of adding a very useful table, in which the minerals are arranged according to their specific gravities.

William R. Jones.

Bergbaumechanik. Text-book for mining institutions and hand-book for practical mining. By Dipl.-Ing. J. Maerks. Paper boards, 451 pages, illustrated. Price 19.50 marks. Berlin: Julius Springer.
In this good book the mechanical laws, leaving out any detailed abstract treatment, are illustrated by the application to mining problems. In succession, statics, dynamics, elasticity of structural materials, and hydraulics, are the subjects taken. Statics and dynamics occupy about two-thirds of the book while of the remaining third hydraulics occupies the greater portion, leaving elasticity of materials only a relatively short section. The diagrams throughout are clear, simple, and convincing, and there are actually more diagrams than there are pages. The book has no index, but this lack is largely made good by a comprehensive table of contents. It is put forward by the author as a text-book for mining schools and as a hand-book useful in mining practice, and for both of these purposes it can be highly recommended. It is a book on mining mechanics of which an English equivalent would be much welcomed.
S. J. Truscott.

Metalliferous Mine Surveying. By T. G. Hanton. Cloth, octavo, 224 pages, illustrated. Price 15 s . London : Crosby Lockwood and Son.
This book has the same title, about the same number of pages, and the same price as one by F. Winiberg published in 1925 by Mining Publications, Ltd., and reviewed by Alex. Richardson in the September, 1925, issue of the Magazine. The printing of the work now under review is more openly spaced between lines and the diagrams, 82 in number, are fewer by 16. The total contents are therefore considerably less.

One of the 18 chapters into which the subject matter of this book is divided is devoted principally to mine plans and includes hints about conventional signs, isometric plans, and the making of tracings and prints. The last page of this chapter contains some rather disparaging remarks about mine models. This is peculiarly unfortunate at a time like the present, when the advantageous use of these auxiliary endoscopic devices is being so greatly extended owing to the rapid growth of a proper appreciation.

The chapter on surface surveys occupies seven pages and includes all that is said about surface triangulation. The one on underground surveys fills only 11 pages. Those on vertical connexions and miscellaneous surface surveys cover 10 plus 12 pages and deal for the most part with setting out. Stadia work receives three pages at the end of a 28 page chapter on the theodolite. Plane tabling is not mentioned, nor is Weisbaching.
According to the preface, the object with which the book was written was to bring the subject of mine surveying up to date. To what extent has this ambitious and laudable intention been implemented? The book is evidence of an earnest effort to produce something really useful to the mine surveyor. It is fairly well arranged, written, and illustrated; it has a pleasing and attractive appearance, and it will no doubt prove helpful to the tiro. Nothing further need be said, excepting it would appear that the author omitted to give due attention to many valuable contributions to the literature of mine surveying, including those of the late Professor L. H. Cooke, of the Royal School of Mines.
F. W. Armstrong.

Outlines of Physical Geology. By Chester R. Longwell. Cloth, octavo, vi +376 pages, illustrated. Price 15 s . New York: John Wiley \& Sons. London: Chapman \& Hall.
The foundations of this book are substantially the recent third edition of Pirsson and Schuchert, that admirable collective work to which the present author contributed no mean share. This volume, however, follows so closely the larger text that it is a little difficult to see exactly what purpose it fills save as a briefer and perhaps more elementary exposition. There are, nevertheless, a number of people to whom " outlines" of a subject make a compelling psychological appeal, to whom a "textbook " savours of something too learned and weighty for digestion, but the serious student of geology would scorn such a short cut, and to him the advice is unhesitatingly given to acquire the larger work. For those who desire an easily readable account of the earth, the processes of its weathering, the action of water and ice, the natural history of oceans, lakes, rocks of all kinds, earth structures and land-forms, and who
prefer their perusal generously punctuated with illustrations, this is the book to get. It is a typical example of Wiley publications of its class, well printed and bound, and is not unreasonably priced.

## H. B. Milner.

ITE 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 <br> JOHANNESBURG January 8.

New Kleinfontein's New Reef.-An interesting discussion has taken place in the Rand Press regarding the new reef which is being opened up in the New Kleinfontein Co.'s property. The company's technical advisers are of opinion that the reef is not a faulted portion of any reef which has hitherto been worked, but is an undenuded remnant of an underlying and geologically older reef. The sub outcrop of this reef runs diagonally through the lower part of the central section of the mine and has been located therein at points along some four thousand feet between the seventh level at No. 3 shaft and the sixteenth level at No. 5 shaft.
Discovery of Banket in Rhodesia.Considerable excitement has been caused in the Fort Victoria district, Southern Rhodesia, by the rediscovery of a gold-bearing banket reef to all appearances identical with that of the Witwatersrand. The strike of the new reef has been traced for seven miles, and forms a continuous unbroken ridge over this distance. The reef was actually exposed when the road to Zimbabwe was made, and can be seen in the cutting now. Its strike is approximately east and west, and its dip almost vertical, with a slight inclination towards the south. Samples from this reef, it is said, might well have been taken from the Rand. In three places where opening up has been commenced the width of the reef is 7 ft ., and its walls are clearly defined and strong. The discoverers panned samples from the outcrop which showed traces of gold and encouraged by this they started to sink on the reef. Below the oxidized outcrop no traces of gold in the pan could be found, but two samples sent to the Standard Bank for assay gave results of 75 and 4.0 dwt . per ton. They continued to sink and reached a depth of 12 ft . from surface and pannings from this depth again showed
no traces of gold, but roasted samples yielded as much as 10 dwt . in the pan. It appears that the gold is contained in iron pyrites and until this is oxidized the gold does not show in the pan, which probably accounts for the fact that the reef has never been pegged by any of the numerous prospectors who have gone over it many hundreds of times. The discoverers of the reef have pegged several blocks of claims, which they have named Rhorand, and they are at present developing in a small way with the object of proving that the reef goes down and carries gold values at depth. They intend having an analysis made of the ore, as it contains a heavy mineral, most difficult to separate from the gold in the pan.

Platinum Disappointments.-Owing to the heavy fall in the price of platinum group metals public interest in the Transvaal platinum industry is practically dead. Operations have been suspended by the Lydenburg Platinum Areas which has been working two dunite pipe occurrences and the only mines still producing are the Potgietersrust Platinums, Ltd. and the Waterval Platinum Mining Co. These two companies are milling rich ore in the Rustenburg district and finding it difficult to make ends meet. Both companies are in debt. At the annual meeting of Potgietersrust Platinums the chairman made the following interesting statement regarding price stabilization and cost of production: "Negotiations have been carried on throughout the year towards stabilizing the price of platinum. There are many factors to contend with, but shareholders may rest assured that everything possible is being done to arrive at an agreement to stabilize the price of the platinum group metals."

Oil Shale Deposits in Natal.-Large oil shale deposits in the Impendhle district, Natal, are to be developed this year by a company that is now being formed in Durban. Samples taken from the deposits, which are in the vicinity of Underberg, have been sent to England, where they have yielded excellent results. Analysis shows that the shale contains an average of 30 gallons of crude oil to the ton. The company will be called Vergelegen Shale Oil and Mineral Company and will have a capital of $£ 15,000$. The deposit is a 3 ft . seam which appears on both sides of a hill. It is thought that it is continuous and runs through from one side to the other. Plant has been ordered, but at present it is proposed only to extract oil and to sell it in its crude state.

It is expected that about 20 gallons of oil will be extracted from each ton of raw material. The plant will be capable of distilling 80 tons of shale a day, giving an approximate yield of 2,400 gallons. It is estimated that there are over $11,000,000$ tons of shale on 12 of the claims at Impendhle, so that the supply is regarded as almost inexhaustible. As the shale occurs in a thick seam in the hillside there will be no difficulty in removing it.

## VANCOUVER

January 10
Mineral Production.-The Department of Mines has issued the following estimate of the mineral production of British Columbia for 1930, compiled by Mr. J. D. Galloway, Provincial Mineralogist: Gold, 163,000 oz. ; silver, $11,800,000 \mathrm{oz} . ;$ copper, $92,000,000$ lb. ; lead, $320,000,000 \mathrm{lb}$; zinc, $250,000,000$ lb. ; coal, 1,878,000 tons; structural materials and miscellaneous metals and minerals to the value of $\$ 4,325,000$. Total value $\$ 55,164,515$. This compares with a production in 1929 of gold, 152,322 oz. ; silver, $9,918,800$ oz.; copper, 101,483,857 lb. ; lead, $302,346,268 \mathrm{lb}$. ; zinc, 172,096,841 lb.; coal, 2,251,252 tons ; and structural materials and miscellancous metals and minerals to the value of $\$ 5,695,613$. The large increase in the production of zinc is due chiefly to the new lead-slag fuming-plant at Tadanac, which was put into operation last summer. Besides treating current slag, which contains about $17 \%$ of zinc, the plant is treating a large accumulation of old slag, running from 15 to $25 \%$ of zinc. The slag is tapped into nine-ton pots and conveyed by a travelling crane to the fuming furnace, which has a capacity of 40 tons; old slag is added and coal dust is blown into the slag, raising the temperature to about $1,800^{\circ} \mathrm{F}$. The zinc is reduced to metal, oxidized in the upper part of the furnace, and the fume after passing through a series of cooling devices is collected in bag houses, whence it is trammed to the electrolytic zinc plant. The treatment is slightly different from that of calcined concentrate. The plant has a rated capacity of 50 tons of metallic zinc daily, but by the addition of a second furnace and another cooling boiler, for which provisions have been made in the building, its capacity can be doubled. It is understood that the plant is likely markedly to change zinc recovery practice at Tadanac and that in future rich lead-zinc ores will be smelted directly for the recovery of silver and lead without any
previous wet concentration, the zinc being subsequently recovered from the slag. A considerable quantity of such ore occurs in the Sullivan mine, and it is believed that this can be treated more economically in this way

Britannia Beach.-Britannia Mining \& Smelting Company, despite curtailment of production in common with other copper producers on this continent toward the end of the year, made a new high record with an output of approximately $45,000,000 \mathrm{lb}$. of copper in 1930. Mr. C. P. Browning, general manager for the company, reports that normal development was carried on during the year and that special attention was paid to the Bluff deposit on the 3,100 ft . level. At the Chelan mine, near Lucerne, in the State of Washington, the company's exploration department carried on development until the end of last June when the Chelan Copper Mining Company was formed as a subsidiary company to take over the work and about 100 men have been and are employed on underground and surface work, with encouraging results. Torbrit Mining Company, which is controlled by Britannia \& Toric Mining Companies, continued the development of the Toric mine near Alice Arm until the end of last March, when, as the important metal in the deposit is silver, further work was suspended owing to the depressed price of that metal. Howe Sound Company, the holding company for Britannia, paid regular quarterly dividends of $\$ 1$ per share during last year and is believed to be the only company operating in British Columbia which was able to maintain its usual dividend rate during 1930 without diminishing its contingent reserve. Its dividend distribution during the year aggregated $\$ 1,984,152$.

Portland Canal.-Consolidated Mining \& Smelting Company of Canada has put the 100 -ton pilot mill at the Big Missouri mine into operation and is gradually tuning it up to capacity. The object of the mill, as clearly stated by officials of the company, is to determine the value of a wide silicified zone that has been explored by diamond drilling, surface, and underground work, in the hope that it may prove profitable to treat either the whole or a considerable part of the deposit in a large mill. In the event of this proving to be the case the pilot plant will be used to work out a flow-sheet for a large mill, probably of 2,000 to 2,500 tons daily capacity. Assays of samples
from this zone have been so erratic that from them it is impossible to obtain a trustworthy idea as to its average value. Premier Gold Mining Company reduced its dividend rate from 6 to $3 \%$ for the last quarter in last year. The company's gold output was appreciably less in 1930 than in 1929 but its silver output was more. The company had slightly to curtail production in the latter part of December by operating the mine for a six-day, instead of a seven-day, week. This was made necessary by the curtailment of output of copper producers tributary to the Tacoma smelter, and consequently the smelter was unable to take so much siliceous ore.

Boundary. - Consolidated Mining \& Smelting Company of Canada sent a party of engineers to make a thorough examination and sampling of Granby Consolidated Mining, Smelting \& Power Company's Copper Mountain mine, and about a week later Mr. S. G. Blaylock, vice-president, and Mr. W. M. Archibald, vice-president in charge of mines, for the company, spent two days at the property. Officials of neither company have any announcement to make as to the significance of these events, but it is well known that, if terms satisfactory to both companies can be made for the operation of the property by Consolidated, that company could operate it more cheaply than Granby can, as it has been supplying the power for its operation through a subsidiary company and Canadian Pacific Railway Company, which controls Consolidated, provides rail service to the mine and mill. In the event of Consolidated operating the property concentrate would be sent to Tadanac for treatment, instead of to Tacoma, and thus Consolidated and its friends would get all profits obtainable from the operation of the mine. Moreover, Consolidated owns claims adjoining the Copper Mountain mine and these could be worked from that mine and the ore could be concentrated in the Allenby mill.

Bridge River.-At an extraordinary general meeting of Lorne Gold Mines, held in Vancouver on January 6, shareholders by a large majority voted to decline the offer of the Bralco Development and Investment Company, an Eastern Canadian company, for a controlling interest in the company. The final payment of $\$ 95,000$ falls due to the original owners of the property at the end of this month, and they have notified the Lorne company that if this payment is
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not met foreclosure proceedings may be started. The Bralco company offered to provide this sum, and to form a new company, $60 \%$ of the shares of which were to be allotted to it and the remainder to the Lorne company. Moreover, the Bralco company offered to provide funds at $6 \%$ interest for the operation and equipment of the property, such funds and interest together with the original $\$ 95,000$ advanced to pay the final payment on the mine to be refunded from the first earnings from the property. The Lorne company owns the Lorne and Coronation mines, situated along Cadwallader Creek, and near to the Pioneer mine, which now is the second largest gold producer in the Province. This is the chief reason why the Lorne property is attracting the attention of capitalists. The Pioneer main vein, however, does not enter the Lorne property, as its strike is in a different direction. The formation, granodiorite, is the same in both properties, and several gold-bearing veins have been developed on the Lorne property, one to a depth of 660 ft .

## TORONTO

January 17.
Ontario Gold Production in 1930.Gold production for Ontario established a new high record in 1930, with a total output valued at $\$ 35,385,274$, exceeding that of the previous year by over $\$ 2,000,000$. According to a report issued by the Ontario Department of Mines, December was the best month of the year and also established a new high record for the month. The output from both the Porcupine and Kirkland Lake camps was the largest of the year, both in tonnage and values.

Porcupine.- The seven producing mines of this camp yielded bullion valued at $\$ 1,835,089$ from the treatment of 250,950 tons of ore, as compared with $\$ 1,517,137$ from 243,658 tons of ore in November. In the course of exploration on the Hollinger Consolidated two veins have been cut by diamond drilling at 400 ft . below the 2,700 ft . level, one of them showing high-grade ore. During the last few months the mill has been handling ore at the rate of 4,600 tons per day. Much development work was done during the past year with satisfactory results, ore values throughout the property being well sustained and in some sections better grades were opened up. Ore reserves at the end of 1929 were valued at $\$ 46,000,000$,
and it is officially stated that the reserves at the end of 1930 showed a slight increase. The difficulties met with in the earlier stages of operation at the new mill of the Dome Mines have now been entirely overcome. The mill is now running satisfactorily and treating ore at its rated capacity of 1,500 tons a day. A production of $\$ 195,000$ from 28,829 tons of ore milled is reporter by Vipond Consolidated for the quarter ended December 31. The company has laid out an extensive development programme to be carried out during the next two years. The first step is now under way with the sinking of the shaft from the 1,000 to the $1,400 \mathrm{ft}$. level, between which points several new levels will be run. On the completion of the shaft a cross-cut $2,000 \mathrm{ft}$. in length will be run towards the Porcupine Crown property now controlled by Vipond. The mill of the McIntyre is handling ore at the rate of 1,500 tons per day. The tonnage will be increased to 2,000 when the new mill goes into operation in about three months. Operations during the ycar have substantially increased the ore reserves. The old No. 7 shaft will be sunk to a depth of $4,000 \mathrm{ft}$. Operation immediately below the $3,000 \mathrm{ft}$. level show favourable ore conditions, and it is expected that high-grade ore will be encountered at depth. Coniaurum has entered the year 1031 on a producing basis of approximately 10,000 tons per month recovering a little over $\$ 6$ per ton. The income continues sufficient to pay all costs and also to provide for extending exploration to the lower levels.

Kirkland Lake.-The December output of bullion of the Kirkland Lake field was valued at $\$ 1,670,967$ from the treatment of 131,753 tons of ore as compared with $\$ 1,481,937$ from 122,477 tons the previous month. The I.ake Shore, which maintains its lead among the six producing mines of the camp, is treating ore at the rate of 2,200 tons daily, with an average recovery of about $\$ 12$ per ton. Some very rich ore has been opened up on the lower levels, development at the $2.000,2,200$ and 2,400 ft. levels having disclosed greater consistency of mineralization than is found on the upper levels. A width of upwards of 40 ft . of high-grade ore has been opened up in the workings between the shaft and the TeckHughes mine. The Teck-Hughes carrying out its programme of deeper mining has opened up the $3,695 \mathrm{ft}$. level, where ore showing good gold content has been encountered. In order to sink to lower
horizons a hoisting plant will be installed on the present bottom level, but the actual sinking work will not be commenced till later in the year, the objective being $6,730 \mathrm{ft}$. in depth which is expected to be reached within three years. The mill at WrightHargreaves has been stepped up to 700 tons per day. Development at the $2,400 \mathrm{ft}$. level is meeting with success, the ore showing increasing values at the lower levels. The present campaign will involve the sinking of the shaft to a depth of $3,000 \mathrm{ft}$., and the establishment of four new levels. As work proceeds on the lower levels of the Kirkland Lake gold mine additional highgrade mineralization is being opened up. Two important parallel veins were located in the $4,000,4,150$, and $4,275 \mathrm{ft}$. horizons. Over drive widths on the present bottom level the ore averages $\$ 17 \cdot 50$ per ton. The mill of the Tellurides is treating ore at the rate of from 40 to 50 tons daily, with mill heads stated to run about $\$ 18$ to the ton. Shipments of gold-copper concentrates will be commenced this month. Barry-Hollinger has completed its new three-compartment winze at the $1,750 \mathrm{ft}$. level, the station has been cut and cross-cutting is under way. The mill is now treating about 100 tons of ore per day, with mill heads running at $\$ 12$ to the ton. Sinking is ultimately planned to reach $2,000 \mathrm{ft}$.

Sudbury.-The International Nickel Company has nearly completed its four year programme of expansion. A limited amount of work, however, remains to be done in the transferring of No. 1 unit of the Port Colbourne refinery to Copper Cliff, and the outfitting of No. 4 shaft at the Frood mine with new fire-proof surface buildings, head frame, and ore hoisting equipment. In magnitude and permanence this development undoubtedly transcends any similar undertaking which has yet been attempted in the history of Canadian mining. During the four years in which actual construction work and preliminary mine development was in progress some 2,000 men in addition to the regular working force were employed. With the election of Mr. E. W. Beatty, President of the Canadian Pacific Railway, as a director of the International Nickel, in place of I-ord Melchett, the two companies have been brought into closer affiliation. Through its subsidiary the Consolidated Mining and Smelting Company, the C.P.R. is jointly interested with International Nickel in the Ontario Refining Company
plant at Copper Cliff. All Consolidated Smelter's ore is now being refined at this plant. A small but definite increase in orders for nickel has been noticed since the beginning of the year. The Falconbridge has resumed production with the new year. The completion of the new blast furnace addition has brought the capacity of the plant up to 450 tons daily, but for the present production will be limited to 250 tons per day. Development is being actively carried on including the sinking of No. 2 shaft to the 350 ft . level. The ore-body on the 500 ft . horizon will be developed as rapidly as possible and supplies for the smelter are now being drawn from the 225 and 250 ft . levels. The Treadwell Yukon is continuing its endeavours to locate large bodies of ore on the $1,500 \mathrm{ft}$. level of the Errington mine.

Patricia District-The only producing property in this district is the Howev gold mine, which in December produced $\$ 70,72^{\circ}$, representing a recovery of $\$ 4.90$ per ton. The ore now going to the mill shows an improvement in grade being drawn from the lower levels where widths and values are better than on the upper horizons. The management of Central Patricia is considering plans for mill installation to treat the ore already indicated and blocked out for which refinancing will probably be necessary. A new company has been formed to take over the property of the Birch Lake Syndicate in the Sunimit Lake section north of the Canadian National Railway. Shaft sinking operations have been commenced in the course of which good values have been encountered.

Manitoba.-The Hudson Bay Mining and Smelting Company commenced shipments of ore to eastern points from the Flin Flon mine on November 17, since when a total of 107 cars of blister copper and zinc have gone forward. Production is being actively continued. The mill of the Central Manitoba gold mine is treating an average of 150 tons daily, with mill heads at $\$ 9$ a ton. A shipment of 12 gold bars valued at $\$ 83,640$ representing 10 weeks production was recently made to the Mint at Ottawa. An English Syndicate represented by Mr. G. Bottoms has started work on a group of claims in the Beaver Lake area about 12 miles west of Flin Flon. A shaft is being sunk on a promising gold showing and a diamond drilling campaign will be carried on. The syndicate has also 20 other claims
in the locality under option, and development work on an extensive scale is planned for the coming season. Other gold areas in Northern Manitoba will receive attention this spring and Copper Lake where the Rose claim is being opened up will attract a number of prospectors. The diamond drilling which will start in March on the North Star claims by the Consolidated Mining and Smelting Company will draw attention to the Morton Lake area. A Northern Manitoba Syndicate is continuing work on the Baby group of claims at Cold Lake and reports indicate good copper values.

## BRISBANE

Decernber 24.
Mount Isa Operations.-The Queensland District Inspector of Mines at Cloncurry (Mr. F. Young), reporting for November, says that development work at the Mount Isa mines is still progressing, but that the water difficulty is as troublesome as ever. The ore-pocket in the main haulage shaft was being sunk and foundations had been laid for five electric pumps which are intended to deal with all the mine water that can be drained to this point. The end of the main cross-cut is out 800 ft . from the shaft and had to go 850 ft . further before it broke through. Another cross-cut, designed to intersect No. 1A winze in Doherty's shaft on the Black Rock lode, has been started from a point in the main cross-cut and has to be taken about 450 ft . before completion. The superintendent (Mr. G. J. Gray), in his report for the period ended November 29, states that the bailing at the rate of $2,000,000$ gallons a day had been continued from Davidson's shaft and the supply shaft and that the erection of the five pumps was in progress. Referring to the ore-pockets, he mentions that the ore-pocket winze had been sunk 27 ft . to a total of 54 ft . and says the water then had not increased, but was still making about 150 gallons a minute.

Details of underground operations during November given by the local warden (Mr. S. Wilson) are to the effect that the water door had been installed in the main haulage level which is being driven westward from the Urquhart shaft, at the bottom of which there is now a busy scene. In this shaft the pump chamber and the sump have been finished; the shaft circle which is being constructed for the running of the ore trains round the oreloading pockets is also completed ; and the
southern ore-pocket has been excavated to 40 ft . At the man and supply shaft the water level had been lowered to 20 ft . from the haulage level. The driving of the main haulage level eastward to the Urquhart shaft is to be resumed after the large power plant is in operation. Mr. Wilson states that until then the power will be sufficient to cope with the additional water expected to be encountered. He adds that the power plant would be completed by December 15, that the mill would be finished about the same time, and that steady progress was being made with the smelter.

The Drilling Campaign.-In the four weeks ended November 1.5, 658 ft . of diamond drilling was carried out on the Black Star lode at Mount Isa, and three of the holes$11 \mathrm{~B}, 5 \mathrm{C}$, and 1 D -were finished. In the succeeding four-week period No. 4C hole was deepened 130 ft ., to a total of $1,244 \mathrm{ft}$. The core was shale and dolomite to $1,212 \mathrm{ft}$. and thence dense, fine-grained, pyrites to $1,231 \mathrm{ft}$. At $1,231 \mathrm{ft}$. the bore-hole cut the lode and continued in ore. The subsequent drilling programme was left to be decided by the new General Manager (Mr. J. Kruttschnitt), who has since arrived at Mount Isa from America, where he was for many years in charge of a portion of the development and exploration work of the American Smelting and Rcfining Company. Mr. Kruttschnitt was accompanied to the Mount Isa mines by Mr. J. P. B. Webster, a director of Mount Isa Mines, Ltd., and Mr. D. P. Mitchell, a director and one of the technical committee of the Mining Trust, Ltd. An interesting feature mentioned in connexion with the drilling in bore-hole 4 C is that from 988 ft . to $1,067 \mathrm{ft}$. the ore averaged $5 \cdot 2 \%$ copper. As mentioned by Mr. Urquhart at the last annual meeting of Mining Trust, there had been occurrences of copper in previous boring.

## Queensland Mining Concessions.-

 There are now four schemes in which the Queensland Government has agreed to give special concessions to corporations that are prepared to spend foreign capital in helping towards a much needed revival in our mineral industry. The first of these was that granted about a year ago to the Mining Trust over an area at Lawn Hills, in the extreme northwest of the State. In addition, bills have just been passed through Parliament ratifying agreements made in three other cases. All of these are based on the same general conditions as those covering the Lawn Hillsmines, the chief differences being in the size of the areas involved, the amount of money to be spent, and the periods stipulated in which that money is to be expended. The first of the measures dealt with relates to a proposed undertaking of the Palmer Development Company, Ltd., which purposes testing, to a greater depth than yet prospected, the once famous Palmer goldfield, inland from Cooktown. The principal mines in this field were practically abandoned over 40 years ago when the water level was reached and the auriferous ground has never been tested below 700 ft . The company that has obtained the concession has to spend $£ 36,000$ in five years and is relieved from the payment of rent and labour conditions for that period unless gold is found sooner, in which case leases have to be taken up under the usual conditions. The Government, also, grants a subsidy of $£ 2$ per ft. of sinking carried out by the company. The second concession, granted under similar conditions, covers six different areas in two separate fields $-45,000$ acres on the Etheridge, North Queensland, and 15,000 on the Palmer field. In the third case, the concession has been granted to Mr. Alexander Macdonald, of Chillagoe, North Queensland, who is now on a visit to Scotland. The area covered, as mentioned in last month's letter, is at Cardross, an old mining centre about 30 miles from Mungana, in the Chillagoe district, North Queensland.

New Mining Legislation.-The Queensland Parliament has also passed a bill amending and liberalizing the mining laws of this state. Several of the amendments embraced in the measure are the result of a conference held nearly two years ago at Canberra and called by the Development and Migration Commission to consider the mining laws of the Commonwealth ; while other new provisions are based on recommendations of the Royal Commission on the Mining Industry of Queensland, which brought up its report early last February. One of the principal recommendations of the conference was that mining conditions in Australia should be made more attractive to outside capital and that encouragement be granted for the working on a large scale of low-grade propositions. This objective has been kept in view in the amendments in the law that have now been adopted. Under the new Act, the Government has authority to make agreements for mining concessions under special conditions without having to seek Parliamentary ratification of such agreements;
a gold-mining lease can be granted for gold mining outside a proclaimed goldfield ; the minimum area of a lease of 50 acres for goldmining has been doubled; and the manning condition of such a lease has been liberalized so as to make it the same as that for a mineral lease-namely, by allowing one man to every ten acres instead of to every four acres. It is also provided that the manning conditions may be carried out by the expenditure in machinery and other equipment of a certain sum of money, which may be regarded as the equivalent of the employment of a prescribed number of men. Provision is likewise made for an increase in the maximum area of a mineral lease from 160 to 300 acres ; also for conferring greater facilities for the union of amalgamation of gold-mining or mineral leases, as well as to simplify the working of such joint holdings.
Shale-Oil Industry.-A committee has been formed in New South Wales, to operate under the Government of that State, to investigate the development of its shale-oil resources. The Commonwealth Government has two representatives on the committee (Messrs. W. Gepp and Thomas Leahy), and there are two representatives of New South Wales. A similar committee is being formed in Tasmania and it is hoped that these two, with other State committees which may be appointed, will be able to co-operate to establish an industry on a nation-wide basis. Known deposits of shale in the two States named alone amount to $100,000,000$ tons and it is believed that the establishment of the industry would do much to solve the unemployment problem. Such an industry has already been started in a small way at Latrobe, in Tasmania, and employs 25 men. A try-out has been given to the petrol produced, which is said authoratively to have given remarkably efficient results, the calorific value of the oil being very high. The genesis of the conference was the promise of the Prime Minister, made over a year ago, to provide $£ 100,000$ for the repatriation of coal miners who cannot find work at their ordinary occupation.

The Briseis Tin Mine.-The historical Briseis tin mine, which had to be closed in 1929 as a result of disastrous floods in Tasmania, is to be re-opened. The old company, following the failure of a scheme for reconstruction, went into voluntary liquidation and tenders were called for the purchase of the plant, buildings, mine, races, and water rights at Derby. Word has lately
been received of the acceptance of the tender of a Tasmanian syndicate and arrangements are being made for an early resumption at the mine. It appears that the clearing away of debris and over-burden by the floods exposed rich tin drifts and although the mine will not in future be working on so pretentious a scale as formerly, it should have at least a new lease of life.

## PERTH

## January 1.

A Mining Revival.-The coming year promises well for the gold-mining industry in this State. The output will be greater owing to the increase in the yield from the present mines enlarging their plants and treating a greater tonnage of ore and, to a smaller extent, the finding of new mines. The need of the Empire for gold, the decrease in favour of base metals and industrial investments, unemployment which has caused many men to go out prospecting, and also the incentive of the gold bonus, supply the reasons for the revival of interest in gold mining.

Lake View and Star.-At Kalgoorlie the Lake View and Star, Ltd., has for the past year or two been reorganizing its metallurgical plant and carrying out flotation experimental work on a large pilot plant. The results of this have been so satisfactory that the company has now decided to prepare for a plant that will treat 30,000 tons of ore per month, using this method of concentration and roasting, thus effecting a considerable saving in cost. In order to supply the tonnage necessary for this increased output the underground system is being revised. Greatly increased efficiency has been secured by the tuning up and checking of the rock drills used and costs have been materially reduced. The correlation of the workings on the Ivanhoe, Horseshoe, and Chaffers, hitherto worked as separate mines, has been started, so that mechanical haulage underground can be carried out on the same random in the deeper levels. New ideas of team work have been introduced which will not only intensify the interest of the different members of the underground staff but will enable a keener watch being kept on the fullest development and mining of the ore-bodies, so that in future there will be less ore left for tributors to take out. To bring to fruition such a scheme is a big task, but the general manager with his staff
is settling down to it to show what can be done on several mines which were supposed to be finished.

Enterprise Syndicate.-The Enterprise Syndicate, in which the Boulder Perseverance holds a quarter interest, and whose leases adjoin, has crushed from the 365 ft . level 863 long tons for a return of 22 dwts. per ton taken over a width of 12 ft . This ore-body has been located at the 504 ft . level, where a crushing of 40 tons yielded a return of 14 dwts. per ton.

North Kalgurli.-The North Kalgurli Company, which for many years did no work other than by tributors, started active development work recently and the results have been most satisfactory. On the No. 3 level a drive was started off an old cross-cut and has now reached a distance of 860 ft . north. For the first 415 ft . of this distance low-grade ore up to 8 dwt. per ton was met with. At that point a shoot of ore was struck and continued for 120 ft . averaging 12 dwts. over a width of 8 ft . After passing through 35 ft . of lower-grade ore, another shoot was opened up for 251 ft . in length, averaging 17 dwts. per ton over a width of 7 ft . The No. 4 level is now being developed with very encouraging results. These new developments, with those on the Union Jack and Crœsus Proprietary Leases further north again, are of great importance and will add considerably to the ore available on the Kalgoorlie field.

Sons of Gwalia.-The Sons of Gwalia mine, which was assisted by the Collier Government to carry out development work, has been rewarded in the opening up of new ore-bodies. The constantly increasing gold output from this mine, with excellent costs, will give an impetus to other companies to carry out prospecting development work on sound geological lines.

Wiluna Mines.-The new plant on Wiluna Mines is rapidly nearing completion, and the output of the State should be increased by $£ 70,000$ to $£ 80,000$ per month from this mine alone during the next few months.

Prospecting Activity.-There have been some new finds made by prospectors on the various fields, but none of these have yet proved any of their lodes or reefs to be good enough for a company. At Larkinville on the old Widgiemooltha field, there are 200 alluvial men at work, some of whom are doing remarkably well, slugs up to 70 oz . having been found. Several cross-leaders of quartz running into horn
blende schist have been found, and contain very rich coarse gold, and it is probable that the alluvial slugs have come from these as in some cases the quartz and schist can be seen adhering to the gold, which is flattened as if coming out of a narrow vein. So far no true lode formation carrying payable gold has been found. A slight interest continues in the Patricia field near Edjudina, but, as mentioned in my last letter, the shoots of gold are short and most of the option holders after prospecting along the line of country have left the field. The Patricia has just had a crushing which yielded $2 \frac{1}{2}$ oz. to the ton from shaft sinking, but so far little driving on the lode has been carried out.

At Broad Arrow, another old field, several prospectors are working lodes with satisfactory results, and some working options have been taken to develop them.

On the old Golden Valley and Westoma fields small parties are mining ore from old workings, and which pays them well. The Radio mine has been yielding high-grade ore for years past to a small party of men.

Nalgoo, on the North Murchison Field, has had quite a revival, a number of small but rich shoots having been opened up during the past year. There are 60 prospectors at work and during the past month they crushed 334 tons for a return of 544 oz . by amalgamation and 230 oz . by cyanidation of the tailing.

Prospectors are returning to Darlot, Ularring, Davyhurst, Yarri, and Mount Malcolm fields, while other parties are out looking for a new field between Southern Cross and Bremer Range. The country is rough and water is scarce yet reports have come in at various times of prospectors finding floaters of gold-bearing stone, but never being able to stay out long enough to find the lode which shed them, due to the scarcity of water.

Thus, while the wool, wheat, and timber industries are having a disastrous time in Western Australia, gold which made it famous decades ago will again play its part in bringing back prosperity to the youngest of the States, but this can only be brought about by a better feeling between the representatives of the various parliamentary parties in Australia.

West Australian Gold Yield.--The West Australian gold yield for 1930 totalled 416,369 fine oz. compared with 377,176 fine $o z$. for 1929 , an increase of $10.39 \%$ for
the year. The December yield was $8,389 \mathrm{oz}$. greater than that of November of last year. Owing to the exchange position banks in Western Australia have offered a premium for gold since March 30, 1930. The amount received to date by gold producers in respect of the year's output is approximately $\notin 90,781$, of which $£ 45,121$ was paid through the Perth Branch of the Royal Mint. The balance of $£ 45,659$ was paid by the banks direct to the mines.

## IPOH

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\text { January } 10 .
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International Tin Restriction Scheme.
-The price of tin suffered further decline in December to $£ 105$ 12s. 6d. per ton, on December 17, but reacted strongly on the publication of the proposal for an international quota agreement, reaching $£ 119$ 10s. in the end of the month. Since the beginning of the new year there has been a helpful upward tendency as to the permanence of which there is still some doubt. After announcement of the quota scheme the F.M.S. Government promptly issued the following circular to all producers :-
"With reference to the international scheme to restrict the output of tin ore, details of which were recently published in the press, the Federated Malay States Government is prepared to consider the introduction of legislation to give effect to the scheme, if it is satisfied that the bulk of local producers are in favour of it.
"The Dutch, Nigerian and Bolivian Governments (provided Malaya joins in) are ready to accept the scheme which consists in the restriction of the 1931 world output to 145,000 tons. The Federated Malay States would limit its export to 52,000 tons or a reduction of approximately $22 \%$ of the 1929 output and the other three Governments would collectively reduce their exports by the same proportion. It is proposed in order to bring the scheme into effect in the Federated Malay States to prohibit the sale or export of ore from the larger producers beyond $78 \%$ of their 1929 output. Restriction of the smaller producers would be effected by limiting the amount their buyers can buy to $78 \%$ of their 1929 purchases.
" Producers are invited to communicate to the Senior Warden of Mines or the Warden of Mines within seven days their reply to the following question:-
"Are you in favour of such legislation?

If not, for what reason do you object ? In replying, producers are requested to state (a) their status as producers (e.g. Manager, Owner, Sub-lessee, etc.), (b) their actual production for the years 1929 and 1930.
" It is essential for the purpose of ascertaining the attitude of the mining community that all persons to whom this circular is addressed should reply to it as requested without fail."
Following upon this a public meeting was called in Ipoh to meet the Senior Warden on January 7 to enable the mining communities to obtain fuller details of the proposed restriction scheme. Both in Perak and in Selangor the Chinese miners, at largely attended meetings, approved of the proposed international tin control scheme.

Dredges.-The ore in Malaya occurs under a variety of conditions and only a moderate proportion of the deposits can be efficiently worked out by dredging which, where applicable, is generally the cheapest method of production on a large scale. Dredging does not employ much labour, however, and one effect of widespread stoppage of mining by other methods would be to throw out of work a large proportion of those who depend on mining for their livelihood. The F.M.S. Government would view any cause tending to such a result with the gravest concern. Besides being only applicable under special conditions dredging is a method that often loses much of the ore in the ground treated, and also that cannot reach the gencrally valuable ground in the cavities, cracks, and between pinnacles of a limestone bedrock. It may also be argued that very deep ground (say over 120 ft .) containing high average values should not be given out to be worked by dredging on account of the large quantity of valuable ore that would be left buried under that depth of tailings.

From the above it will appear that dredging may under common conditions and in certain respects be an inefficient method of working even though a large output may be attained at a very low average cost, and it is therefore not fair nor economically desirable to allow this particular class of cheap producers to flood the market with ore or to dominate the industry. There are many comparatively small producers, employing a considerable number of people, who are just able to keep going giving food and nominal wages to their employees.

They cannot restrict without loss nor close down without withdrawing their plant and abandoning their mines which would soon fill with water. Most of such cases will be covered by the proposed B class of producers of which restriction would be effected through the buyers licensed to receive their ore.
Statistics.-The monthly Bulletin of Statistics for November, with prefactory notes dated December 16, has now been issued. Consideration of recorded production in 1928, 1929 and 1930 by dredges and by gravel pump mines shows the following proportions in relation to total from all sources :-

|  | Gravel <br> Dredges. |
| :--- | :---: | :---: |
|  | Pumps. |
| $\%$ |  |

The Census of Labour shows that since June, 1930, there had been no great decline in the labour employed.

Figures published on information cabled from London show the tin position at the end of December, 1930, to be as below :-

|  | Tons. |  | Tons. |
| :--- | :--- | :--- | :--- |
| Visible supplies | 42,300 | Increase. | 1,800 |
| Consumption | 11,100 | Increase. | 1,000 |
| Supplies | 12,900 | Increase | 1,500 |

From these particulars it appears that though there has been a considerable increase in consumption the supplies for the month have added to the stocks held.

## CAMBORNE

## February 5.

The Outlook. - Notwithstanding low prices and bad times, confidence in the future is demonstrated by the steps which have been wisely taken at South Crofty, Geevor, and other mines to husband their financial and underground resources. Further proof of confidence is seen in the continuation of certain prospecting and preparatory operations - a making-ready for the brighter times coming. For example, progress is being made in the Mount Wellington programme, in the Carnan Valley neighbourhood, and work on a limited scale is in hand for the investigation of the Towan lodes near the coast-line at Porthtowan. Moreover, strenuous endeavours are being made to reduce working costs, by means of
laboratory research and also by experiment on a working scale. These endeavours relate to improved methods of concentration and crushing. For instance, progress is being made in the application of flotation to tinbearing pyritic ores, with the object of facilitating the extraction of tin from complex products, and the Cornish Institute of Engineers announces a meeting of members on the 14th inst. to discuss the abrasive milling of tin ores introduced by Mr. John G. Cloke in East Cornwall, where he claims to have made a higher recovery at a reduced tonnage cost of treatment.
Some Effects of the Tin Slump.-While several of the old-established mines are well able to mark time financially, effects upon less fortunately placed properties are evidenced in the occasional addition to the list of companies going into liquidation.

## PERSONAL

Clyde Allak is home from Nigeria.
H. C. Boydell has gone to the Massachusetts Institute of Technology, Boston, U.S.A., where he is giving a course of lectures on certain aspects of economic geology.
A. O. Brown has returned from Norway:

Robert E. Cranston has returned to New York after visiting Australia, Tasmania, and New Zealand.
Cecil H. Feldtmann is home from Venezuela.
J. E. Halford has left for the Gold Coast.
H. W. Hardinge is here on a visit from the United States.
J. O. Howells has returned to Calgary, Alberta.
C. F. W. Kup has returned from Brazil.
V. F. Stanley Low is home from Panama.
D. H. McCall is returning from Burma.
R. A. Mackay has returned to Cyprus.
h. R. Mackilligan is leaving for Nigeria.

Malcolm Maclaren has returned from West Africa and left again for South Africa.
H. F. Marriott has left for Panama.

John A. Nogara has returned from France.
H. C. Orford is home from Burma.

Gerald Robinson has left for Egypt on a short visit.
F. J. Ryeland is returning from Cyprus.
J. Stuart-Smith has returned to Ecuador.
M. H. Thomas is returning to West Africa.
W. E. Thorne has returned from the United States.

Richard Bishop Moore, who died at the end of last month at the age of 60 , was in charge of the helium wark of the United States Bureau of Mines from 1928 to 1923.

Lloyd T. Emory died at Barcelona on January 5 at the age of 48 . At the time of his death he was engaged in making investigations on behalf of the American Cyanamid Company, of the English branch of which (Cyanamid Products, Ltd.) he was a director.

Leonard George Attenborough died on January 11 at Farnborough at the age of 58. He was a graduate of the Royal School of Mines and a Member of the Institution of Mining and

Metallurgy, serving on the Council for a short time. Mr. Attenborough was for over 30 years in the Middle East, having joined the Borneo Company as chemist at their Bidi Gold Mines, in Sarawak, in 1899. Later he became manager and subsequently proceeded to the Federated Malay States, where he took over the management of the Bruseh Hydraulic and Jalapang properties. In 1914 he was appointed manager of Ipoh Tin Dredging, Ltd., and also occupied a similar position in connexion with their subsidiary companies, retiring in 1929.

## TRADE PARAGRAPHS

Elbof Geophysical Co., of Kassel, Germany, and 668, Salisbury House, London, E.C. 2, inform us that they have entered into a contract with the Chilean Government for the investigation of oil and mineral areas by geophysical methods.
E. G. Acheson, Ltd., of 40, Wood Street, Westminster, London, S.W. 1, issue a booklet and the first of a series of periodical technical bulletins describing colloidal graphite, its properties, uses and advantages as a lubricant and its applications in industry.

Power Corporation of Canada, Ltd., of 355, St. James Street, Montreal, Canada, have published a brochure containing many illustrations of Canadian power schemes which they have been instrumental in designing, constructing, and in many cases financing.
J. Pohlig, A.G., of Köln, Germany, have issued a catalogue which is fully illustrated with photographs devoted to loading bridges and cranes such as are employed in works and docks and in conjunction with aerial ropeways and a variety of other handling operations.
International Geophysical Prospecting Co., Ltd., of $10-12$, Copthall Avenue, London, E.C. 2, have concluded a contract with the Attock Oil Co., Ltd., for the examination by geophysical methods of the structures at Khaur and outfields and the representatives of the International Company have now arrived on the field.

The British Industries Fair is being held as usual simultaneously in Birmingham, at Castle Bromwich, and in London, at Olympia, from February 16 to 27, the heavy industries being located entirely at Birmingham. Some particulars with regard to the exhibits of major interest at both these sections will appear in a subsequent issue of the Magazine.

Head, Wrightson, and Co., Ltd., of Stockton on Tees, send us a booklet describing the Akins classifier. Originally devised for a specific separation in the cyanide process it has not only come to be considered as the best machine for that work, but experience has opened up a wide field of usefulness for it in analogous separations occurring in ore treatment and in other industries.

Evershed and Vignoles, Ltd., of Acton Lane Works, London, W. 4, inform us that at the recent Physical Society Exhibition held at the Imperial College their chief exhibit was the working facsimile model of the Midworth system for distant control as recently installed in one of the principal railways in this country. Another model of interest was the "Megger" earth tester as used for geophysical surveying, particulars of which instrument have already appeared in an article in the Magazine.

Galigher Co., of 228-32, South West Temple Street, Salt Lake City, Utah, have sent us a copy of one of their booklets entitled Modern Metallurgical Control. This deals with the Geary-

Jennings sampler for taking samples from pulp stream. The method of operation of this contrivance is demonstrated with sectional drawings. Another sampler referred to is the Improved Auto Sampler No. 2, particulars of the method of operation of which are also furnished. The Geary lime feeder and the Geary reagent feeder are also similarly described. The booklet is handsomely illustrated.

Petters, Ltd., of Westland Works, Yeovil, inform us that they are exhibiting at the British Empire Trade Exhibition at Buenos Aires to be held in March next. Their exhibits will include an 80 b.h.p. Atomic Diesel twin cylinder, twostroke cycle, cold starting, airless injection heavyoil engine, a similar engine of $25 \mathrm{~b} . \mathrm{h} . \mathrm{p}$. with electric generator, a 24 b.h.p. surface ignition, crude fuel oil, stationary type engine, and a 5 b.h.p. petrol or paraffin engine. Two examples of their aircraft are also to be shown. They have also sent us particulars of their exhibit at the British Industries Fair. Birmingham, which will be dealt with under this heading in a subsequent issue.

Demag, of Duisburg, Germany, in their Demag News for November have an article on the economic aspect of cogging drags. These drag plants offer advantages for use when cogging as they are able to deal with any kind of gob stuff, no matter what size. The procedure consists of bringing along the gobbing with lorries, shaking troughs or beit conveyors and dumping it on the path traversed by the drag. The latter has thus only to take the gobbing from the heap, carry it to site, and there pack it into the cavities as near the roof of the working as possible. The article gives several photographs and illustrations of the plant.

Colliery Guardian Co., Ltd., of 30 and 31, Furnival Street, London, E.C. 4, the proprictors o the Colliery Guardian send us a copy of their Colliery Manager's Pocket Book for 1931 which contains some 460 pages. Sections are devoted to mining progress during 1930, coal mining statistics, the Coal Mines Act, 1930, coal and its by-products, valuation, depreciation, surveying, mine ventilation, rescue and ambulance, strength of materials, machinery, explosives, approved safety lamps, electricity in and about mines, inspectors of mines, coal exchange meetings, information for candidates for certificates, examination questions, Government offices, departments, and committees, mining institutes, and trade societies.

British Engineering Standards Association, of 28 , Victoria Street, London, S.W. 1, have issued the 1931 edition of the Index to British Standard Specifiçations. It is a complete subject index which, in view of the large number (410) of British Standard Specifications now available, some of which include provisions for several articles or materials, will be of much assistance to those purchasing engineering and allied material apparatus and machinery. A numerical list of the specifications is also included. The list, which covers 38 pages, shows the wide range of subjects covered by the specifications and should be in the hands of all drawing offices and contracts clepartments of firms throughout the engineering and allied authorities who have found the British Standards of such benefit in the preparation of contracts. Copies may be obtained on application price $1 / 2$ post free.

Mavor and Coulson, Ltd., of 47, Broad Street, Glasgow, have issued a statement to the effect that
a contract which they recently secured from the Russian Government for the supply of 250 coal cutters will in no way affect their ability to comply with the requirements of other existing customers as the size of their works and their staff will enable them to continue to fulfil all their orders. They also write us drawing attention to a recently effected development in coal-cutter picks, in which advantage has been taken of experience gained in metal cutting to find an alloy with which to tip coal-cutter picks to give them the requisite hardness combined with toughness to stand up to the work required of them. These new tipped picks will effect important economies where tempered picks are used for cutting hard materials. They also send us a leaflet describing their face belt conveyors, for which the claim is made that during its three years career not only has it proved its reliability, but it shows that its belt lives $50 \%$ longer than the belt on an open type of conveyor.
Mining \& Industrial Equipment, Lid., of 11, Southampton Row, London, W.C. 1, report that new orders have been received for the following cquipment: One No. 0000 Raymond pulverizer for precipitated colours at 2 to $2 \frac{1}{2}$ cwt. per hour, $70 \%$ minus 100 mesh and $97 \%$ minus 40 mesh. One R.L. 5 Lopulco mill for gum at 250 lb . per hour, $95 \%$ through 200 mesh, and one R.L. 5 Lopulco mill for record-covering material, at 440 lb . per hour, 94 to $95 \%$ through 200 mesh. They have also sent us a copy of a paper which Mr. J. C. Farrant read before the Chemical Enginecring Group of the Society of the Chemical Industry at Derby, on January 23, on the subject of modern grinding. This describes various kinds of mills and classifiers and discusses their application to specific problems, the value of the latter section being particularly enhanced by the addition of much operating data in tabular form giving particulars of feed size, mesh analysis of product, capacity and power consumption for a variety of minerals and different mills. Some useful cost figures are appended and the whole paper is well illustrated with many types of crushing machines including the more important of those made by the firm's competitors.

Scott and Strutt, Ltd., of 25, Victoria Street, London, S.W. 1, have issued a leaflet giving particulars of the Morgon hot miller which is a machine which may be utilized for making drillsteel bits. The machine is not intended to replace the existing well-known types of drill-steel sharpeners (which are not, in fact, so much sharpeners as forging machines) but to supplement them. The manner of its employment consists in making a rough bit in the existing sharpener

and finishing it in the Morgon miller which operates on the hot metal, cutting it into the desired shape. Appropriate grinding wheels for any form of bit, i.e. double chisel, rose, $Z$ etc., can be fitted to the machine which like any lathe may be belt or direct-coupled electric motor driven. Reproduced here is a photograph showing a suitable wheel for cutting a double-chisel bit. The speed of rotation of the cutting wheels is of the order of 3,000 r.p.m. and the temperature of the bit should be $800-900^{\circ} \mathrm{C}$. About $4 \mathrm{~h} . \mathrm{p}$. is consumed in running. In a mine where it has been in use for some time nearly 1,000 bits have been made without any appreciable wear on the wheels. As a result of the use of the machine a decrease of $50 \%$ in the number of steels brought up for remaking or resharpening was recorded.

Rexman Mill Co., Lid., of 11, Queen Anne's Gate, London, S.W. 1, have sent us a booklet describing the Rexman balanced rod mill, which is
to a distributing chamber with outlets to the several divisions of grinding media. The material is free to pass into any part of the interior and discharges from the distributing chambers on to and between the rods and the revolving action of the mill causes them to roll and cascade. Crushing caused by impact is the predominating action followed by the weight and rolling motion of the rods. Owing to the method of central feeding and the resultant even distribution of the pulp along the line of rods they maintain at all times a horizontal and parallel position to one another. Reproduced here is a photograph showing a partly sectioned illustration of an end-discharge type of mill which shows also the feed tube and the spider supporting the rod load in groups. The size of feed recommended should not be over 1 in . for the small mill and $2 \frac{1}{2}$ in. for the large. The mills are made in three 'distinct types, namely, end discharge, peripheral discharge and central trunnion


The Rexman Balanced Rod-Mill.

a comparatively recent development. These mills have been perfected and manufactured by the Joshua Hendy Ironworks, of California, and are now manufactured in this country for sale in all countries of the world except Western Canada and the U.S.A. The outstanding feature of the mill is the high duty developed for the small power consumption. The balancing feature is only one of the advantages of the mill, further accepted merits being those of grinding and screening in one operation, equal distribution of the grinding medium in the entire mill, central feeding to ensure maximum efficiency, small volume of pulp, and double-end rapid discharge of the product. The mill is not a compartment mill, the shell being a common chamber and the divisions in it being distinct only in so far as the rod load is concerned. As the centre of gravity of the rod load practically coincides with the axis of rotation of the mill, dynamic balance is obtained, and apart from the friction of the two trunnion bearings, power is only expended on the actual grinding and circulation of material. The feed is picked up at one or both ends of the mill by the usual type of cylindrical feeder and is passed by means of a delivery tube fitted with spiral liner to the centre of the mill
discharge, sizes ranging from 2 ft .6 in . to 8 ft . in spider diameter and varying in length according to requirements. The booklet goes on to give further particulars with regard to the best operating conditions, screen analyses, specifications and a comparative power consumption of cylinder mills taken from Taggart's Ore Dressing, side by side with which are given figures for the Rexman mill.

## A PRODUCER GAS LORRY

Karrier Motors, Ltd., of Huddersfield, have furnished us with information relating to one of their lorries which recently completed a successful journey from Durban, in Natal, to Salisbury, in Southern Rhodesia, equipped with a special type of gas producer which can be operated on a variety of fuels such as wood, maize cobs, cocoanut shells, sisal, etc. This producer is made by the Compound Gas Power Co., Ltd., of Welwyn Garden City, Herts, and is a modified form of that described under this Company's name in these columns in our issue of November, 1925. In this connexion also it is of interest to recall the article in our May, 1924, issue by Mr. S. Dawson Ware and a subsequent letter by the same author in our

November, 1926, issue. Dr. Murray Stuart in an article in our November, 1928, issue on the subject of the World Power Fuel Conference also dwelt on this interesting transport development.

The producer has no moving parts nor is any water required for its operation. The vehicle to which it is attached may be driven by petrol or producer gas at will by simply altering the ignition timing. The lorry to which it was fitted was a Karrier " RMC" type of six wheeler having a four-cylinder engine rated at $32 \mathrm{~h} . \mathrm{p}$. and developing 75. Twin gear boxes are fitted giving eight forward and two reverse speeds. As a road vehicle it will carry a five-ton load, but for crossing rough country three tons is the maximum permissible.

As to the journey, the first part consisted of a trip from Durban to Johannesburg with a load of $3 \frac{1}{2}$ tons 400 miles, a climb of 3,000 feet in the first 20 miles being involved. Wood was consumed during the whole of this run which, although much was in low gear, was accomplished without engine overheat. From Johannesburg the lorry was taken to Pretoria and a load of $4,500 \mathrm{lb}$. of steel boring tools was carried over rough country in a series of tests. The journey was afterwards continued to Salisbury via Pietersburg and Messina and the Limpopo crossed by the new Beit Bridge. Gwanda to Bulawayo was accomplished at an average speed of $20 \mathrm{~m} . \mathrm{p} . \mathrm{h}$. Wattle wood was consumed throughout from Johannesburg-2,650 lb . of it, showing a consumption of 4.6 lb . per mile. On the remaining stage of the journey to Salisbury300 miles - 900 lb . of wood were consumed, costing 15 s . compared with an equivalent petrol cost of $£ 6$.

## QUASI-ARC WELDING

The Quasi-Arc Co., I.td., of 15 , Grosvenor Gardens, London, S.W. 1, recently afforded us the opportunity of visiting their laboratories and demonstrated the many applications of their electric-arc welding process. Welding by this method is applicable to any iron or steel construction of 20 S.W.G. plate and upwards, and is carried out by means of special electrodes which have features that distinguish them from any other electrodes made for similar purposes. The essential distinguishing feature of the "Quasi-Arc" electrodes is that they are coated with a mineral flux which melts under the electric-arc and flows from the electrode to the work, thus protecting the weld metal from atmospheric oxidation. The metal core of which the electrodes are made varies according to the class of material which it is desired to weld. "Quasi-Arc" electrodes are produced for the welding of structural steel-work, boiler work, welding of stainless steel, and also for the reinforcing of worn surfaces on high carbon steel, manganese steel, etc. In addition cast iron can be satisfactorily welded.

In the mining world the proper use of welding is probably not as fully appreciated as it might be. Tanks, pipelines and a wide variety of mining and milling machinery can be satisfactorily welded and produced more cheaply than if riveted. The principal advantages of this method of construction lie in the fact that the joints are strong, cannot become loose from vibration and offer a very high resistance to corrosion. The resistance of the weld metal to corrosion has been proved to equal that of a good quality mild steel, of which material the majority of tanks, etc., are made. Another aspect is the repair of worn-out and fractured
parts. All structures that have become corroded or have failed in practice can be repaired in situ without the necessity of waiting the arrival of replacements, thereby saving considerable time and expense. This is a very important point to be considered where the case applies to plant that may be operating at a considerable distance up country. The re-tipping of worn boring tools and drills has also been carried out successfully in the last few years with certain special "QuasiArc" electrodes.

Among the examples of all-welded constructional work carried out with " Quasi-Arc " electrodes may be mentioned two gasholders for the Melbourne Gas Company, the pipeline for the Lochaber Power Scheme for the North British Aluminium Co., the reinforcement of railway and tramway points and crossings, the welding of large oil storage tanks and numerous constructions and repairs of every description, including a Hardinge ball-mill which was entirely fabricated by welding.

The laboratories we visited are fully equipped with means for subjecting welded joints to a variety of tests such as tension and compression, impact, hardness, torsion, and alternate bending and impact (for disclosing " fatigue") and corrosion resistance. The superior strength of joints in bars, angles, pipes, etc., made by the Quasi-Arc process can be strikingly demonstrated. A chemical laboratory is equipped for all the necessary tests on the materials used in the manufacture of electrodes and metallographic and X ray apparatus is employed to examine the nature of the joints effected by the weld metal.

## METROPOLITAN-VICKERS <br> WINDING ENGINES

Metropolitan-Vickers Electrical Co., Ltd., of Trafford Park, Manchester, have had a remarkably successful year in electric winder work since, in addition to installations completed, it has received new orders for no fewer than 22 equipments, of which nine are Ward Leonard sets of $1.000 \mathrm{~h} . \mathrm{p}$. or over. Of the Ward Leonard sets four are for lead mines in New South Wales, four for copper mines in Rhodesia, and one-a repeat order-for a colliery in this country. The other equipments include a.c. sets for gold mines on the Rand, copper mines in Spain, and collieries in Great Britain.

Two of the large Ward Leonard sets are of special interest in that they are designed for completely automatic control, the winder being started by means of a single push button from any one of four working levels, and the operations of acceleration, deceleration, and decking being regulated by the automatic equipment in accordance with a predetermined schedule. The scheme is remarkable in several respects, notably in the first place in the provision of means of operation from a number of levels, and also in the fact that by means of an automatic brake governor the winder is definitely and positively kept within its predetermined deceleration curve, the mechanical brakes being automatically applied to the necessary degree should the regenerative control of the motor not give exactly the arranged schedule.

This automatic system of braking and a new type of hydraulic regulator are two notable recent developments made by the company which are likely to have considerable influence on winder design. Brief explanatory notes on the two develop-
ments are given below. The favourable impression already made on users is shown by the fact that both types of equipment are being included on no fewer than eight of the nine Ward Leonard sets of last year's orders.

The new slip regulator consists of a hydraulic coupling between the motor and the flywheel of the motor generator set. The device is a develop ment of the well-known Vulcan coupling which has been extensively employed for marine propulsion and industrial drives. It consists essentially of two main elements, an impeller wheel mounted on the motor shaft and a runner wheel mounted on the flywheel shaft, with a casing in which a controlled supply of ail provides the working medium. The oil circulates under pressure and by varying the amount admitted to the coupling the
cages are approaching the end of travel, and a relatively slow rate of retardation selected for operation if the cages are in an intermediate position. The system thus ensures any required stoppage in a reasonably short distance of travel, while eliminating the risk of sudden stoppages, which are a cause of grave danger to passengers and plant.

With regard to the automatic braking equipment it is interesting to note that following on successful tests carried out in the maker's works, tests are at present being carried out in actual service at the Harworth Colliery of Messis. Barber, Walker and Company. In addition to these tests a comprehensive series of general tests on the two $2,400 / 3,850 \mathrm{~h} . \mathrm{p}$. winder sets installed at this colliery has been carried out by the makers. This installa-


Metropolitan-Vickers Fiywheel Generator Sets at Harworth Colliery.
slip can be regulated to any desired value from practically zero to $100 \%$. The system is introduced as an important improvement upon the usual form of slip regulation by means of resistance in the secondary circuit of the driving motor of the flywheel set.

In the automatic braking system the braking effort is applied as a function of the speed change of the cages, compensation being made automatically for all variations of load, speed of travel, and other conditions. The use of this new principle gives the equipment the remarkable and highly desirable characteristics that any given position of the brake lever will give a definte rate of retardation under all conditions and that any desired rate of retardation can be obtained without shock The retardation under emergency conditions is also capable of accurate setting, a definite rapid rate of retardation being set for operation if the
tion was referred to and illustrated in our July, 1929 , issue.

These tests constitute an important practical investigation into actual conditions of winding service and the details of winder performance. The sets, which are among the largest winding equipments in this country, are arranged on the Metropolitan-Vickers "S.P." system, in which a flywheel generator set, gear driven by a high speed condensing turbine, is used to supply d.c. energy to the winding motors, the latter being controlled on the Ward Leonard principle. By this arrangement the peak loads of winding are not reflected on the boiler plant, the steam demand on the turbine being equalized to a value corresponding to the average of the cycle. The consequent reduction in boiler plant and cooling towers, and the possibility of using modern high-pressure water-tube boilers has enabled many improvements to be made whereby
the overall efficiency of the plant is increased and the capital expenditure reduced. In the Harworth installation the auxiliary load of the colliery is supplied by two $1,500 \mathrm{k} . \mathrm{w}$. high-pressure turboalternator sets, although where suitable public supply is available the colliery load, excluding the winding peaks, forms a desirable steady load for which a power supply company will usually quote an attractive tariff. Each flywheel generator set also includes an induction motor which acts as a brake when the set is being driven from the steam end, and can be used as the driving unit if so desired, the turbine being declutched and the motor taking its energy from one of the two 1,500 k.w. turbo-alternator sets. The accompanying photograph gives a general view of the power house, in which one of the flywheel generator sets is seen in the middle and the two $1,500 \mathrm{k} . \mathrm{w}$. turbogenerator sets at the far end of the station.

The tests, which were designed to check calculations and give data for design use, have given valuable and interesting results which it is intended to publish in the near future. The results include confirmation that the actual time, speed, voltage and load conditions throughout the course of the winding operation correspond very closely with the calculated values and also that the equipments are capable of winding their normal load of $7 \cdot 5$ tons from a depth of $2,815 \mathrm{ft}$. within the specified time of 76 seconds.

## METAL MARKETS

Copper.-During January, the American copper market had a rather easy tone, the quotation in New York for electrolytic metal receding from $10 \cdot 50$ to 10 cents per lb., f.a.s. At the lower figure conditions tended to become steadier, particularly as sentiment was strengthened by indications that the statistical position is at long last beginning to show signs of improvement. The world's copper production has of course now been curtailed very substantially. In London, the Standard market has been a narrow one, owing to restricted supplies, and prices have tended to follow the trend of professional market sentiment rather than by the volume of demand by copper consumers. At times the Standard market showed signs of firmness, but on balance values were rather lower on the month

Average price of Cash Standard Copper : January, 1931, $£ 4419 \mathrm{~s} .7 \mathrm{~d}$. ; December, 1930, $£ 46 \mathrm{16s} .4 \mathrm{~d}$. January, 1930, Ł71 11s. 1d.; December, 1929, $\notin 687 \mathrm{~s} .3 \mathrm{~d}$.

Tin.-Values have fluctuated in consonance with the varying trend of market sentiment, which in turn seems to have been largely dependent latterly on developments connected with the quota scheme which is the latest proposal of the " bull " interests whereby prices may be maintained or possibly advanced. It is stated that the Dutch, Bolivian and Nigerian Governments are prepared to support the project provided the Malayan producers can be brought into the scheme, but so far the attitude of the latter has not yet been definitely defined. Meanwhile despite the fact that output has been curtailed in certain directions as a result of economic conditions, world "visible supplies" last month are estimated to have increased by a further 850 tons, which indicates that consumption is still below the level of output. Consequently the market outlook remains discouraging.

Average price of Cash Standard Tin: January, 1931, £ 11517 s .7 d . ; December, 1930, £ $11112 \mathrm{~s} .4 \mathrm{~d} . ;$

January, 1930, £175 10s. 10d.; December, 1929, . 179 10s. 2d

Lead.-Prices drifted downwards during January, as was really inevitable in view of the fact that plenty of metal came forward from producing countries, whereas consumption continued to languish, particularly in America and Germany. Nor was the outlook improved by the settlement of the wage dispute at Broken Hill, as a result of which operations are continuing there, whilst of course the decline in the Australian exchange will tend to encourage production at all the Australian mines, including the new Mount Isa properties, which are expected to start operations about next April. Market sentiment was not improved by the obvious disinclination of the Lead Producers Association to give the market any fresh support. and the position must be regarded with some distrust in view of the large surplus stocks which are known to exist and the rather dubious world industrial outlook.

Average mean price of soft foreign lead : January, 1931, £13 17s. 9d.: December, 1930, £15 5s. 8d. ; January, 1930, $£^{21} 11 \mathrm{~s} .1 \mathrm{~d} . ;$ December, 1929, \&219s. 6d.

Spelter.--The tendency was easy throughout last month, despite the fact that in America the situation showed a slight improvement as stocks have at last begun to decline. The seriousness of the American statistical position is, however, plainly indicated by the fact that at the end of December last stocks amounted to no less than 143,500 short tons compared with 86,000 tons on February 1, 1930. Latterly spelter prices have been ruling at a lower level than for many decades past. Production is of course being slowly strangled by the present price and eventually this fact alone should put the market on a healthier basis. Demand from consuming industries has remained disappointingly restricted.

Average mean price of spelter: January, 1931, $f 1218 \mathrm{~s} .7 \mathrm{~d} . ;$ December, 1930, £ 13 9s. 9d. ; January, 1930, £ 19 18s. 9d. ; December, 1929, £20 7s. 5d.

Iron and Steel.-The Cleveland pig-iron market seems to have been a little more cheerful and active as a result of a 5 s. "cut" in quotations made by producers during January, which brought down the price of No. 3 foundry to 58 s . 6 d . per ton. Certain. contracts booked by engineering firms and steelworks in the North of England are beginning to be reflected in a better consumption of pig-iron, but the blast furnaces are still working far below total capacity and there is no evidence that any general trade revival is imminent. Meanwhile the undertone in hematite seems rather easy although makers are endeavouring to maintain the quotation at 70 s . for East Coast Mixed Numbers. In finished steel there has been no appreciable expansion in interest, although British makers have increased the rebates granted to home consumers. British export quotations have been left unchanged. The Continental steel market has opened the year in a quiet fashion and steelworks across the Channel are somewhat apprehensive as to the immediate future.

Iron Ore.-Generally speaking the market has shown no improvement during the past month, most ironmasters being fully covered by delayed deliveries against 1930 contracts with the exception of an occasional cargo of best Bilbao rubio, which realizes around 15 s .9 d , to 16 s . per ton c.i.f.

Antimony.-The range of prices for English regulus has narrowed, the quotation now being $\notin 36$ to $£^{42} 10$ s. according to brand. There is not much demand for Chinese regulus on spot, but the

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 <br> Selected． |  |  |  | Soft | English | sh． | For－ |  |
|  | Cash． | 3 Months． |  |  | Cash． |  | 3 Montbs． |  |  |  |  |  |  |
| Jan． | fr s． <br> 44 d． <br> 11 10 |  | $\begin{array}{ccc}E & \text { s．} & \\ 47 & 5\end{array}$ |  | ${ }_{114}{ }_{\text {E }} \mathrm{s}$ S |  | ${ }_{16}$ s．d． |  | ${ }_{\text {f }}^{6} \mathrm{~s} . \mathrm{d}$ ． |  | $\mathrm{f}_{5} \mathrm{~s} . \mathrm{d}$ ． | $\mathrm{d} .$ | ${ }_{1}^{\text {d．}}$ | ${ }_{85}^{\text {s．}}$ d． |
| 12 | $44{ }^{4} 1616{ }^{4}$ |  | $\begin{array}{lll}47 & 5 & 0 \\ 47 & 5 & 0\end{array}$ | $4510 \quad 0$ | 114 16 |  | $\begin{array}{lll}116 & 1 & 3 \\ 115 & 1 & 3\end{array}$ | $\begin{array}{lll}13 & 5 & 0 \\ 13 & 0 & 0\end{array}$ | $\begin{array}{lll}14 & 7 & 6 \\ 14 & 6 & 3\end{array}$ | $\begin{array}{llll}15 & 15 & 0 \\ 15 & 15 & 0\end{array}$ | 14 析 | 13 l | 850 |
| 14 | 4414 47 | $441010 \frac{1}{2}$ | 4750 |  | 11412 | 6 | 115176 | 12126 | 1426 | 15100 | 131 | $13 \frac{1}{18}$ | 850 |
| 15 | 4411 102 | $4494 \frac{1}{2}$ | $47 \quad 50$ | － | 1131 | 3 | 11489 | 12139 | 1400 | 15100 | $13 \%$ | 137 | 850 |
| 16 | 44126 | $4410 \quad 0$ | $47 \quad 50$ | $45 \quad 10 \quad 0$ | 1142 | 6 | $115 \quad 76$ | $12 \quad 89$ | 13150 | $15 \quad 50$ | 13！ | 131 | $8411 \frac{1}{4}$ |
| 19 | 451317 | $45 \quad 10 \quad 7 \frac{1}{2}$ | 4876 |  | 11612 | 6 | 117176 | 12126 | 13150 | $15 \quad 50$ | 131 | 138 | 8411 1 |
| 20 | $45 \quad 26$ | $4418 \quad 9$ | $48 \quad 00$ | 4650 | 11418 | 9 | 11663 | 12113 | $1313 \quad 9$ | $15 \quad 50$ | 13 唇 | 134 | $8411 \frac{1}{2}$ |
| 21 | 45071 | $45 \quad 0 \quad 72$ | 480 |  | 1177 | 6 | 11816 | 12126 | 13126 | 1500 | 14 | 13 星 | $8411 \frac{1}{2}$ |
| 22 | 4418 11 | $441610 \frac{1}{2}$ | 47100 | － | 11513 | 9 | $117 \quad 3 \quad 9$ | 12113 | 13126 | 150 | 1318 | $13 \frac{7}{16}$ | 8411 3 |
| 23 | $441610 \frac{1}{2}$ | 44150 | 47126 | $46 \quad 50$ | 1143 | 9 | $11513 \quad 9$ | 1263 | 130 | 14150 | $13+$ | 132 ${ }^{2}$ | 84 111 |
| 26 | 44113 | $44 \quad 9 \quad 4 \frac{1}{2}$ | 47100 |  | 11411 | 3 | 115189 | 1250 | $\begin{array}{llll}13 & 6 & 3\end{array}$ | 14150 | 1318 | 1314 | $8411 \frac{1}{2}$ |
| 27 | 44573 | $44 \quad 3 \quad 9$ | 4776 | 45100 | 1152 | 6 | 116126 | 1276 | $13 \quad 63$ | 14150 | 137 | 135 | $8411 \frac{1}{2}$ |
| 28 | $44610 \frac{1}{2}$ | $44 \quad 4 \quad 4 \frac{1}{2}$ | $47 \quad 76$ |  | 1157 | 6 | 116150 | $12 \quad 50$ | 1376 | 14150 | 13 ？ | 138 | $8411 \frac{1}{2}$ |
| 29 | $44 \quad 0 \quad 7 \frac{1}{2}$ | 4319 4 ${ }^{\frac{1}{2}}$ | 4700 | － | 11318 | 9 | 115113 | $12 \quad 50$ | $\begin{array}{llll}13 & 3 & 9\end{array}$ | 14100 | 131 | 1316 | $8411 \frac{1}{2}$ |
| 30 | $\begin{array}{llll}44 & 3 & 9\end{array}$ | 44110 | $47 \quad 0$ | $45 \quad 50$ | 11318 | 9 | 11563 | 1250 | $\begin{array}{llll}13 & 3 & 9\end{array}$ | 14100 | 13 暏 | 139 | 8411 12 |
| Feb． | 4311101 | $43 \quad 8 \quad 1 \begin{array}{lll}\text { 17 }\end{array}$ | 4610 |  | 1138 | 9 | 11416 ？ | 11176 | 1218 | $14 \quad 50$ | 13 ${ }^{\frac{1}{4}}$ | 134 | 84 117 |
| 3 | 43941 | $\begin{array}{llll}43 & 4 & 4 & 4\end{array}$ | $46 \quad 0$ | $4410 \quad 0$ | 1123 | 9 | $11313 \quad 9$ | 11150 | 12189 | $14 \quad 50$ | $12 \frac{1}{8}$ | 12\％ | 84111 |
| 4 | $\begin{array}{llll}43 & 16 & 3\end{array}$ | $\begin{array}{llll}43 & 8 & 9\end{array}$ | $46 \quad 50$ |  | 11413 | 9 | 116 | 1111 | 12163 | $14 \quad 50$ | 12 \％ | $12{ }^{\frac{7}{16}}$ | 84113 |
| 5 | $43 \quad 4 \quad 4 \frac{1}{2}$ | $43110 \frac{1}{2}$ | $46 \quad 50$ |  | 1147 | 6 | $11513 \quad 9$ | 1111 | 12126 | 1400 | 125 | 12 星 | 84 111 |
| 6 | 43 6 102 | 43110 2 | $46 \quad 50$ | $4410 \quad 0$ | 1152 | 6 | 1168 | 11126 | 12150 | 1400 | 12 | 12. | $8411 \frac{1}{2}$ |
| 9 | $441110 \frac{1}{2}$ | $44 \quad 3 \quad 1 \frac{1}{2}$ | 46100 |  | 11616 | 3 | 1186 | 1200 | $13 \quad 26$ | $14 \quad 50$ | 12 | $11 \frac{18}{88}$ | $8411 \frac{1}{4}$ |
| 10 | $45 \quad 57$ | 450 | 47176 | $46 \quad 50$ | 1167 | 6 | 11717 | $12 \quad 5$ | 1310 | $15 \cap 0$ | $12 \frac{5}{18}$ | 12 咅 | 8411 |

price is pretty steady at $£ 2510 \mathrm{~s}$ ．to $£ 26$ ex ware－ house．Metal to be shipped from China has been quoted recently around $£ 23$ to $£ 235$ s．c．i．f．

Arsenic－Cornish $99 \%$ white is scarce and rather nominal at $£ 19$ per ton f．o．r．mines，whereas Mexican is offering at about $\AA 1710$ s．c．i．f．Liverpool．

Bismuth．－The official price remains at 5 s ．per lb．for merchant quantities，a fair business being reported

Cadmium．－Quotations are unchanged at about 1s． $9 \frac{1}{3} \mathrm{~d}$ ．to 1 s ． $10 \frac{1}{2} \mathrm{~d}$ ．per lb．，demand being only moderate．

Cobalt Metal－Business remains slow，but the official price is upheld at 10 s ．per lb．

Cobalt Oxides．－Quotations are unchanged officially at 8 s ．per lb ．for black and 8 s .10 d ．for grey．

Chromium Metal．－There is a fairly steady demand at about 2s．7d．per lb．

Tantalum．－Business is practically at a stand－ still and quotations are nominal at $£ 40$ to $£ 45$ per lb．

Platinum．－Inquiry has been somewhat meagre during the past month，but quotations are without alteration at $\not \subset 610 \mathrm{~s}$ ．to $\ell_{6} 615 \mathrm{~s}$ ．per oz．for refined metal．Production appears to be in excess of requirements．
Palladium．－There is a steady call for this metal at about $£ 315 \mathrm{~s}$ ．to $£ 45 \mathrm{~s}$ ．per oz．

Iridium．－Business is still very restricted，but sponge and powder are fairly well maintained at about $£ 33$ to $£ 35$ per oz．

Osmitum．－Although the turnover is not large the market wears a very steady appearance，prices being unaltered at $\notin 16$ to $£ 1610$ s．per oz．
Tellurium．－Quotations can only be called nominal in the absence of business，the present figure being somewhere about 10 s ，to 12 s ． 6 d ．per 1 b ．

Selenium．－Business is proceeding quietly at the unaltered price of $7 \mathrm{~s}, 8 \mathrm{~d}$ ．to 7 s .9 d ．per lb ．ex warehouse Liverpool．

Manganese Ore．－During January some best Indian ore was sold to France at around $1 \mathrm{~s} .0 \frac{3}{4} \mathrm{~d}$ ．per unit c．i．f．，but Russia remains a seller at 11 d ．or possibly $10{ }_{4}^{3} d$ ．per unit c．i．f．for washed Caucasian． At the moment demand is stagnant．

Aluminium．－This market has been very dis－ appointing lately，demand remaining at a low ebb， partly owing to the quietness in the motor car trade．Quotations，however，are unchanged at $£ 85$ ， less $2 \%$ delivered，for ingots and bars．

Sulphate of Copper．－There is no change to report，English material remaining at $f 21$ to $£ 2110 \mathrm{~s}$ ． per ton f．o．r．，less 5\％．

Nickel．－The outlets for this metal are not absorbing the available supplies and mining opera－ tions have been curtailed in Canada．Prices，how－ ever，remain at $£ 170$ to $£ 175$ per ton for both home and export．
Chrome Ore．－Although business is rather slack just now，quotations show no change at 77s．6d． to 80 s．per ton c．i．f．for good $48 \%$ Rhodesian ores， up to 95 s．c．i．f．being named for high grade New Caledonian．

Quicksilver．－Towards the end of January a temporary scarcity of spot supplies resulted in prices advancing to about $£^{22} 12 \mathrm{~s} .6 \mathrm{~d}$ ．per bottle， at which they now stand，but the turnover continued restricted．

Tungsten Ore．－Continued abstention on the part of buyers has resulted in still further depression in this commodity，forward shipment from China now being obtainable at about 12 s ． 6 d ．to 13 s per unit c．i．f．
Molybdenum Ore－－There is no demand worth speaking about and prices are still largely nominal at around 32 s ． 6 d ．to 35 s ．6d．per unit c．i．f．for 80 to $85 \% \mathrm{MoS}_{2}$ concentrates．

Graphite．－Business is very depressed，but prices are still nominally maintained at $£ 25$ to $\AA 27$ per ton c．i．f．for 85 to $90 \%$ raw Madagascar flake and $f_{24}$ to $£ 26$ c．i．f．for $90 \%$ Ceylon lumps．

Silver．－The general tone of this market during the past month has remained anything but strong． On January 1 spot bars were quoted at $14 \frac{5}{5} \mathrm{~d}$ ．but by January 15 had declined to $13 \not \frac{1}{8} \mathrm{~d}$ ．Several suggestions were put forward during the month for measures to improve the price and rehabilitate the Chinese exchange，but there was no real buying interest and by January 31 spot bars had sagged
to 13 d．

## STATISTICS

PRODUCTION OF GOLD IN THE TRANSVAAL.

|  | Rand. | $\begin{aligned} & \text { ELSE- } \\ & \text { wHERE. } \end{aligned}$ | Total. |
| :---: | :---: | :---: | :---: |
| January, 1930 | $\begin{gathered} \mathrm{O}_{2} \\ 848,245 \end{gathered}$ | $\begin{gathered} \mathrm{Oz} . \\ 34,556 \end{gathered}$ | $\begin{gathered} \mathrm{Oz} . \\ 882,801 \end{gathered}$ |
| February | 783,086 | 35,102 | 818,188 |
| March | 852,089 | 37,281 | 889,370 |
| Apri] | 831,996 | 36,610 | 868,606 |
| May. | 876,893 | 39,320 | 916,213 |
| June | 847,352 | 40,515 | 887,867 |
| July | 871,468 | 41,184 | 912,652 |
| August | 878,474 | 42,607 | 921,081 |
| September | 860,311 | 42,865 | 903,176 |
| October. | 884,682 | 41,929 | 926,561 |
| November | 841,038 | 40,715 | 884,753 |
| December | 897.202 | 41,290 | 908,492 |
| J anuarv, 1 n31 | 873.8972 | 40,704 | 011,576 |

TRANSVAAL GOLD OUTPUTS.

|  | December. |  | Jandary. |  |
| :---: | :---: | :---: | :---: | :---: |
|  | Treated Tons, | Yield $\mathrm{Oz} .$ | Treated Tons. | Yield Oz . |
| Brakpan | 92,800 | £143,177 | 95,000 | $£ 147.013$ |
| City Deep | 89,000 | 24,201 | 100,000 | 25,486 |
| Cons. Main Reef | 66,000 | 22,935 | 67,000 | 23,431 |
| Crown Mines. | 247,000 | 79,360 | 256,000 | 80,695 |
| D'rb'n Roodepoort Deep | 46,000 | 15,194 | 46,700 | 15,392 |
| East Rand P.M. | 153,000 | 40,860 | 156,000 | 41,805 |
| Geduld | 84,000 | 27,091 | 85,000 | 27,231 |
| Geldenhuis Deep | 68,500 | 16.062 | 69, 500 | 16,310 |
| Glynn's Lydenburg | 6,200 | 2,296 | 6,300 | 2,333 |
| Government G.M. Areas | 203,000 | £394,866 | 212,000 | £409,867 |
| Kleinfontein | 50,700 | 10,999 | 52,500 | 11,389 |
| Langlaagte Estate | 80,000 | ¢110,857 | 81,000 | 6115,108 |
| Luipaard's Vlei | 30,000 | 7,655 | 32,000 | 8,102 |
| Meyer and Charlton | 18,400 | 118,270 | 18,400 | £17,265 |
| Modderfontein New | 163,000 | 70,183 | 161,000 | 70,349 |
| Modderfontein B | 69,500 | 22,684 | 71,500 | 23,066 |
| Modderfontein Deep | 44,200 | 22,900 | 46,000 | 23,422 |
| Modderfontein East | 70,000 | 20,588 | 72,000 | 21,144 |
| New State Areas | 78,000 | ¢167,857 | 81,000 | £172,396 |
| Nourse | 64,800 | 19,348 | 68,100 | 20,064 |
| Randfontein | 221,000 | £248,557 | 220,000 | ¢257, 352 |
| Robinson Deep | 96,800 | 27,873 | 98,000 | 27,942 |
| Rose Deep | 62,500 | 13,276 | 62,000 | 13,305 |
| Simmer and Jack | 76,000 | 22,280 | 76,700 | 22,218 |
| Springs | 69,000 | €144,749 | 71,500 | ¢146,416 |
| Sub Nigel | 31,000 | 27,784 | 31,000 | 27,757 |
| Iransvaal G.M. Listates | 15,200 | 5,115 | 15,216 | 4,963 |
| Van Rya | 41,500 | ¢42,191 | 42,500 | 642,507 |
| Van Ryo Deep | 67,000 | ¢104,746 | 63,000 | ¢100,140 |
| West Rand Consolidated | 93,000 | ¢106,713 | 98,000 | E107,206 |
| West Springs | 63,100 | £76,176 | 71,500 | €76,863 |
| Witw'tersr'nd (Kaights) | 55,500 | E49,896 | 57,000 | E49,609 |
| Witwatersrand Deep .. | 40,500 | 12,389 | 39,900 | 9,331 |

COSI 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. |
| :---: | :---: | :---: | :---: | :---: | :---: |
| October, 1929 |  | S. ${ }_{28} \quad 1$ | s. d. | s. 8. | $\underset{, 115,744}{f}$ |
| November . . | 2,559,450 | 28 3 | 1911 | 84 | 1,071,199 |
| December | 2,528,000 | 283 | 1911 | 84 | 1,058,231 |
| January, 1930 | 2,618,600 | $28 \quad 2$ | 199 | 85 | 1,103,718 |
| February | 2,421,100 | $28 \quad 5$ | 200 | 85 | 1,019,482 |
| March | 2,663,820 | 281 | 198 | 85 | 1,121,216 |
| April | 2,549,250 | 287 | 20 1 | 86 | 1,084,504 |
| May | 2,741,634 | 281 | 198 | 85 | 1,153,549 |
| June | 2,651,970 | $28 \quad 2$ | 197 | 87 | 1,141,197 |
| July | 2,706,900 | 285 | 198 | 89 | 1,184,107 |
| August | 2,693,100 | 283 | 196 | 89 | 1,174,828 |
| September | 2,653,250 | 285 | 198 | 8 y | 1,160,430 |
| October | 2,741.080 | 285 | 197 | 810 | 1,212,822 |
| November | 2,628,800 | 284 | 197 | 89 | 1,145,097 |
| December. |  |  |  |  | 1,160.548 |

NATIVES EMPLOYED IN THE TRANSVAAL MINES.

|  | Gold <br> Mines. | Coal <br> Mines. | Diamond Mines. | Total. |
| :---: | :---: | :---: | :---: | :---: |
| January 31, 1980 | 190,663 | 15,288 | 5,889 | 211,840 |
| February 28 .... | 196,752 | 15,495 | 6,584 | 218,831 |
| March 31 | 200,134 | 15,350 | 7,002 | 222,316 |
| April 30 | 202,434 | 15,109 | 5,565 | 223,108 |
| May, 31 | 202,182 | 15,028 | 5,340 | 222,550 |
| June 30 | 201,324 | 14,943 | 5,126 | 221,393 |
| July 31 | 201,111 | 14,670 | 5,490 | 221,271 |
| August 31 | 202,257 | 14,788 | 5,754 | 222,799 |
| September 30 | 205,061 | 14,706 | 5,767 | 225,534 |
| October 31. | 206,778 | 14,482 | 5,032 | 226,292 |
| November 30 | 205,030 | 13,973 | 4,748 | 223,751 |
| December 31 | 203,473 | 13,763 | 4,607 | 221,843 |
| January 31, 1931. | 209,442 | 13,865 | 4,32) | 227,632 |

PRODUCTION OF GOLD IN RHODESIA.

|  | 1927 | 1928 | 1929 | 1930 |
| :---: | :---: | :---: | :---: | :---: |
| January | $\begin{gathered} \text { oz. } \\ 48,731 \end{gathered}$ | $\stackrel{\text { oz. }}{51,356}$ | $\begin{gathered} 02 . \\ 46,231 \end{gathered}$ | $\begin{gathered} \mathrm{oz} . \\ 46,121 \end{gathered}$ |
| February | 46,461 | 46,286 | 44,551 | 43,385 |
| March | 50,407 | 48,017 | 47,388 | 45,511 |
| April | 48,290 | 48,549 | 48,210 | 45,806 |
| May | 48,992 | 47,323 | 48,189 | 47,645 |
| June. | 52,910 | 51,762 | 48,406 | 45,203 |
| July | 49,116 | 48,960 | 46,369 | 45,810 |
| August | 47,288 | 50,611 | 46,473 | 46,152 |
| Septembe | 45,838 | 47,716 | 45,025 | 46,151 |
| October | 46,752 | 43,056 | 46,923 | 45,006 |
| November | 47,435 | 47,705 | 46,219 | 44,351 |
| December. | 49,208 | 44.772 | 46.829 | 46,485 |

RHODESIAN GOLD OUTPUTS.

|  | December. |  | Janvary. |  |
| :---: | :---: | :---: | :---: | :---: |
|  | Tons. | Oz . | Tons. | Oz . |
| Cam and Motor | 24,400 | 10,558 | 24,400 | 10,576 |
| Globe and Phoenix | 6.026 | 5,393 | 6,066 | 5,813 |
| Lonely Reef | 6,400 | 3.675 | 6,400 | 3,263 |
| Luiri Gold | 1,711 | £2,412 |  |  |
| Rezende | 6,400 | 2,685 | 6,400 | 2,663 |
| Sherwood Star | 4,600 | 611,081 | 4,600 | £11,390 |
| Wanderer Consnlidated | 15,900 | 4,077 | 15,90n | 4.061 |

WEST AFRICAN GOLD OUTPUTS.

|  | December. |  | January. |  |
| :---: | :---: | :---: | :---: | :---: |
|  | Ton | Oz . | Tons. | Oz . |
| Ariston Gold Mines | 4,280 | ¢7,928 | 4,419 | ¢8,368 |
| Ashanti Goldfields | 11,620 | 13,958 | 11,750 | 13,971 |
| Taquab and Aboss | 10,080 | 615,921 | 10,332 | ¢16,301 |

AUSTRALIAN GOLD OUTPUTS BY STATES.

|  | Western Australia. | Victoria. | Queensland |
| :---: | :---: | :---: | :---: |
| January, 1930 | $\begin{gathered} \mathrm{Oz} \\ 25,472 \end{gathered}$ | Oz . 952 | $\begin{gathered} \mathrm{Oz}_{2} \\ 209 \end{gathered}$ |
| February .... | 31,307 | 1,354 | 350 |
| March | 27,946 | 2,562 | 382 |
| April | 36,652 | 1,812 | 1,081 |
| May | 32,967 | 3,480 | 580 |
| June | 41,738 | 812 | 673 |
| July. | 31,174 | 2,327 | 728 |
| August | 38,579 | 1,864 | 323 |
| September | 32,034 | 1,992 | 429 |
| October | 39,687 | 1,685 | 628 |
| November | 33,708 | - | - |
| December | 42,097 | - | -- |
| January, 1931. | 27,306 | - | -- |

AUSTRALASIAN GOLD OUTPUTS.

|  | December. |  | Jandary. |  |
| :---: | :---: | :---: | :---: | :---: |
|  | Tons | Value 6 | Tons. | Value $£$ |
| Associated G.M. (W.A.) | 3,596 | 4,739 | 4,640 | 5,840 |
| Blackwater (N.Z.) | 2,860 | 4,730 | 2,965 | 5,023 |
| Boulder Persev'ce (W.A.). | 5,032 | 10,841 | 6,261 | 12,012 |
| Grt. Boulder Pro. (W.A.) | 7,674 | 18,372 | 9,003 | 20,846 |
| Lake View \& Star (W.A.) |  |  |  |  |
| Sons of Gwalia (W.A.) | 8,514 | 12,213 | 11,380 | 14,349 |
| South Kalgurli (W.A.) | 6,042 | 11,351 | 6,835 | 13,498 |
| Waihi (N.Z.) |  | $\left\{\begin{array}{r}9,084 * \\ 83,435\end{array}\right.$ |  | - |

[^0]GOLD OUTPUTS, KOLAR DISTRICT, INDIA

|  | December. |  | Jandary. |  |
| :---: | :---: | :---: | :---: | :---: |
|  | Tons Ore | $\begin{gathered} \text { Total } \\ \mathrm{Oz} . \end{gathered}$ | Tons Ore | Total $\mathrm{Oz}$ |
| Falaghat | 3,500 | 2,107 |  |  |
| Champion Reef | 8,760 | 5,863 | 8,300 | 5,555 |
| Mysore........ | 18,608 | 12,109 | 17,255 | 11,297 |
| Nundydroog | 11,540 | 7,667 | 12,013 | 7,221 |
| Ooregum .... | 12,000 | 6,139 | 10,500 | 5,145 |

## MISCELLANEOUS GOLD, SILVER, AND PLATINUM OUTPUTS

|  | December. |  | Jancary. |  |
| :---: | :---: | :---: | :---: | :---: |
|  | Tons | Value \& | Tons | Value 6 |
| Chosen Corp. (Korea) | 10.038 | 14.117 | 9,410 | 14,033 |
| Frontino \& Bolivia (C'lbia) | 2,670 | 10,398 | 2,600 | 10,267 |
| Lena (Siberia) <br> Lydenburg Plat. (Trans.) | - |  | 2,500 |  |
| Marmajito (Colombia) .. | 1,100 | 5,064 | 1,120 | 5,698 |
| Fresnillo .......... | 78,122 | 26,694d |  |  |
| Onverwacht Platinurn Oriental Cons. (Korea) | 15,011 | 86,698d | - |  |
| Oriental Cons. (Korea) <br> St. John del Rey (Brazil). | 15,011 | $\begin{aligned} & 86,698 d \\ & 43,500 \end{aligned}$ | -- | $\begin{aligned} & 87,4081 \\ & 47,500 \end{aligned}$ |
| Santa Gertrudis (Mexico). | 45,745 | 87,196d | - |  |

d Dollars. $p \mathrm{Oz}$, platinoids.
PRODUCTION OF TIN IN FEDERATED MALAY STATES.
Estimated at 70\% of Concentrate shipped to Smelters. Long Tons.

| July, 1980 | 5,525 | Taouary, 1931 | - |
| :---: | :---: | :---: | :---: |
| Angust | 4,153 | Febraary |  |
| September | 4,048 | March | = |
| October | 4,807 | April | - |
| November | 4,812 | May | E |
| December | 5,019 | June |  |

OUTPUTS OF MALAYAN TIN COMPANIES.
In Long Ions of Concentrate.

|  | Nov. | Dec. | Jan. |
| :---: | :---: | :---: | :---: |
| A ver Hitam | $65 \frac{1}{2}$ | 119 | 131 |
| Batu Caves |  |  | 22 |
| Changkat | 55 | 60 | 53 |
| Cbenderiang. |  |  |  |
| Gopeng | $65 \frac{1}{2}$ | $65 \frac{1}{2}$ | $71 \frac{1}{2}$ |
| Hongkong Tin | 63 | 62 | $53 \frac{1}{2}$ |
| Idris Hydraulic | 29 9 | 38 | 28 |
| Ipoh .... | 4812 | $56 \frac{1}{2}$ | 554 |
| Kampar Malaya | 80 | 93 | 87 |
| Kampong Lanjut | 110 | 75 | 55 |
| Kamunting | - | - |  |
| Kent (F.M.S.) | 40 | 444 | 29 |
| Kepong..... | -33 | 33 | 30 |
| Kinta Kellas. | 35 | $74 \frac{1}{2}$ | $59 \%$ |
| Kuala Kampar | 100 | 75 | 65 |
| Kundang ..... | - |  | 35 |
| Lahat . . . . . . | 201 | 201 | 20.4 |
| Malaya Consolidated | 531 | 374 | 55 |
| Malayan Tin | 131 | 154 | 1488 |
| Meru . | 15 |  |  |
| Pahang | 255 | 255 | 256 |
| Penawat | $74 \%$ | $58 \frac{1}{2}$ | $73 \frac{1}{2}$ |
| Pengkalen | $62 \frac{1}{2}$ | 66 | $77 \frac{1}{3}$ |
| Petaling | 127 | 145 | $184 \frac{1}{2}$ |
| Rahman | 531 | 597 | $53 \frac{1}{2}$ |
| Rambutan | 9 | $7 \frac{1}{2}$ | $9 \frac{1}{2}$ |
| Rantau | - | 46 | $30^{2}$ |
| Rawang | 100 | 65 | 65 |
| Rawang Concessions | 55 | 30 | 35 |
| Renong | 53 | 66 | 631 |
| Selayang. |  | - |  |
| Southern Malayan | 2237 | 2231 | 1993 |
| Southern Perak | 23. | 384 | 37 ${ }^{\text {2 }}$ |
| Southern Tronoh | 51 | $34 \frac{1}{2}$ | 45 |
| Sungei Besi . | 39 | $39^{\circ}$ | 42 |
| Sungei Kinta | 314 | $13 \frac{3}{4}$ | 24 |
| Sungei Way | $107 t$ | 113 | 119 |
| Taiping ... | - | 28 | 18 |
| Tanjong | - | - | 45 |
| Teja Malaya | 268 | $18 \frac{1}{4}$ | 298 |
| Tekka .... | 33 | 28 | $50 \frac{1}{2}$ |
| Tekka-Taiping. | 30 | 32 | $60^{\circ}$ |
| Temoh. |  | $46{ }^{1}$ | 57 |
| Tronoh | 96 | 651 | ת0 |

OUTPUTS OF NIGERIAN TIN MINING COMPANIES. In Long Tons of Concentrate.

|  | Nov. | Dec. | Jan. |
| :---: | :---: | :---: | :---: |
| Amari | - | - |  |
| Anglo-Nigerian |  | 403 | 250 |
| Associated Tin Mimes. | 200 | 200 | 7 |
| Baba River | 7 | 7 | $4{ }^{2}$ |
| Batura Monguna | $3 \frac{1}{6}$ | $3{ }^{3}$ | 50 |
| Busichi | 40 | 12 | 109 |
| Daffo. | 13 | 12 |  |
| Ex-Lands |  | - | $4 \frac{1}{2}$ |
| Filani | 20 | 22 | 22 |
| los. | 281 | $24 \frac{1}{2}$ | 24 |
| Tuga valtey | 17 | 17 | 8 |
| Junction |  |  |  |
| Kaduna Syndicate. | 13 | 13 |  |
| Kaduna Prosjectors | 10 | 10 |  |
| Kassa | 12. | 9 |  |
| London Tia | 10 | 80 | 80 |
| Lower Blsicla | 9 | $6 \frac{1}{2}$ |  |
| Naraguta | - | - |  |
| Naraguta Durumi | - | - |  |
| Naraguta Extended | - | - | 10 |
| Naraguta Kırama . | - | - |  |
| Naraguta Kornt | - | - | $\vec{\square}$ |
| Nigerian Consolidated | 14 | 14 | 14 |
| Oftion River. . . . . . . . | 31 | 5 | 6 |
| Ribon Valley | 108 | 8 ? | 11 |
| Soutb Bukeru Areas |  | - | 12 |
| Tin Fields | - | - |  |
| Tin Properties | 8 | 13 | - |
| United Tin Areas | 29 | 19 | 23 |
| Yarde Kerri | 10 |  | 11 |

OUTPUTS OF OTHER TIN MINING COMPANIES. In Long Tons of Concentrate.

|  | Nov. | Dec. | Jan. |
| :---: | :---: | :---: | :---: |
| Anglo-Burma (Burma) | 363 | 25 | 20 年 |
| Aramayo Mines (Belivia) | 199 | 245 | 285 |
| Bangrin (Siam) | 89 | $59 \frac{1}{2}$ | 79 |
| Consolidated Tin Mines (Burma) | 118 | 113 | 120 |
| East Pool (Cornwall) | $37 \frac{3}{4}$ | 37\% |  |
| Fabulosa (Bolivia) | 163 | 140 | 120 |
| Geevor (Cornwall). |  |  |  |
| Jantar (Cornwal) |  |  |  |
| Kagera (Uganda) | 28 | 28 | 28 |
| Malaysiam Tin | $20{ }^{\text {a }}$ | 239 | 23 \% |
| Northern Tavoy |  |  |  |
| Patino. | 1,330 | 1,380 | - |
| Polhigey (Cornwall) |  |  |  |
| San Finx (Spain) | $3{ }^{*}$ | 29* |  |
| Siamese Tin (Siam) |  | 1391 | $148 \%$ |
| South Crofty (Comwall) | $57 \frac{3}{4}$ |  |  |
| Tavoy Tin (Burma) |  | $78 \frac{3}{8}$ | 60 |
| Thenndaw (Burma) |  |  |  |
| Tangkah Harbour (Siam) <br> Toyo (Japan). | $53$ | $54$ | 29 |
| Wheal Kitty (Cornwali) |  |  |  |
| Zaajplaats | 28 |  |  |
| * Tin and Woltram. <br> COPPER, LEAD, AND ZINC OUTPUTS. |  |  |  |
|  |  |  |  |
|  |  | Dec. | Jan. |
| Broken Hill South . . . $\left\{\begin{array}{l}\text { Tons lead conc. . } \\ \text { Tons zinc conc. . }\end{array}\right.$ |  | . 4,949 |  |
| Burma Corporation ... $\left\{\begin{array}{l}\text { Ton } \\ \mathrm{Oz} .\end{array}\right.$ | refined | 6,420 | 6,420 |
| Bwana M'Kubwa....... T Electrolytic Zinc. | refined st | 571,380 | 540,000 |
|  | zinc. | 452 |  |
| Electrolytic Zinc ...... . To Indian Copper | copper | 4,190* | 4,1571 |
| Messina.............. To | copper | 849 | 359 766 |
| Mount Lyell . . . . . . . . To | concen | 3,476 |  |
| North Broken Hill. . . . f Ton | lead con | 3,470 4,680 | 3,530 |
| Poderosa ........... To | copper |  |  |
| Rhodesia Broken Hill . To | lead. | 1388 | 392 |
|  | slab zin | 1,250 | 1,254 |
| San Francisco Mexico . To | s zinc con | 4,180 | 4,195 |
| Sulpbide Corporation . . \{ To | lead con | 4,575 | 4,705 |
| Sulphide Corporation .. T Ton | zinc co |  |  |
| Tetiuhe | ead | 970 |  |
| Trepca ............... To | lead co | 2,415 |  |
|  | zinc co | 4,089 | 3,190 |
| Zinc Corporation ..... \{ | lead co | 5.251 | 2,557 |
|  | inc co | 4.074 |  |

## G COMPANIE

| De |  |
| :---: | :---: |
| 420 |  |
|  |  |
| 31 |  |
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| 12 |  |
| 22 |  |
|  |  |
| $\frac{24}{17}$ |  |
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| 10 |  |
| $\underline{1}$ | 89 |
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| conc.. |
| ned lead. |
| d silver |
| er oside |

[MPORTS OF ORES, METALS, ETC., INTO UNITED KINGDOM

|  |  | November. | December, |
| :---: | :---: | :---: | :---: |
| Iron Ore | Tons | 228,862 | 239,780 |
| Manganese Ore | Tons | 17,633 | 19,275 |
| Iron and Steel | Tons | 209,769 | 283,038 |
| Copper and Iron Pyrites | Pons | 23,182 | 20,575 |
| Copper Ore, Matte, and Prec. | Tons | 3,933 | 2,879 |
| Copper Metal | Tons | 13,162 | 13,906 |
| Tin Concentrate | Tons | 6,244 | 5,853 |
| Tin Metal | Tons | 202 | 600 |
| Lead Pig and Shee | Ions | 30,939 | 25,745 |
| Zinc (Spelter) | Tons | 8,108 | 9,673 |
| Zinc Sheets, etc. | Fons | 451 | 2,121 |
| A lumin ium ... | Tons | 1,472 | 1,38:) |
| Mercury | Lb.. | 70,691 | 134,176 |
| Zinc Oxid | Tons | 644 | 3,652 |
| White Lead | Cwt. | 15,179 | 12,857 |
| Red and Orange Lead | Cwt. | 3,282 | 4,572 |
| Barytes, ground | Cwt. | 31,180 | 37,906 |
| Asbestos | Tons | 873 | 2,448 |
| Boron Minerals | Toas | 742 | 732 |
| Borax | Cwt. | 13,755 | 23,535 |
| Basic Slag | Ions | 1,666 | 3,014 |
| Superphosphates | Tons | 6,214 | 7,965 |
| Phosphate of Lime | Tons | 22,285 | 30,413 |
| Mica | Tons | 341 | 187 |
| Sulphur | Tons | 7,418 | 5,370 |
| Nitrate of Soda | Cwt. | 56,234 | 127,660 |
| Potash Salts | Cwt. | 148,087 | 169,908 |
| Petroleum: Crude | . Gallons | 23,449,026 | 41,187,447 |
| Lamp Oil | . Gallons | 22,783,042 | 16,009,101 |
| Motor Spirit | . Gallons | 56,681,205 | 52,621,660 |
| Lubricating Oil | Gallons | 8,038,130 | 8,498,232 |
| Gas Oil | Gallons | 3,902,902 | 7,644,814 |
| Fuel Oil | Gallous | 29,873,962 | 44,779,714 |
| Asphalt and Bitumen | Fons | 10,508 | 11,372 |
| Parafin Wax | Cwt. | 85, 231 | 109,252 |
| Turpentine | cwt | 24,295 | 91,123 |

OUTPUTS REPORTED BY OIL-PRODUCING COMPANIES In Tons.

|  | November. | December. | January. |
| :---: | :---: | :---: | :---: |
| Anglo-Ecuadorian | 15,323 | 17,339 | 17,040 |
| Apex Trinidad. | 36,850 | 37,280 | 40,060 |
| Attock | 1,815 | 1,680 | 1,081 |
| British Burmab. | 4,497 | 4,648 | 4,614 |
| British Controlled | 33,990 | 35,074 | 36,073 |
| Kern Mex | 822 | 894 | 785 |
| Kern River (Cal.) | 1,751 | 1,541 | 1,482 |
| Kern Romana | 2,290 | 2,182 | 1,822 |
| Kern Trinidad | 4,389 | 4,494 | 5,457 |
| Lobitos | 28,164 | 28,401 | 26,605 |
| Phomix | 50,985 | 70,523 | 62,149 |
| St. Helen's Petroleum | 6,137 | 6,243 | 6,003 |
| Steaua Romana | 51,310 | 91,250 | 88,950 |
| Tampico | 2,998 | 3,171 | 3,187 |
| Tocuyo | 2,459 | 2,293 | 2,382 |
| Trinidad Leaseholds | 23.300 | 24,400 | 23,5\% |

QUOTATIONS OF OIL COMPANIES' SHARES.
Denowination of Shares $£ 1$ unless otherwise noted.

|  | $\begin{gathered} \mathrm{Jan} 9, \\ 1931 . \end{gathered}$ | $\begin{gathered} \text { Feb. } 10 . \\ 1931 . \end{gathered}$ |
| :---: | :---: | :---: |
| Anglo-Ecuadorian | $\begin{array}{lrl} E & \text { s. } & \text { d. } \\ & 11 & 6 \end{array}$ | $\begin{array}{lll} E & \text { s. } & \text { d } \\ & \text { di } & 0 \end{array}$ |
| Anglo-Egyptian B. | 1176 | 239 |
| Anglo-Persian 1 st Pref. | 186 | $1 \quad 70$ |
| " ${ }^{\text {c }}$ " Ord. | 2150 | $\bigcirc 150$ |
| Apex Trinidad (is.) | 120 | -11 0 |
| Attocls | 189 | 176 |
| British Burmah (80.) | 49 | 40 |
| Mritish Controlled ( $\$ 5$ ) | 16 | 13 |
| Hurmah Oil . | 3126 | 3113 |
| Kero River Cal. [i0s.] | 30 | 30 |
| Lobitos, Peru | 189 | 180 |
| Mexican Eagle, Ord (4 peros) | 80 | 106 |
| " ${ }^{\text {a }}$ " $8 \%$ Pref. (4 pesos) |  | 106 |
| Phonix, Roumanian ............ | 69 | 76 |
| Royal Dutch [100 ni.) | 2480 | $26 \quad 50$ |
| Sthell Transport, Ond. | 3139 | 3163 |
| .. ${ }^{\text {a }}$ \% Pref. ( $¢ 10$ ) | 1013 | 1026 |
| Steaua Romana . . . . . . . . . . . | 109 | 106 |
| Trinidad Leaseholds | 189 | 11 |
| United British of Trinidad ( 6 s .8 d .) | 1 56 | 56 |
| V.O.C. Holding . . . . . . . . . . . . . . | 1106 | 1130 |

PRICES OF CHFMICALS. Feb. 9.
These quotations are not absolute; they vary according to quantities required and contracts running.


## SHARE QUOTATIONS

Shares are $£ 1$ par value except where otherwise noted


LEAD-ZINC:
Amalgamated Zine (8s.), N.S.W. Broken Hill Proprietary, N.S.W. Broken Hill, North, N.S.W Broken Hill'South, N.S.W. Burma Corporation (10 rupees) Electrolytic Zinc Pref., Tasmania Mount Isa, Queensland.
Rhodesia Broken Hill ( 5 s. )
San Francisco (10s.), Mexico
Sulphide Corporation (15s.), N.S.S.W ditto, Pref.
Zinc Corporation (10s.), N.S.W ditto, Pref.

## TIN



## DIAMONDS

| Consol. African Selection Trust (5s. Consolidated of S.W.A. (10s.) <br> De Beers Deferred ( $£ 210 \mathrm{~s}$.) Jaggersfontein <br> Premier Preferred (5s.) |
| :---: |
|  |  |
|  |  |
|  |  |

FINANCE, Etc.:
Anglo-American Corporation (10s.)
Anglo-French Exploration
Anglo-Oriental (Ord., 5 s.)
ditto, Pref.
British Suuth Africa (15s.
Central Mining ( $£ 8$ )
Consolidated Gold Fields
Consolidated Mines Selection (10s.
Fanti Consols (8s.).
General Mining and Finance
Gold Fields Rhodesian (10s.)
Johannesburg Consolidated
London Tin Corporation (10s.)
Minerals Separation
Narional Mining (8s.)
Rand Mines ( 5 s.$)$
Rand Selection (55.)
Rhodesian Anglo-American (10s.)
Rhodesian Congo Border
Rhodesian Selection Trist (5s.)
South Rhodesia Base Metals
Tigon (5s.)
Union Corporation (12s. 6d.)
Venture Trust (10s.)
Jan. $y_{1}$
1931.
s $\quad$.
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Feb.
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| 0 |
| 9 |
| 6 |
| 0 |
| 3 |
| 0 |
| 9 |
| 9 |
| 9 |
| 6 |
| 0 |

13

16
3
3
0
3
510
12
0


## THE MINING DIGEST

A RECORD OF PROGRESS IN MINING, METALLURGY. AND GEOLOGY
In this section we give abstracts of important articles and papers appearing in technical journals and proceedings of societies, together with brief records of other articles and papers: also notices of new books and pamphiets, lists of patents on mining and metallurgical subjects, and abstracts of the yeariy reports of mining companies.

## COPPER RECOVERY FROM FINE ORES AND DUMP MATERIALS

In Bulletin 329 of the United States Bureau of Mines, J. D. Sullivan and A. P. Towne give the results of an investigation into the agglomeration and leaching of slimes and other finely divided ores. The authors say that certain sections of the United States contain Jarge tonnages of concentrator tailings in which there is considerable copper in both the oxidized and sulphide conditions, the oxidized form usually predominating. Concentrator tailings from tables and vanners frequently contained more copper than many ores now being mined in certain parts of the South-West. One plant in the South-West United States has $15,000,000$ tons of tailings containing approximately one-quarter of a billion pounds of copper, about two-thirds of which exists in the oxidized condition and one-third in the sulphuric condition largely as chalcocite.

Nearly all copper concentrators to-day employ flotation, and the tailings are usually lower in their copper content than those of the older methods of concentrating; but in many plants the tailings loss is still high, especially where the feed contains oxidized copper. Hydrometallurgical processes offer the best method of recovering the copper in concentrator tailings. As part of the copper exists in an oxidized condition, the ore is not adapted to treatment by flotation processes. Copper often exists largely in an oxidized condition, which lends to its amenability to leaching. Finely ground tailings are advantageous regardless of the method of recovery employed.

Concentrator tailings can be leached and a large portion of the copper values extracted ; the method to use, however, is a problem on which the hydrometallurgists have been working for many years. When tailings are taken from a concentrator to a disposal dump the material is usually transported by flume to the desired place. The moisture content of the tailings as they leave the concentrator usually ranges from 50 to $80 \%$. In forming the disposal pond the tailings classify; the coarser material drops off near the flume; and the finer material is transported a greater distance before it settles. The tailings are thus classified into two products, sand and slimes. Typical tailings obtained from a dump in Arizona contained sand, all of which was - 10 mesh with $47 \%+28$ mesh and $14 \%-200$ mesh, and slimes, $1 \%$ of which was +28 mesh and $84 \%$ of which was - 200 mesh.

The sands of the tailings are not particularly difficult to leach, because the material is coarse and porous enough for standard percolation methods, especially if leaching is preceded by hydraulic classification to remove the minus 200 -mesh material. The slimes present a much more difficult leaching problem. Slimes, especially those found in certain tailings of the South-West,
are colloidal in nature ; therefore, any solutions resulting from the agitation of slimes and aqueous solutions are difficult to settle. Any countercurrent decantation process would require a large amount of expensive equipment. Filtration would be expensive and probably not entirely satisfactory owing to the colloidal nature of the material.

Slimes, being in a finely divided state, are ideal in physical character for agitation leaching, but in addition to the settling problem the objection to agitation leaching is that usually considerable sulphide copper is present. An agitation leaching process usually is relatively short, whereas at least two weeks are required to extract a reasonable amount of copper from chalcocite or bornite at ordinary temperatures. The time could be reduced by using warm or hot leaching solutions, but such a procedure is expensive.

Disposal dumps of tailings cannot be leached in place. If the dumps were built on prepared bottoms or footings one might leach the sand portion; unfortunately, however, when these old tailings dumps were made the idea of later leaching them in place was not considered, and consequently they were stored where convenient and without prepared bottoms. The slimes could not be leached in place in any event, as the materjal is packed hard and is impervious to solutions.

The large tonnages of concentrator tailings and the enormous quantity of copper available in the United States, if a satisfactory metallurgical process could be employed led the United States Bureau of Mines to undertake an investigation of the recovery of copper from concentrator tailings by hydrometallurgical methods. That the ore was already mined, crushed, and ground was an added incentive to carry on the investigation

Early experimental work was done by H. E. Keyes, formerly associate metallurgist of the Southwest Experiment Station. His work indicated the possibility of using surface forces to aid the leaching process. Preliminary experiments carried on by Keyes at Tucson showed that if a small quantity of water or other solution were added to tailings or ore, at the same time giving the mass a moving, rolling, or shaking movement, the material would become agglomerated into balls, generally uniform in shape. If the mass was then charged into a column and leaching solution added by the open-drainage trickle method, so that the material was not flooded, fairly satisfactory extractions of the copper values were obtained. Surface tension holds the particles together, and if the solution is added slowly so that a film of solution surrounds the particles the fine material is not washed away and the mass will stand up under certain conditions of leaching.

Keyes also did considerable experimental work in co-operation with the Pinto Valley Copper Co.,
using the open-drainage principle of leaching, and in many of these experiments agglomeration was employed. The work done by Keyes, both at the Tucson station and in co-operation with the Pinto Valley Cooper Co., is described in Bureau of Mines Bulletin 321 . His experiments on the leaching of agglomerated concentrator tailings were preliminary in nature and were on too small a scale to be considered quantitative. In this paper experimental data are presented to show what may be expected when leaching on a larger scale under conditions approximating those in practice.

Experimentar Work.-Of the vast number of tests performed only those are reported that have a definite bearing upon the resuits finally attained.

The first leaching experiments were made in glass columns about $1 \frac{1}{2} \mathrm{in}$. in diameter and 5 ft . high ; the next, in square columns 10 in . by 10 in . and 10 ft . high and in circular columns 12 in . in diameter and 10 ft . high ; and the last, in a vat 7 ft .6 in . wide by 8 ft .4 in . long and 7 ft .6 in . deep. The glass columns used about 1,500 grams of material, the square and circular columns about 500 lb ., and the large vat 12 tons. After the 12 -ton test further experiments were made on a smaller scale to study certain phases of the problem.

It was found that to secure the best results sand and slimes should not be agglomerated alone, but should be diluted with a coarse material, preferably capping or some other copper-bearing ore suitable for leaching. The results indicated that not over 30 or $35 \%$ of -200 -mesh material should be present in the agglomerated mass. Experiments showed that 8 to $12 \%$ of moisture was the best quantity to add in agglomerating. About 2 or 3 in. of coarse rocks were first placed in the bottom of the leaching column; the agglomerated material was then charged: and a laver of coarse sand, rock, or leaching ore about 1 or 2 in . deep was placed on top to protect the surfaces of the glomerules from the direct fall of solution and also to act as a distributor of solution. The solution was added to the top of the column of ore drop by drop so that it passed through the entire column of ore in the form of a film around the particles of ore and out the bottom of the column through prepared channels. Even with as much as $35 \%$ of - 200 -mesh material, the effuent solution was perfectly clear, requiring neither settling nor filtration. The material acted as its own filter. Solution must be added very carefully and slowly until the ore becomes saturated and solution comes through the bottom, after which the rate cf addition can be increased.

Method of Agglomeration,-Various methods of agglomeration were tried, but, for the purpose of the experimental tests, a concrete mixer proved best. For best results, if coarse material, sand, and slimes were to be agglomerated, the coarse material or coarse material and sand were first put into the mixer, and the required volume of water or leaching solution was added. After this mass was thoroughly mixed, the slimes were added. Glomerules formed which usually contained a nucleus of a large particle or particles surrounded by the sand and slimes. By following this proccdure uniform glomerules were obtained. The water or leaching solution could be added to the mixer first, then the coarse material and sand, and finally, after the coarse material was thoroughly wet, the slimes. Both methods gave glomerules of the same character. A typical screen analysis
of agglomerated material, after drying for about 24 hours at: $110^{\circ} \mathrm{C}$. to prevent the glomerules from sticking to each other, follows :-

$$
\begin{array}{lll} 
& \% \\
+\frac{1}{2} \text { inch } & & 6 \\
-\frac{1}{2}+\frac{1}{4} \text { inch } & \cdot & \cdot \\
-\frac{1}{4} \text { inch }+10 \text { mesh } & \cdot & 38 \\
-10+28 \text { mesh } & \cdot & 30 \\
-28+100 \text { mesh } & \cdot & \cdot  \tag{8}\\
-100+200 \text { mesh } & \cdot & 16 \\
-200 \text { mesh } & . & 8 \\
\hline
\end{array}
$$

This analysis is not the same as that before drying, because in drying and screening some small particles are knocked off the larger ones, but it shows roughly the size of particles usually obtained by the procedure outlined above. The screen analysis, before agglomeration, was :-

|  |  | $\%$ |
| :--- | :--- | ---: |
| $-\frac{1}{2}+\frac{1}{4}$ inch | 2 |  |
| $-\frac{1}{4}$ inch +10 mesh | $:$ | 32 |
| $-10+28$ mesh | $:$ | 16 |
| $-28+100$ mesh | $:$ | 18 |
| $-100+200$ mesh | $:$ | 5 |
| -200 mesh. | $:$ | 27 |

Larger particles can be obtained by adding the coarse material, sand, and slimes together, then adding solution, and agglomerating all of the mass at once. Intermediate sizes are secured by adding part of the slimes at the start with the coarse material, then adding the water, and finally the remainder of the slimes.

For the 12 -ton test the ore was agglomerated in a concrete mixer in batch runs usually of 150 lb . each. Ore and sand were first put into the mixer, and all of the water was added. When the mass was thoroughly mixed slimes were added, the mixer revolving continuously throughout the entire operation. This procedure caused the building of a glomerule which had coarse material as a nucleus. An examination of the glomerules in nearly every instance showed the particles to consist of this nucleus surrounded by fine material. In some batches the water was added to the mixer first, then the coarse material and sand, followed by slimes when the coarse material was thoroughly wet and mixed. The method used made no difference in the glomerules, as far as could be discerned from their appearance. Adding the water first and the ore afterward caused less dust loss than the other method. The maximum rate of agglomeration was $3,000 \mathrm{lb}$. per hour, or an average of 1 batch per 3 minutes. If the coarse material is first wet and the slimes are then added, about 1 minute is all that is required for mixing.

In the large scale tests the leaching solution used at the start was $0.25 \%$ of iron as ferric sulphate plus $1 \%$ of sulphuric acid.

As a result of the work done it was decided that the copper in concentrator tailings can be recovered by agglomerating the ore and leaching by the opendrainage trickle method. Coarse material must be added to the sand and slimes to act as a nucleus upon which the fine material can build.

Tests were made in column sizes from glass ones $1 \frac{1}{2} \mathrm{in}$. in diameter and 5 ft . high up to a vat containing 12 tons of agglomerated ore. In the smaller tests the support of the side walls was evident, as charges that would collapse in a 12 in . circular column could be successfully leached in a $1 \frac{1}{2} \mathrm{in}$. diameter glass column. Solution percolated freely through agglomerated ore containing up to $30 \%$
of - 200-mesh material and very good extraction of the copper values are obtained. It was easy to extract over $90 \%$ of the acid-soluble copper present in the ores and $80 \%$ of the total copper when the ratio of sulphide to oxidized copper was approximately 1 to 1 . By recirculating solutions, the concentration of copper was built up to as high as 61 grams per Iitre, which is higher than would be required in standard tank-house precipitation. The leaching solutions can be added slowly and the strength of the reagents controlled so as to obtain an effiuent solution that will use a minimum of scrap iron, if the copper in the pregnant solution is to be precipitated as cement copper.

By using solutions of sulphuric acid alone, considerable sulphide copper can usually be extracted, probably because by the extraction of soluble iron salts from the ore ferric sulphate is formed which attacks the sulphide minerals, although sulphuric acid in the presence of air attacks chalcocite slowly and converts it into the soluble sulphate. A fairly good extraction of sulphide copper was obtained on one ore when sulphuric acid and ferrous sulphate were used as the leaching solutions. Part of the ferrous sulphate was oxidized to ferric sulphate which attacked the sulphide portion of the minerals.

In practically all of the experiments on ores ferric sulphate was generated, probably owing partly to the dissolving of iron from the ore but in many instances the gain in ferric iron was considerably more than that dissolved from the ore. A study was undertaken to determine the factors governing this increase in ferric iron and it was concluded that impurities, particularly manganese, existed in the ore and during leaching oxidized ferrous ions to ferric ions.

The moisture content of the glomerules is very important and when the agglomerated ore contains approximately $30 \%$ of - 200 -mesh material and is all crushed through one-fourth inch the moisture
content should be about $10 \%$. It is preferable to agglomerate the ore with a solution such as acidified ferric sulphate that will attack the copper minerals. Drying or baking the glomerules before leaching was found to be deleterious. One test on a 500 -pound batch of agglomerated ore in which the leaching period was 13 days and the washing period 3 days showed an extraction of $80 \%$ of the total copper and approximately $95 \%$ of the oxidized copper. The leaching solution was acidified ferric sulphate. In commercial practice the cycle including charging, leaching, washing, and discharging would probably be about 20 days, varying, of course, with the character of the ore being leached, the ratio of acid-soluble to sulphide copper, the mineralogical association of the minerals, the acid-consuming constituents, and the temperature. The cycle would probably be a little longer than that now employed in standard leaching practice. The effluent solution was perfectly clear, even when $30 \%$ of - 200 -mesh material was present in the agglomerated ore. From this standpoint the solutions were ideal for electrodeposition.

The study of the distribution of solution in the 12 -ton test showed that the liquors spread out very evenly.
The purpose of agglomeration is to add permeability to the column of ore so that solution may get through and come in contact with the copper minerals. As mentioned early in the report, slimes dumps are packed hard and are impervious to solutions; rain water remains on the surface and does not penetrate into the body of the dumps; copper salts do not come to the surface by capillarity; and the incrustations of salts found on the surface are from the evaporation of surface waters that have formed pools on the piles of tailings. As is shown in the paper, agglomeration does add permeability to the ore and thus permits solution to get through and dissolve the copper minerals.

## FAN TESTING

In Bulletin No. 28 of the Kolar Gold Field Mining and Metallurgical Society J. E. Davies gives some notes on fan testing. After dealing with various uses to which fans are applied the author goes on to say that much has yet to be learned about fans. Their efficiency compared with that of electric motors and generators is low, the efficiency of all electrical plant having reached a very high standard. No doubt this is largely due to the accuracy with which test figures can be taken and the conditions under which the machines have to operate can be determined pretty closely. Unfortunately, in mine fan engineering, things have not been brought to such a fine art owing to the difficulty, in the first place, of accurately determining the resistance under which the fans have to work and secondly, the difficulty of getting large fans tested under load at the makers' works before accepting the delivery of them. If these tests could be taken at the works and fans were likely to be left on the makers' hands should their outputs and efficiency fall below the estimated values, things would rapidly improve.

There is no doubt that the customer himself has to be blamed to a certain extent for this, as he often neglects to send sufficient data to the makers with his inquiry, such data being the
volume and temperature of the air to be dealt with and also its barometric pressure and density and whether the water-gauge is to be taken on the suction or the delivery side of the fan. These are important factors in the determination of the size of the fan.

Air consists essentially of two elements, oxygen and nitrogen, their ratios in volume being 20.9 to 79.1 and in density 23.1 to 76.9 respectively. The weight of air at sea level and at a temperature of $32^{\circ} \mathrm{F}$. is 0.08072 lb . or, approximately, $13 \mathrm{cu} . \mathrm{ft}$. per lb . Water weighs 62.5 lb . per cu. ft. and therefore is 781.25 times the weight of air. In fan engineering the low positive or negative pressures used therein are expressed in inches of 'water gauge' in preference to ' lb. per sq. inch.' The specific heat of air has a value of 0.24 which is recommended for general engineering calculations, from which it will be seen that one British Thermal Unit will raise 4 lb . or 52 cu . ft . of air through $1^{\circ} \mathrm{F}$.

The volume of air varies inversely as its absolute temperature and this temperature may be taken as $-461^{\circ} \mathrm{F}$. This fact plays a very important part in the calculation necessary in order to determine the size of a fan which has to be used for inducing draught in a boiler installation, and although its influence is smaller in mining work, it should, nevertheless, be taken into acconnt

The pressure set up in a fan duct is dependent upon the resistance against which the fan has to work, and may be either positive or negative It is usually measured in inches of water-gauge. The total pressure is made up of two components, i.e. the static or pressure head which is due solely to the resistance of the circuit, and the velocity head which is due to the velocity at which the air travels.

The static pressure is measured on the usual " U" type water gauge, the lengths of the legs of which depend upon the pressure against which the fan has to work. It is preferably fitted with a sliding scale which can be set at zero by means of an adjusting screw when the gauge is entirely disconnected from the air system.


Fig. 1.
The velocity pressure should be measured by a more sensitive type of gauge, on account of the exceedingly low velocity pressures which occur in many cases. This gauge is on the same principle as the " $U$ " type, but is inclined at an angle to the horizontal, which angle may on occasion be as small as $5^{\circ}$. To increase its sensitivity further, the liquid used should have a smaller specific gravity than water; consequently, when such liquids as alcohol, paraffin, or petrol are used, a correction must be made to compensate for the difference in specific gravity as compared with water. There are certain disadvantages connected with the uses both of paraffin and petrol in that they both attack rubber tubing and after the gauge has been used, the rubber tubing must be thoroughly dried out, otherwise it will rapidly perish.

On the Kolar goldfield a most sensitive water gauge is used for determining these velocity pressures which is on a slightly different principle,
in that one leg is kept at a constant length and is connected to the source of higher pressure, whilst the other consists of a reservoir which can be raised or lowered by means of a fine screw to which is attached a micrometer head graduated in hundredths of a millimetre. It is easy to estimate to one-fifth of the space between two of these divisions. The water level indicator is very ingenious. It consists of a small gold-tipped pointer, which is placed below water level with its tip arranged just at water level within a short piece of tube fitted with a ground glass at one end and a lens at the other. On looking through the lens the pointer is seen, and opposite it is also seen its image reflected in the under surface of the water. As the level of water fluctuates, the distance between the tip and its image increases or decreases accordingly, and is exactly double the distance actually moved by the water level itself. Thus we have a most sensitive and simple indicator of low pressures. It has been found that for underground use, the illuminant of the ground glass should be either an electric flash lamp or other electric lamp as the proximity of an acetylene lamp causes an error to creep in which is produced by the gradual heating of the water gauge and frequent zero adjustments have to be made in consequence. This type of water gauge is called the "Askania Minimeter" and is a thoroughly satisfactory instrument, being very easy to operate and read. It has, however, two principal defects: the first is that when pressure fluctuates, as it nearly always does, it is only possible to read the maximum pressure at which point the water level descends and just touches the tip of the arrow; hence the determination of a mean pressure is difficult, if not impossible. This defect has been got over by observing the movements of the water level through a telescope in which has been inserted a small graduated scale which is so set that one or more graduations on the micrometer-head correspond with the apparent distance between the images of the tip of the arrow as seen on the graduated scale in the telescope. By this means the total movement of the water level can be seen and recorded.
(Fig. 1.)
It has also been found that filtered water must be used, owing to tiny particles of flocculent matter collecting around the tip of the arrow, rendering it difficult to see the reflection of the tip when the tip and its reflection are close together. Before commencing a test, it is necessary, therefore, to run fresh water through the meter until there are no signs of floating matter in the instrument. Previously this was a tedious operation; but has been got over by arranging inclined surfaces leading upwards to the outlet pipe in the indicator tube which, when fresh water flows in, carry out all floating matter. The maximum pressure for which these minimeters are graduated is 120 mm . or nearly $4-7 / 8 \mathrm{~m}$. water gauge.

In determining the efficiency of a fan, it is necessary to know the brake $h . p$. of the motor driving it, which in the case of an electrically driven fan is easily determined provided that the power factor of the motor is known and in any case it can easily be estimated fairly closely. When the fan is driven by compressed air, its efficiency cannot be determined unless indicator diagrams can be taken of the work done in the engine cylinder and a previous brake horse-power test made of the engine. However, we can easily and from this we can obtain a figure which will be useful in comparing the outputs of fans relative to the volume of compressed air consumed in driving them.

This exhaust air is measured in a duct in which is placed a sensitive anemometer which is calibrated immediately before and after the test. This gives the velocity at which the air is leaving the motor and knowing the area of the duct one can arrive at the volume of air passing. In order to standardize the test, the figure arrived at is afterwards corrected to suit standard conditions, i.e. $60^{\circ} \mathrm{F}$. and 30 in . barometric pressure.

There are two methods of testing fans. The first and the most usual is by means of a testingduct having a length of from 12 to 20 ft . attached to the delivery side of the fan. This duct is provided with a movable shutter at the end remote from the fan by means of which the volume of air passing, and its pressure, can be controlled, these two quantities being inter-dependent. The duct is
a branch which is connected with the second minimeter which indicates static pressure only. For convenience in arriving at the velocity of the air in the test duct it should be considered as being divided into a number of concentric zones of equal area, and readings of velocity head should be taken at points along two diameters at right angles to each other, the positions of the points being such that the circle passing through each divides one of the concentric zones or the central core into two equal areas. It follows that four readings will be taken in each zone. Ducts over 12 jn . in diameter should be divided into five equal zones, so that ten readings will be taken along each of two diameters at distances of $0.026 \mathrm{D}, 0.082 \mathrm{D}$, $0.147 \mathrm{D}, 0.226 \mathrm{D}, 0.342 \mathrm{D}, 0.658 \mathrm{D}, 0.774 \mathrm{D}, 0.854 \mathrm{D}$, 0.919 D and 0.975 D , D being the diameter of the duct in inches.

The Pitot tube used on the Kolar goldfield is graduated as above for use in an 18 in. diameter duct, having in addition a mark giving the centre of the duct.


Fig. 2.
also provided with a hole or two holes at right angles to each other through which a Pitot Tube can be inserted for the determination of static and velocity pressures. In this case the static water gauge indicates the resistance against which the fan has to operate. (Fig. 2.)

In the second method the duct is attached to the suction side of the fan and of the two methods the first is to be preferred as mistakes are less likely to happen, for in this case the static water gauge indicates the negative resistance pressure plus the positive velocity pressure.

The Pitot tube consists of two concentric tubes of sufficient length to pass across the testing duct. One end is bent at right angles so that its axis faces the current of air. The inner tube has its upstream end open and in it is set up a pressure by virtue of (1) the velocity of the air stream, and (2) the resistance in the duct, and is connected to one side of the minimeter. The outer tube has its upstream end closed, but bears on its side several small holes which are at right angles to the air flow. These enable the static or resistance pressure to be taken. (Fig. 3.)

This tube is connected with the other leg of the velocity pressure minimeter and it will be seen that if one side of this instrument has on it a pressure corresponding to velocity plus resistance, and on the other side of it a pressure corresponding to resistance only which tries to balance the water level, then the minimeter will give a reading which gives velocity pressure only. The static tube has

In determining the characteristic or output curve of fans, or of any other machine, it is advisable to obtain as many points on the curve as possible, and in fan curves about ten points will be ample, although on the sample test sheet given in this paper only four have been taken. These points are obtained by first closing the shutter so as to get the highest possible static reading with no air flow, and then for each set of velocity pressure readings opening the shutter a little way until full bore of the duct is reached. The mean of each set of velocity pressure readings is taken and converted into velocity only by means of a formula. The resistance or static readings are taken as indicated on the instrument.

The formula is arrived at as follows :
If a body falls from rest, its velocity V , after having fallen a certain distance H , is given by the well-known formula-

$$
\mathrm{V}=\sqrt{2 \mathrm{gH}}
$$

where $\mathrm{V}=$ velocity in ft. per sec.
$\mathrm{g}=$ acceleration due to gravity. = 32.089 ft . per $\mathrm{sec}^{2}$ on the Kolar goldfield.
$\mathrm{H}=$ height in ft .
On the Kolar field the temperature of the water in the water-gauge can be taken as $75^{\circ} \mathrm{F}$. The density of it at this termperature is 62.430 lb . per cu . ft., multiplied by $0.997=62 \cdot 24$. The density of air may be taken as 0.0675 lb . per cubic foot. The ratio of the density of water to that of air is $62 \cdot 24 / 0 \cdot 0675=922 \cdot 1$.


Fig. 3.
The formula may then be arranged thus:

$$
\mathrm{V}=\sqrt{2 \times 32.089 \times 922.1 \times \mathrm{h} / 12}
$$

where $h=$ velocity water gauge in inches, or V in ft per min. $=4208 \sqrt{\mathrm{~h}}$.
The above is given as an example, but the formula is usually worked out completely for every test on account of the variation in air density on the surface. The results from this formula are easily worked out on the slide rule.

Having determined the velocities in the above manner, they may be set out in the test sheet with their corresponding static pressures and having added the allowance for friction in the duct between the point of measurement and the fan (this is determined from a convenient chart which, it is hoped, will be placed before you at a later date) the quantities may be plotted on a graph having the pressures as ordinates and the volumes as abcissæ, which is the most convenient form for future reference.

Test of Hele-Shaw-Beacham Air Motor Driving a 20 in. by 11 in. Sirocco Fan.-Type of Fan, "Sirocco." Size of runner, 20 in . by 11 in . dia. Suction, 1 ft .11 in . Dely., 18 in . Direct driven by Hele-Shaw-Beacham Motor. Size, H.L.M.

| Test No. | A | B | C | D |
| :---: | :---: | :---: | :---: | :---: |
| Motor Data. |  |  |  |  |
| Time of start <br> Air pressure. lb./in. ${ }^{2}$ | 11-22 | 11.42 | 12.01 | $12 \cdot 17$ |
| gauge | 60 | $59 \cdot 9$ | 59. | $60 \cdot 1$ |
| Cu. ft./min. free air | $183 \cdot 9$ | $167 \cdot 3$ | $190 \cdot 9$ | $189 \cdot 6$ |
| F. deg. temp. comp, air | 123 | 138 | 136.8 | 136 |
| F. deg. temp. exh, |  | 48 | $49 \cdot 5$ | $49 \cdot 05$ |
| F. deg. temp. drop | $75 \cdot 6$ | $89 \cdot 5$ | $87 \cdot 3$ | 87.6 |
| Fan r.p.m. mean Motor casing temp. F . | 1230 | 1162 | 978.5 | $920 \cdot 7$ |
| Motor casing temp. F. deg. | $87 \cdot 5$ |  |  | 158 |
| Barometer | $27 \cdot 171$ |  |  |  |
| Fan Data. |  |  |  |  |
| Press. in in. of wrater static- |  |  |  |  |
| As shown on gauge | 4.607 | 3.579 | 1.582 | 0.684 |
| Friction <br> Friction added (a) | $\begin{array}{r} .002 \\ 4 \cdot 609 \end{array}$ | .050 3.629 | -. 0971 | . 119 |
| Velocity (b) ${ }^{\text {a }}$ | $\stackrel{1}{4.022}$ | 3.629 0.402 | $1 \cdot 673$ |  |
| Dymamic a + b | 4.631 | 4.031 | O.728 | 1.04 |
| Velocity, ft. per min. | 635.7 | 2690 |  |  |
| Volume, cu.ft. min. | 1124 | 4754 | 6400 | $\begin{aligned} & 4350 \\ & 7681 \end{aligned}$ |
| Volume at $60^{\circ} \mathrm{F}$. and 30 in. bar. | 918 |  |  |  |
| Static b.p.in air | 816 | $2 \cdot 72$ | $1 \cdot 69$ | ${ }^{261}{ }_{0.97}$ |
| Cu1. ft. air $\mathrm{d} / \mathrm{d} \div \mathrm{ct}$. it. comp, air | $6 \cdot 1$ | 28.4 | 13.69 |  |
| Temp, of atmosphere. |  |  | $33 \cdot 6$ | $40 \cdot 6$ |
| F. deg. dry bulb | 75 | 76 | 77.5 | 77. |
| F. deg. dry bulb |  |  |  |  |
| Time of finish . | 11.39 | 11.50 | $12 \cdot 13$ | $\begin{aligned} & 78 \cdot 5 \\ & 12 \cdot 28 \end{aligned}$ |

3 cylinders, 5 in. dia. by $1 \frac{1}{2}$ in. stroke, cut off at 0.40 of stroke.

Dia. at position in fan discharge pipe where velocity pressure was taken $=18$ in. Area $=$ 1.76 sq . ft.

Conditions. Test was made at Compressor House Compound, Bullen's Shaft, using on the discharge side of the fan a 12 ft . length of 18 in . diameter air pipe which was fitted with an adjust-
able baffle at the outlet end. The air measurements were taken at a point 7 ft .0 in . from the fan evasee.

The volume of air used by the motor was measured in a special wooden tube fitted with distribution baffles. The velocity of the air was indicated on a sensitive Short and Mason anemometer which was calibrated immediately after the test by means of a stream-lined whirling arm.

## SMELTING OF POTASH AND PHOSPHATE MINERALS

Two papers in Industrial and Engineering Chemistry for January deal with the recovery of potash from the leucite deposits of Wyoming, which are known as wyomingite. The first paper, by S. L Madorsky deals with the volatilization of potash from wyomingite and the second, by T. P. Hignett and P. H. Royster covers the smelting of wyomingite and phosphate rock in the blast furnace.

In the first paper the author says that the potashbearing leucite deposits of Wyoming, known as wyomingite, constitute one of the principal potential sources of American potash. The problem of converting this potash into soluble form, available for agricultural purposes, has been the subject of discussion and research for many years, particularly since the war, when dependence upon foreign potash forced it more vigorously on attention in the United States. The Bureau of Chemistry and Soils of the Department of Agriculture is conducting a series of experiments designed to convert the potash in wyomingite and similar minerals into soluble form. Some of these experiments are based on the principle of smelting the mineral at high temperatures, together with suitable reagents and fluxes. The reagents combine with the potash of the rock to form soluble salts which volatilize at high temperatures and can be collected by means of precipitators. The fluxes combine with the other constituents of the rock to form a fluid slab which is run out of the furnace. The object of this research is to ascertain the relative value of the reagents or promoters in inducing volatilization of potash in such a smelting process and to investigate the effects of time of heating the mixtures and temperature at which they are heated on volatilization.

Leucite is a potassium aluminium silicate and is usually represented by the formula $\mathrm{K}_{2} \mathrm{O} \cdot \mathrm{Al}_{2} \mathrm{O}_{3} .4 \mathrm{SiO}_{2}$. The pure mineral contains about $21.5 \% \mathrm{~K}_{2} \mathrm{O}$, but in wyomingite it is mixed with silica and other impurities, so that the potash content is only $10-12 \%$. In 1901 Rhodin heated finely ground mixtures of 100 parts felspar, 53 parts slaked lime. and 40 parts sodium chloride at $900^{\circ} \mathrm{C}$. for 1 hour He found that from 60 to $70 \%$ of the potash in the felspar was changed into potassium chloride. The temperature was too low for volatilizing the chloride, but it could be dissolved out from the insoluble mass. In 1912 Ross heated felspar with various amounts of calcium carbonate, calcium chloride, and sodium chloride at $1000-1050^{\circ} \mathrm{C}$. Most of the potash in the felspar - 60 to $99 \%$-was rendered soluble. Wells, in 1916, heated wyomingite together with calcium carbonate, calcium chloride, and other reagents to a dull-red heat. On heating 1 gram of wyomingite with 0.3 gram of calcium carbonate only a trace of potash was rendered soluble. On
heating 1 gram of wyomingite with $0.2,0.4$, and 0.6 gram of calcium chloride, the amounts of potash rendered soluble were $27.3,59.0$, and $73.0 \%$ respectively

In a series of experiments conducted by Jackson and Morgan, greensand was mixed with various proportions of calcium chloride, calcium carbonate, and sodium chloride, and the mixtures were heated to temperatures from $1050^{\circ}$ to $1300^{\circ} \mathrm{C}$. The potash volatilized from the greensand in one form or another ranged from 0 to $100 \%$, depending on the amounts of reagents used and on the temperature and time of heating.

The materials charged into the kiln for making Portland cement contain small amounts of potash, which is volatilized in the process of heating the charge. The volatilization is probably induced by the calcium carbonate and the potassium comes off as a carbonate or sulphate.

The method of adding chlorides to a blast-furnace charge for the purpose of inducing a greater volatilization of potash was tried in England by Chance, who observed, while studying the flue dust from the blast furnace, that the amount of potassium carbonate in the dust varied considerably, while the amount of potassium chloride remained constant and smaller than that of potassium carbonate. This led him to the idea that the constancy of potassium chloride was due to the constancy of chlorine present in the raw charge, and that all the chlorine was volatilized in the form of potassium. or sodium chloride, the ratio between the two salts in the dust also being almost constant-namely, 85 to $90 \% \mathrm{KCl}$ and 10 to $15 \% \mathrm{NaCl}$. By adding a sufficient amount of sodium chloride to the raw charge, Chance was able to volatilize all the potash present in the charge and to collect it as potassium chloride.

The wyomingite used in the series of experiments described in this paper was collected from various parts of a pile of about one carload size. It had the following composition:-

|  | $51 \%$ | CaO | 5.07 |
| :---: | :---: | :---: | :---: |
| $\mathrm{K}_{2} \mathrm{O}$ | $12 \cdot 76$ | ${ }_{\mathrm{P}_{2} \mathrm{O}_{5}}$ | 1.97 |
| .$_{42} \mathrm{O}_{3}$ | 11.68 | $\mathrm{TiO}_{2}$ | $2 \cdot 12$ |
| $\mathrm{Fe}_{2} \mathrm{O}_{3}$ | $4 \cdot 90$ | $\mathrm{Na2} \mathrm{O}$ | $1 \cdot 42$ |
| MgO | $6 \cdot 92$ |  |  |

It was ground to pass through a 100 mesh screen and dried in an oven at $140^{\circ} \mathrm{C}$. for 15 hours. A 0.5 gram sample was used in each case. The calcium carbonate, calcium chloride, sodium chloride, and calcium fluoride, which were used as promoters to induce volatilization of potash from the wyomingite, were of c. P. quality. They were ground to fine powders and dried in the same way as the wyomingite. The materials were weighed in a
small platinum crucible, 2 cm . diameter and 3 cm . high, thoroughly mixed, and kept in an oven at $140^{\circ} \mathrm{C}$. until the crucible was ready to go into the furnace

The furnace consisted of an alundum tube 2.5 cm . inside diameter and 25 cm . long about which a platinum wire was wound, surrounded by an alundum tube of 11 cm . outside diameter wound with nichrome wire. In all runs the time of heating was 40 min ., reckoned beginning with the fifth minute after the crucible was lowered into the furnace. Temperature readings were taken every 5 min . The temperature usually fluctuated a few degrees one way or the other from $1510^{\circ} \mathrm{C}$., but the average temperature was $1510^{\circ} \mathrm{C}$. The $\mathrm{Pt}-\mathrm{Pt} \mathrm{Rh}$ thermocouple was calibrated up to $1000^{\circ} \mathrm{C}$. against a standard couple of the United States Bureau of Standards.

Analysis for residual potash was made in the same crucible in which the material was heated. The amount volatilized was then calculated as the difference between the original $\mathrm{K}_{2} \mathrm{O}$ in the sample and the residual potash. The method of analysis consisted in dissolving the sample by means of hydrofluoric and sulphuric acids, precipitating the potassium as potassium sodium cobaltinitrite, and then analyzing for nitrogen by the Kjeldahl method. When the samples were heated above about $1200^{\circ} \mathrm{C}$., they fused to a glassy mass. It was found difficult to dissolve thin glass with acids, but this difficulty was overcome by allowing the sample to stand covered with hydrofluoric acid for 24 to 48 hours.

As a result of the experiments it was found that potassium can readily be removed from wyomingite by volatilization by means of calcium carbonate and a halogen salt promoter. Calcium carbonate alone is not very effective in inducing volatilization. Using a ratio of wyomingite to calcium carbonate of 1 to 2 , the amount of potash volatilized was only $42.79 \%$. However, calcium carbonate is necessary to flux the silica in the wyomingite, if this method of potash volatilization is to be applied in a smelting process-for instance, in a blast furnace. In that case the amount of calcium carbonate to be used will be governed by the amounts of alumina and silica in the wyomingite, so that the resulting slag will have the proper fluidity.

Of the halogen salt promoters calcium chloride is the most effective. This promoter should not be used in amount far above the potash equivalent in the wyomingite. A mixture of wyomingite and calcium carbonate in the ratio of 1 to 1 and 1 potash equivalent of calcium chloride will give a volatilization of 95 to $98 \%$ at $1200-1500^{\circ} \mathrm{C}$. in a short time. Any excess of calcium chloride will be volatilized and the gain in volatilization will be only a few per cent.

Time is not an important factor in a smelting volatilization process of potash. Most of the potash will leave the wyomingite in a short time, and any further heating will help Iittle. With sodium and calcium chlorides as promoters it was found that in the first 10 minutes about 70 and $90 \%$ of potash, respectively, left the crucible. It is true that these particular relations of time to volatilization are characteristic of the amount of material used, size of particles, and the design of the furnace. In a smelting process, such as in a blast furnace, where the material would be charged into the furnace in large lumps and where a large volume of gases would be blown through the material, the time effect might be different in degree, but not in the general trend.

It seems to make little difference what the temperature is, provided it is above $1100^{\circ} \mathrm{C}$. Although the experiments indicate that volatilization in the interval between $1110^{\circ}$ and 1310 C . is slightly greater than between $1310^{\circ}$ and $1510^{\circ} \mathrm{C}$, the difference is only about $4 \%$.

In the reactions between potash of the wyomingite and the various reagents studied there is in every case, theoretically, a certain amount of heat evolved, the amounts being $216,349,104$, and 198 kilojoules, respectively, for calcium carbonate, calcium chloride, sodium chloride, and calcium fluoride. This fact seems to indicate why the reactions whereby potash changes into potassium chloride, potassium fluoride, and potassium carbonate take place at all, as a reaction will tend favourably in a direction of exothermicity.

The study presented in the paper indicates that the method of volatilization of potash from wyomingite by some smelting process is chemically feasible. The successful application of this method on a commercial scale will depend on the proper design of a furnace. Experiments reported were undertaken to lay the foundation for the design of such a furnace

In the second paper Messrs. Hignett and Royster state that an important part of the work on fertilizer technology at the Bureau of Chemistry and Soils in the United States is concerned with the possibility of applying blast-furnace technique to the production both of phosphoric acid and of potash. Although the misused expression " volatilization of phosphoric acid " is rather firmly fixed in the literature, in actual fact the $\mathrm{P}_{2} \mathrm{O}_{5}$ in phosphate rock is not volatilized at any attainable furnace temperatures. The removal of $\mathrm{P}_{2} \mathrm{O}_{5}$ in a furnace can be accomplished only by the reduction of phosphoric oxide to elementary phosphorus. This reduction reaction is strongly endothermic and does not take place with any great rapidity below $1300^{\circ} \mathrm{C}$. In a blast furnace blown with air preheated to $750^{\circ} \mathrm{C}$. gas is produced in the combustion zone at about $2000^{\circ} \mathrm{C}$. As it passes through the phosphate charge this gas can supply the reduction reaction with heat only while its temperature is greater than $1300^{\circ} \mathrm{C}$. In other words, only the fraction $\frac{2000-1300}{2000}$, or $35 \%$ of the heat, is available for reduction. By heating the blast to a higher temperature the combustion-zone temperature can be raised and the fraction of the heat usable in phosphate reduction can be increased. It is obvious, therefore, that any important reduction in the fuel consumption of the phosphate furnace must come through an improvement in the design of the hot blast stoves.

It should not be thought that the so-called "shaft heat "-that is, the more than $65 \%$ of the heat not usable for phosphate reduction-all goes to waste. As the hot gas from the reduction zone ascends the furnace shaft, it must preheat the descending charge and melt the slag. In many cases, however, the heat required for slagging the charge is considerably less than the shaft heat, and in consequence the over-all thermal efficiency of the process is relatively low.

It was in an effort to utilize some of this waste shaft heat for the volatilization of potash that experiments were undertaken. Some such process is uniquely applicable in the Wyoming potash field, where high-grade phosphate rock is available both from Wyoming and from southern Idaho. Although in a strictly logical sense the potash produced in


Fig. 1.
this process is a by-product of a phosphate furnace, economically the phosphoric acid is more nearly a by-product in the production of potash.

In smelting high-grade phosphate rock in any furnace it is necessary to add to the charge some form of siliceous material as a flux. The use of a potash-bearing silicate for fluxing phosphate rocis and recovering both phosphorus and potash has been suggested a number of times. Recently Pike has described the smelting of Idaho phosphate rock and wyomingite in an experimental blast furnace. In the experiments described in this paper, however, the potash silicate was added to utilize the shaft waste heat, and the amount of silicate used in each case was more than enough to flux the phosphate rock, so that a further addition of limestone or burnt lime was necessary to flux the excess silica in the charge. In other words, a potash furnace was operated to smelt wyomingite, and the lime contained in phosphate rock was used as a flux for the silica in the charge up to the limit of the heat available for phosphate reduction and limestone was used for the rest of the needed flux

The blast furnace used in the experiment is shown in Figure 1. It is 80 in . tall and has a hearth diameter of $13 \mathrm{in} .$, a bosh diameter of 19 in ., and a total volume of $12 \mathrm{cu} . \mathrm{ft}$. For comparison a modern blast furnace is 90 ft . tall, has a 25 ft . hearth and a total volume of over $30,000 \mathrm{cu} . \mathrm{ft}$. The experimental furnace is therefore $0.04 \%$ of a commercial unit. The furnace was blown with about 63 to 70 cu . ft. of air per min. preheated in an iron pipe stove. The stove operated on city gas, and temperature in excess of $700^{\circ} \mathrm{C}$. could not be readily maintained. The preheated air entered the furnace through one or both of two tuyeres. These tuyères, as well as the brick work in the tuyère breast and bosh walls, were protected by cooling coils, and the heat loss through the furnace walls was measured throughout each experiment by observing the temperature
rise and the amount of the cooling water. In a large furnace this heat loss is a matter of a very few per cent, but in the experimental furnace it was an importantly large part of the total heat and was lost from the hottest part of the furnace that is, from the heat available for phosphate reduction. Except for this loss of available heat by the conduction through the walls, the furnace is as satisfactory for phosphate smelting as a large commercial unit.

A photograph of the furnace in operation is shown in Figure 2. In a production plant the furnace gases would, of course, pass through an electrical precipitator for the recovery of phosphorus and potash, and the gases after being cleaned in the precipitator would be used as fuel in the hot blast stoves, and for the generation of power for blowing and for other plant purposes. In the experiments, however, the gases were exhausted to the air, and the reduction of phosphorus and the volatilization of potash calculated from the weight and the $\mathrm{K}_{2} \mathrm{O}$ and $\mathrm{P}_{2} \mathrm{O}_{5}$ content of the slag. The time of passage of the stock through the furnace was about $1{ }^{3}$ hours. Although this is much longer than is necessary for the heating and slagging of the charge for the reduction of $\mathrm{P}_{2} \mathrm{O}_{5}$, or for the volatilization of potash, it was found not to be sufficiently long to calcine the limestone completely. In every case where limestone was used the reduction of $\mathrm{P}_{2} \mathrm{O}_{5}$ fell off to about one-third of the value calculated from the available hearth heat. In each case numerous lumps of limestone in a partly calcined condition but still contajning a substantial fraction of its carbon dioxide content were found suspended in the slag emerging from the furnace and remaining imbedded in the slag when it solidified. The excessive length of time required for the calcination of limestone is due to the endothermic reaction involved in the thermal dissociation of calcium carbonate, involving as it does 420 calories per gram.


Fig. 2.

When limestone containing even a small fraction of its original carbon dioxide content reaches the reduction zone above $1300^{\circ} \mathrm{C}$., the carbon dioxide is evolved vigorously and to the 955 calories per gram of carbon dioxide absorbed in the endothermic reaction

$$
\mathrm{CaCO}_{3}=\mathrm{CaO}+\mathrm{CO}_{2}-42,000 \text { calories }
$$

is added a second 945 calories per gram of carbon dioxide absorbed in the equally endothermic producer gas reaction

$$
\mathrm{CO}_{2}+\mathrm{C}=2 \mathrm{CO}-41,500 \text { calories }
$$

with a net loss of heat of 1900 calories per grans of carbon dioxide. Of the nine experiments in which phosphate rock and wyomingite were charged, limestone was used in three and burnt lime in six In an actual furnace project of this kind one would naturally burn the stone before introducing it into the furnace, using blast-furnace waste gas for calcination. This is the customary procedure in English iron blast-furnace practice, where low-grade carbonate iron stoves are used. In the experiments
cold blast with more than one molecular equivalen of sodium chloride gives only $54 \%$ volatilization comparison with $82.8 \%$ in run 4 and $64.4 \%$ in run 6 Although extreme blast temperatures do not seem necessary for potash volatilization, unlieated blas seems to show worse results

It is perhaps to be expected that the result obtained with a furnace too small properly to calcine limestone will be rather variable when limestone is in the charge. The results are instructive, however and the runs 4 and 10 , which show potash yields 0 82.8 and $89.7 \%$, show that substantial volatilization can obtain with rock salt and unburned limestone
The last five runs in Table I show in a somewhat remarkable way the influence of calcium chloride on the potash volatilization. All five runs were made with burnt lime, phosphate rock present, and variable amounts of calcium chloride added. With no chloride (runs 11 and 13) the potash yield was 44.00 and 42.58 . With 0.77 molecular equivalent of chloride added the potash recovery is 59.64 (test 12) with twice that amount (test 14) it is 81.03 and with $2 \cdot 62$ molerular eqquivalent it us $95 \cdot 35$.

TABLE I

with burnt lime the Iow reduction of $\mathrm{P}_{2} \mathrm{O}_{5}$ was not observed.

The results of fifteen runs on the experimental blast furnace are shown in Table I. The materials used were wyomingite containing $12.76 \% \mathrm{~K}_{2} \mathrm{O}$ and $1.97 \% \mathrm{P}_{2} \mathrm{O}_{5}$, and a washed Florida rock containing $31.63 \% \mathrm{P}_{2} \mathrm{O}_{5}$ amd $0.26 \% \quad \mathrm{~K}_{2} \mathrm{O}$. The colke was of poor grade, containing $79.5 \%$ fixed carbon and $15 \%$ ash. The charge in each case is given in terms of the interesting constituents, $\mathrm{K}_{2} \mathrm{O}$ and $\mathrm{P}_{2} \mathrm{O}_{5}$, and the carbon in the fuel. In tests 1 and 2 phosphate alone was smelted and in tests $3,4,5$, and 6 , potash alone ; the lost nine experiments contained a binary charge of phosphate and potash.

In four of the potash runs ( $3,7,11$, and 13) no chlorides were used. The per cent $\mathrm{K}_{2} \mathrm{O}$ volatilized was $43.2,51 \cdot 1,44 \cdot 0$, and 42.6 for an average of $\mathbf{4 5 . 9} \%$. In the two experiments given in Pike's paper no chlorides were used and he reports volatilizations of 41.0 and $46.9 \%$. This result would be more or less expected from the results announced by Madorsky. The theory that the addition of lime to potash silicates will cause the volatilization of $\mathrm{K}_{2} \mathrm{O}$ seems in the actual case to be slightly less than half true ( $44 \%$ ). In experiments $3,4,5$, and 6 sodium chloride was used and no phosphate rock. The use of rock salt is not of great practical interest, in that calcium chloride has been found to be much better and is more readily obtainable. It might be pointed out that run 5 on

The percentage of $\mathrm{P}_{2} \mathrm{O}_{5}$ reduced in these five last runs are quite low. Little significance should be attached to the amount of $\mathrm{P}_{2} \mathrm{O}_{5}$ reduced in per cent of that charged. The actual number of grams of $\mathrm{P}_{2} \mathrm{O}_{3}$ reduced per gram of fuel carbon is the important figure, which is readily arrived at by multiplying the charge by the per cent reduced. In operating the furnace one estimates ahead of time how much hearth heat will be available for reduction and then puts in somewhat more $\mathrm{P}_{2} \mathrm{O}_{3}$ to be sure of using up all the available heat. The low percentage recovery then means, if anything that the writers were poor at guessing

The analyses of the raw materials and of the slag are given in Table II.

TABLE II
Analyses of Raw Materials and Slag

| Constituent | Wyomingite. | Phosphate Rock. | Iypical Slag. |
| :---: | :---: | :---: | :---: |
| CaO | $5 \cdot 07$ | 46.50 | \% |
| $\mathrm{SiO}_{2}$ | $51 \cdot 34$ | 6.90 | $\begin{aligned} & 35 \cdot 13 \\ & 34 \cdot 16 \end{aligned}$ |
| ${ }_{\text {Al2 }}{ }_{\text {M }}$ | 11.68 | $2 \cdot 13$ | 34.16 10.22 |
| $\mathrm{K}_{2} \mathrm{O}$ | 6.92 12.76 | 0.26 | 4.89 |
| $\mathrm{P}_{2} \mathrm{O}_{5}$ | 1.97 | 31.63 | 0.77 $3 \cdot 51$ |
| $\mathrm{Fe}_{2} \mathrm{Cl}_{3}$ |  |  | $2 \cdot 66$ |
| $\mathrm{TiO}_{2}$ | $2 \cdot 12$ | 1.91 |  |
| $\mathrm{Na}_{2} \mathrm{O}$ | 1.42 | 0.72 | $\begin{aligned} & 169 \\ & 595 \end{aligned}$ |

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phate sock presell a chloride added 3) the potash moleculat equir ecovery is 59.61 los test 14 ) it is $8\left(\frac{1}{4}\right.$ alent it us 953

## TANTALUM

Tantalum is a rare element which, next to tungsten, has the highest melting point and the lowest vapour pressure of all metallic elements. It is unusually resistant to corrosion and when heated above $350^{\circ}$ will take up 740 times its own volume of hydrogen. Data on the properties, uses, and resources of tantalum are given in Information Circular 6328 of the United States Bureau of Mines, by E. P. Youngman.

The author says that after remaining a laboratory curiosity for many years, tantalum was used to a limited extent for a few years in incandescent electric-light-bulb filaments, and interest in the element was again aroused when its electrolyticvalve action was discovered and taken advantage of in charging storage batteries, especially for wireless work. Tantalum chargers were eventually displaced by other types, but for a time they were manufactured in sufficiently large numbers to create a demand large enough to bring about its production on a commercial scale in the United States. As tantalum became available in larger quantities and at substantially lower prices, and as high prices for platinum encouraged the employment of tantalum as a substitute, the metal was put to many new uses. Ferrotantalum was made and sold before the war, and patents have been taken out for a number of special alloys for industrial purposes, but probably the largest use for the metal to-day is in vacuum tubes. The rapid increase in production reflects the increasing use to which tantalum is being put.

Commercial tantalum has a purity of at least $99.5 \%$. It is a platinum-white metal when polished, though it often has a steel-blue colour, probably owing to a thin film on the unpolished surface. Its tensile strength is two and one-half times that of hard platinum and it can easily be made as hard as iridioplatinum.

The most characteristic chemical property of tantalum is its unusual resistance to chemical corrosion. It is not attacked by hydrochloric or nitric acids or by aqua regia, either hot or cold. Dilute sulphuric acid also does not attack it, but boiling concentrated sulphuric acid does appear to have some action upon it. The metal is attacked with difficulty by solutions of caustic alkalies, and in fact, hydrofluoric acid seems to be the only chemical agent that will attack it.

Tantalum can be worked cold, drawn, hammered, machined, polished, hardened, rolled, and punched, the pure metal being rather easily worked. The forms in which the metal may be readily obtained include wire from .001 in . diameter up to heavy bar, sheet from 002 in . in thickness to varying widths, and tubing of various sizes.

Probably the largest use of tantalum now is in connexion with the manufacture of wireless and power valves. Increasing quantities are being used in the manufacture of certain alloys, in the manufacture of spinnerets employed in the making of rayon, in the lining of chemical equipment, and in jewellery. As to further extension of the use of the metal, the chief problem is to ascertain to what extent it can replace platinum in the laboratory and factory and for acid-resisting equipment. It has not been proved that tantalum will provide a cheaper substitute for platinum in these connexions. For precision weights, however, it is recognized internationally as a substitute for platinum. In electrical appliances (vacuum tubes, electrolytic apparatus, rectifiers), tantalum offers possibly a
better service. Although, among the noble metals platinum alone is a strong rival, tantalum is limited in usefulness chiefly by the fact that it can not be raised above the temperature of about $350^{\circ}$ without absorbing gases and without undergoing deterioration. When it is used hot it must be in a high vacuum.

Alloys of Tantalum.-Many alloys of tantalum have been described, though few have entered industry. The alloys may be conveniently grouped in three classes as follows:-
(a) The alloys of high melting point contain from 1 to $40 \%$ tantalum, combined with different proportions of molybdenum, tungsten, carbon, manganese, nickel, vanadium, and silicon. Tantalum it is claimed, may replace all or part of the tungsten or the molybdenum.
(b) The hard alloys, containing as much as $50 \%$ of tantalum, combined with iron, chromium, vanadium, tungsten, molybdenum, or carbon, are employed in the manufacture of tools. Ferro-tantalum-columbium (niobium) has been produced for many years for use especially in high-speed steel.
(c) Acid-yesisting Alloys.-The amount of tantalum used in acid-resisting alloys seems to be rather small. Since the introduction of the first rustless steel (an alloy of tantalum and iron), other alloys have been developed that have caused keen competition. Recently alloys of tantalum with iron and aluminium have come into existence

Occurrence.-Tantalum and columbium (or niobium), almost invariably found together, occur in a large variety of minerals, none of which, however, are very widely distributed. Tantalite, skogbolite, and tapiolite (tantalates of iron and manganese), and microlite (a calcium tantalate) are the richest in tantalum. Tantalite, or columbotantalite, is the principal commercial source of the metal. Since at the present time columbium, having no commercial importance, only increases the cost of tantalum, a grade of tantalite containing at least $60 \%$ tantalum oxide and only a few per cent. of columbium is generally used. Simpler methods of extraction would bring about a greater use of tantalum and would probably introduce columbium to industry.

Tantalum minerals, though known to exist in many mineralized localities throughout the world, are produced in commercial quantities in but a very few-Western Australia ranking first, followed by South Dakota (United States). There is enough interest in the tantalum deposits in Northern Australia, in Rhodesia, and in south-west Africa to justify the expectation that these countries will soon produce small quantities at least and a property in Northern Australia, recently optioned, is reported to contain one of the largest known deposits of tantalite in the world.

A Chicago firm, which in 1922 began the production of metal in sheets and rods large enough to be employed in pen points, dental instruments, chemical apparatus, and like equipment, is the only firm in the United States that is manufacturing the metal.

Without adequate import and export figures, it is difficult even to suggest probabilities for the future tantalum market or to interpret the past at all accurately. It is known that most of the United States producton has been shipped to England and Germany and that quantities of Australian ore, which is of a higher grade than the American ore,
are shipped to the United States. In 1922 there was a definite increase in the United States production and in 1928 production was 34 times that of 1927. It was in 1922 that the manufacture of
electrolytic rectifiers, in which tantalum was used, began; and it was in 1927 that a company at Malvern, Pa., began making use of tantalum in laboratory equipment.

Extraction of Tantalum and Columbium. In Technical Publication No. 379 of the American Institute of Mining and Metallurgical Engineers, C. G. Fink and L. G. Jenness describe the extraction of tantalum and columbium from their ores. They say that tantalum and columbium occur together in tantalite and columbite ores, which may be considered as ferrotantalate $\left(\mathrm{FeTa}_{2} \mathrm{O}_{6}\right)$, with part of the iron and tantalum replaced by manganese and columbium respectively, the general formula, therefore, becoming ( $\mathrm{Fe}, \mathrm{Mn}$ ) O . $(\mathrm{Ta}, \mathrm{Cb})_{2} \mathrm{O}_{5}$. The ratio of tantalum to columbium is not fixed ; the amount of tantalum may vary from one-third to three times that of columbium. Minerals having a high content of tantalum are called tantalite, while those possessing larger amounts of columbium are classified as columbite ores. These minerals are found in pegmatites and often occur in veins associated with cassiterite and wolframite, and may contain small amounts of tin, tungsten, titanium and silica.
Several methods have been proposed for the extraction of tantalum and columbium from their ores, among them being:

1. Fusion with Potassium or Sodium Bisulphate. -The finely ground ore is fused with potassium bisulphate, after which the mass is boiled with water and the fusion repeated several times. The residue finally resulting is digested with ammonium sulphide to remove traces of tin and tungsten, boiled with hydrochloric acid, filtered and washed. These oxides are then dissolved in hydrofluoric acid, the silica evolved as silicon tetrafluoride and the hydrofluoric acid solution used for the potassium double fluoride separation of tantalum.
2. Fusion with Sodium Carbonate and Sodium Nitrate.-This fusion renders the tantalum and columbium soluble, and they are extracted with a. small quantity of soluble impurities. The tantalum, columbium and titanium are the only metals present which are precipitated from this solution by sulphur dioxide, thus enabling the separation of these metals from the remainder of the ore.
3. Volatilization with Chlorine.--H. S. Cooper states that tantalum, columbium and iron can be volatilized as chlorides by passing chlorine over the ore at $500^{\circ} \mathrm{C}$. The chlorides are then hydrolyzed in a sodium chloride solution, to precipitate tantalic and columbic acids and retain the iron as soluble ferric chloride.
4. Fusion with Sodium Hydroxide.-The ore is fused with sodium hydroxide, the fused mass leached with sulphuric acid to dissolve manganese and iron, and the remainder of the treatment continued as described under method 1 . This method is preferred to that of the bisulphate fusion, since it can be carried out in iron.

A review of these methods, as well as the prevailing price of tantalum oxide, encouraged the authors in their search for a simpler and cheaper method. This led to a study of the leaching of tantalum and columbium ores with aqueous solutions comprising reagents readily obtainable at low cost. It soon became evident that a leaching solution for $\mathrm{Ta}, \mathrm{Cb}$ ores must be capable of de-
composing the ore, as well as acting as a solvent for the two metals, tantalum and columbium. Hydrofluoric acid and carboxylic acids are the only commercial, cheap acids which dissolve tantalum oxide. Upon trial the authors found that these two acids will decompose the ore, hydrofluoric acid being more effective. An important turn in the research followed the discovery that, when hydrofluoric acid and oxalic acids were used together, the ore was attacked much more readily than when either acid was used alone. Accordingly, investigation was then directed toward a study of :

1. The effect of carboxylic acids.
2. The optimum conditions for leaching, using both acids.
3. A method of recovering tantalum and columbium from the solution after leaching.
4. The efficiency and cost of extraction by the new method.

Study was devoted to the recovery of tantalum in the form of potassium tantalofluoride and to the recovery of the combined oxides of tantalum and columbium from the solution after leaching. Tantalite, columbite, and samarskite ores were investigated. On the basis of the authors' experimental results it was concluded that

1. Hydrofluoric acid acts as a good decomposing agent for the tantalum and columbium ores.
2. The presence of carboxylic acids greatly increases the rate of decomposition and solution of the ore.
3. The effectiveness of the carboxylic group decreases with increased molecular weight of the acid containing the group, oxalic acid being by far the most efficient.
4. Hydrofluoric acid can be produced during the leaching, by employing fluorspar and sulphuric acid.
5. The combination of hydrofuoric and oxalic acids is capable of retaining more tantalum and columbium in solution than it can decompose from the ore at a given acid concentration.
6. This makes it more feasible to start with a high concentration of acids and utilize steam condensation for heating and diluting the solution.
7. The quantity of materials selected for leaching should be such that an excess of fluorspar is present, and 30 g . of oxalic acid and 40 c.c. of sulphuric acid per litre of final solution.
8. About $60 \%$ of the tantalum can be recovered in the form of potassium tantalofluoride directly from the solution after leaching, but the crystals will contain a large amount of oxalic acid.
9. By recrystallization of the above product, a large amount of oxalic acid can be recovered for leaching, and a pure salt of tantalum can be prepared.
10. The combined oxides of tantalum and columbium can be recovered from the solution by fractional precipitation with ammonium hydroxide.
11. The cost of producing $\mathrm{Ta}, \mathrm{Cb}$ oxides by this method makes the process look very attractive in view of present prices.

Montreal Mine, Montreal, Wisconsin.-In Information Circular 6369 of the United States Bureau of Mines, O. M. Schaus describes the geology, methods of ore sampling and tonnage estimation, development, mining methods and practices, at a large underground mine on the Gogebic Iron Range and gives underground operating costs over a period of one year. Costs are expressed both in terms of dollars and in units of labour (man-hours per ton), power, and principal supplies.

Open sub-level stoping is employed in the firmer ores where the walls are also firm, while the sublevel caving method typical of the Gogebic Range practice is employed in weaker ground. The operations extend over a wide area and for $2 \frac{1}{4}$ miles along the strike of the formations and to a depth of $2,550 \mathrm{ft}$.

In 1928, 450,000 tons were mined by sub-level caving at a stoping cost of 36 cents per long ton and 630,000 tons by open, sub-level stopes at a stoping cost of 25.5 cents. Total underground operating cost including surface expense directly applicable to underground operation was $\$ 1-279$ per long ton for sub-level caving and $\$ 1 \cdot 160$ for sub-level stoping. Average labour for stoping only in sub-level caving stopes was 0.352 man-hours per long ton ( 22.7 tons per man-shift) for development 0.222 man-hours per long ton mined, and for the entire operation 1.336 man-hours per ton In sub-level stoping, the stope labour was 0.216 man-hours per ton ( 37 tons per man-shift), development labour 0.524 man-hours per ton, and total labour 1.129 man-hours per ton.

In sub-level caving 2.76 board ft . of timber, 0.59 lb . of explosive and 6.24 k. w.h. were consumed per long ton produced by that method. In sublevel stoping these figures were 1.65 board ft., 0.85 lb . explosive, and $12.61 \mathrm{k} . \mathrm{w} . \mathrm{h}$. per ton respectively.

Molybdenum Analysis.- Some notes on the determination of molybdenum with details of analytical procedure are contained in Information Circular 6335 of the United States Bureau of Mines. An investigation has been conducted in the Rare and Precious Metals Experiment Station of the Bureau into widely divergent results which had been obtained by different laboratories on quartered portions of the same sample. An oxidized lead ore which contained considerable vanadium and less than $1 \%$ of molybdenum was reported as containing molybdenum trioxide ranging from $3 \cdot 14$ to $0.24 \%$. The high results were due to the noncomplete elimination of vanadium from the molybdenum. A fine grained rock containing considerable graphite did not indicate clean residues by the usual acid decomposition. Several chemists used prolonged fusion with soda ash and nitre. The solutions contained phosphorus derived from the ore which was precipitated as lead phosphate and mistaken for the molybdate.

The elements most likely to cause trouble are vanadium, tungsten, uranium, arsenic, antimony, titanium, tin, phosphorus and chromium. The precautions necessary to eliminate these and other impurities vary with the type of ore and the method of analysis.

Concentration of Manganiferous Iron Ores. -Report of Investigations 3045 of the United States Bureau of Mines, by F. D. DeVaney and J. B. Clemmer, shows that preliminary concentration tests on the black manganiferous iron ores of
the Cuyuna district of Minnesota indicate that some of these ores may be beneficiated by ore dressing methodsand that concentrates of commercial grade may be produced from what is now waste. The large tonnages of these ores available makes the matter one of considerable economic importance.
The association of manganese and iron is such that there is little possibility of producing concentrates sufficiently high in manganese and low in iron to be used in the manufacture of ferromanganese. The silica content of some of the ores can, however, be reduced to within commercial limits. On the cleaner ores this reduction can be accomplished by crushing to 8 or 10 mesh, classifying, tabling, and concentrating the resulting fines by flotation. The more difficult ores must be ground finer to secure liberation. Tables may be used to recover some of the more granular material, leaving the fines to be treated by flotation, or the ore may be crushed directly to flotation size and an all-flotation process used. Both gravity concentration and flotation yield a better recovery of manganese than of iron.

## SHORT NOTICES

Handling Rock in Narrow Stopes.-S. N. Hoffenberg describes a new and improved method for handling broken rock in flat, narrow, stopes on the Sub-Nigel mine, Witwatersrand, in the Journal of the Chemical, Metallurgical, and Mining Society of South Africa for November, 1930.

Deep Mining Methods.-Ground movements and methods of support in deep mining on the Kolar goldfield are described by P. J. Crowle in the Bulletin of the Institution of Mining and MetalIurgy for January.

Square-Set Stoping.-Engineering and Mining World for January contains an article by M. J. Elsing on square-set stoping.

Ore Losses in Mining.-In the Bulletin of the Institution of Mining and Metallurgy for January, G. W. Eaton Turner discusses the losses obtaining in extracting ore from mines.

Scraper-Loading.-Mine scraping practice is discussed by A. J. McDermid in Engineeving and Mining World for January.

Mechanical Mining in Algeria.-The use of mechanical methods in the Algerian mines is described by M. Nicolet in Revue de l'Industrie Minevale for January 5.

Underground Hoisting.-C. E. Mills describes the transfer and erection of underground hoisting plant in Engineering and Mining World for January.

Rock Asphalt Mining.-The mining of rock asphalt in Utah is described by G. Martin in Engineering and Mining World for January.

Ore Grinding.- At a meeting of the Chemical Engineering Group of the Society of Chemical Industry held in Derby on January 23, J. C. Farrant delivered a lecture on modern grinding in which he gave actual operating data on different materials in order to indicate the fields in which different classes of mills may be most efficiently applied.

Lead Smelting.-K. Prior describes the smelting of lead in a shaft kiln with zinc-rich slags in Metall und Erz, 2 Januarheft.

Metallurgy at Broken Hill, N.S.W.-Chemical Engineering and Mining Review of Melbourne for December 5 last contains an article by M. R. McKeown on the progress of metallurgy at Broken Hill, N.S.W.

Zinc Smelting in High-Silica Retorts.--The use of high-silica retorts at the Rose Lake Smelter of the American Zinc, Lead and Smelting Company is described by G. L. Spencer in Technical Publication No. 378 of the Ámerican Institute of Mining and Metallurgical Engineers.

Blast-Furnace Slags.-R. S. McCaffery and co-workers give the results of research on iron blast-furnace slags in Technical Publication No. 383 of the American Institute of Mining and Metallurgical Engineers under the title "Viscosity of Blast-Furnace Slags."

Blast-Furnace Data.-A statistical analysis of blast-furnace data by R. S. McCaffery and R. G. Stephenson is given in Technical Publication No. 384 of the American Institute of Mining and Metallurgical Engineers.

Chromium and Vanadium Determination.H. H. Willard and R. C. Gibson in Industrial and Engineering Chemistry (Analytical Edition) for January 15 describe the determination of chromium and vanadium in ores and alloys after oxidation with perchloric acid.

Cadmium Assay.-The determination of cadmium by gravimetric and direct volumetic methods is described by R. C. Wiley in Industrial and Engineering Chemistry (Analytical Edition) for January 15.

Electrical Prospecting.-A. Broughton Edge describes alternating current bridge methods of geo-electrical prospecting in an article which appeared in Nature for January 3.

Origin of Rand Gold.-At a meeting of the Geological Society of South Africa held on October 27 last a discussion was held on the origin of the gold in the Witwatersrand System, originated by the paper of Prof. L. C. Gaton on the hydrothermal origin of the Rand gold deposits noticed in the Magazine for July last. Papers were read by Professors R. B. Young and J. W. Gregory, Dr. A. W. Rogers and E. Homersham.

Petroleum in North America.-The occurrence of petroleum in North America is discussed by S. Powers in Technical Publication No. 377 of the American Institute of Mining and Metallurgical Engineers.

## RECENT PATENTS PUBLISHED

- A copy of the specification of any of the patents mentioned in this column can be obtained by sending 1 s . to the Patent Office, Southampton Buildings, Chancery Lane, London, W.C. 2, with a note of the number and year of the patent.
15,363 of $1929(338,488)$. Siemens and Halske A.-G., Berlin-Sicmensstadt, Germany. In the separation of tin electrolytically from alkalistannate or stannite solutions it is found that by influencing the content of the electrolyte in free alkali the separation of spongy tin can be avoided.

16,330 of 1929 ( 316,177 ). Mitsubishi Kogyo Kabushiki Kaisha, Tokyo. Tin is recovered by treating the raw tin-containing material with a mixture of a reducing agent and sulphide, sulphite, or sulphate, in a directly heated rotary tube-furnace in an atmosphere of reducing gas. The tin is volatilized as stannous sulphide and collected by an electrical dust collector.
26,914 of 1929 ( 339,340 ). Odda Smelteverk $\mathrm{A} / \mathrm{S}$ and E. Johnson, Odda, Norway. A nitric acid process for the treatment of phosphate rock.

27,136 of 1929 ( $\mathbf{3 1 8 , 5 9 9 \text { ). Metallgesellschaft }}$ A.-G., Frankfort-on-Main, Germany. Alloys of calcium or strontium with lead are produced by
the electrolysis of saline melts of one or more of the requisite halides, by the aid of molten lead cathodes and in a single cell.

27,792 of 1929 (339,964). R. Ambronn, Gottingen, Germany. An improved process of investigating the geological structure of the sub-soil.

28,454 of $1929(340,027)$. L. Andrews, London. Material is classified by elutriation which is effected by subjecting a mixture of the material and liquid to the combined action of centrifugal force and gravity within a classifier having free outlets at top and bottom and controlling the rate of discharge of liquid with admixed particles through the upper and lower outlets by syphonic or suction effect produced on the liquid leaving the top of the classifier, the fluidity of the oversize particles required for the effective discharge of such particles being maintained by automatic admixture of liquid therewith.

11,663 of $1930(338,556)$. E. A. Ashcroft, Ashburton. An improved process for the extraction of copper and/or nickel, particularly from partly oxidized sulphide ores.

## NEW BOOKS, PAMPHLETS, Etc.

per Copies of the books, etc., mentioned below can be obtained through the Technical Bonkshop of The Mining Magazine, 724, Salisbury House, London, E.C. 2.
Flow Measurement of Air and Gases. 2nd edition. By Alec B. Eason. Cloth, octavo, 254 pages, illustrated. Price 20s. London: Charles Griffin and Co.

Lehrbuch der Bergwerksmaschinen (Kraftund Arbeitsmaschinen). 2nd edition. By H. and C. Hoffmann. Cloth, quarto, 402 pages, illustrated. Price 24 RM. Berlin: Julius Springer.

Géologie et Industrie Minérale du Pays de Liege. By P. Fourmarier and L. Denoél. Paper covers, 238 pages, illustrated. Price 35 francs. Paris and Liège: Librairie Polytechnique Ch . Béranger.

Living Africa. A Geologist's Wanderings. By Bailey Willis. Cloth, octavo, 320 pages, illustrated. Price 20s. London: McGraw-Hill.

Handbuch der Geophysik. Band III, Lieferung 1. Kräfte in der Erdkruste. By B. Gutenrerg. Plutonismus und Vulkanismus. By F. von Wolff. Eidkrustenbewegungen. By A. Born. Geotektonische Hypothesen. By B. Gutenberg. Mechanische Wirkungen von Eis, Wasser und Wind auf die Erdkruste. By H. Hess. Paper covers, 570 pages, illustrated. Subscription price 48 RM. Berlin: Gebrüder Borntraeger.

Enstehung, Veredlung und Verwertung der Kohle. Lectures given at the German Technical High School in Prague. Published by order of Prof. K. A. Redich, Prof. J. C. Breuil, and Priv.-Doz. H. Tropsch. Paper covers, 359 pages, illustrated. Price, bound, 33 RM. Berlin: Gebrüder Borntraeger.

Industrial Britain. A Survey. By Dr. A. Wilmore. Cloth, octavo, 366 pages, illustrated. Price 5s. London: George G. Harrap and Co.
Gmelins Handbuch der anorganischen Chemie. 8 Auflage. System-Nummer 59 : Eisen. Teil A-Lieferung 3. Paper covers, pp. 313-586, illustrated. Subscription Price, 32 RM. Berlin Verlag Chemie.
The Ignition of Firedamp by the Heat of Impact of Hand Picks against Rocks. By M. J. Burgess and R. V. Wheeler. Safety in

Mines Research Board Paper No. 62. Paper covers, 21 pages, illustrated. Price 9d. London H.M. Stationery Office.

The Propagation of Combustion in Powdered Coal. By H. E. Newall and F. S. Sinnatt. Safety in Mines Research Board Paper No. 63. Paper covers, 58 pages, illustrated. Price 1s. 3d. London : H.M. Stationery Office.

Tantalum and Niobium. Imperial Institute publications on the Mineral Industry of the British Empire and Foreign Countries. Paper covers, 24 pages. Price 6d. London: H.M. Stationerv Office.

The Salt Industry of Canada. By L. Heber Cole. Canadian Department of Mines publication No. 716. Paper covers, 116 pages, illustrated, with maps. Price 20 cents. Ottawa: Department of Mines.

British Columbia. Department of Mines Bulletin No. 3, 1930. Preliminary Review and Summary of Mining Operations in 1930. By J. D. Galloway. Paper covers, 77 pages, illustrated. Victoria: B.C. Department of Mines.

Gold Coast Colony. Report of the Geological Survey Department, 1929-30. Paper folio, 14 pages. Price 2s. London: Crown Agents for the Colonies.

On Fossil Reptilia from Sokoto Province, Nigeria. By W. E. Swinton. With a preliminary note on the sedimentary rocks of the province by Dr. C. Raeburn and Dr. C. M. Tattam. Bulletin No. 13 of the Geological Survey of Nigeria. Paper boards, 60 pages, with 15 plates and a map. Price 10s. London: Crown Agents for the Colonies.

South Australia. Department of Mines Mining Review for the half-year ended June 30, 1930, No. 52. Paper covers, 87 pages, illustrated. Adelaide: Department of Mines.

Potash Bibliography to 1928 (Annotated). Review and compilation of technical literature on potash salts (including the alunites) and their foreign occurrences. United States Bureau of Mines Bulletin No. 327. By J. F. T. Berliner. Paper covers, 578 pages. Price 90 cents. Washington: Superintendent of Documents.

United States Bureau of Mines. List of publications, 1910-1930, with an index by subjects and authors. Paper covers, 222 pages. Washington: Superintendent of Documents.

Mineral Resources of the United States, 1929. Part I, pp. 79-116, Rare Metals, by P. M. Tyler and A. V. Petar; pp. 117-142, Mercury, by P. M. Tyler. Part II, pp. 139-145, Potash, by A. T. Coons ; pp. 147-160, Salt, Bromine, and Calcium Chloride, by A. T. Coons; pp. 161-174, Slate, by O. Bowles and A. T. Coons. Washington: Superintendent of Documents.

United States Geological Survey. Annual Report of the Director for the year ended June 30, 1930. Paper covers, 91 pages, with map. Price 15 cents. Washington: Superintendent of Documents.

Boundaries, Areas, Geographic Centers, and Altitudes of the United States and the Several States. By E. M. Douglas. United States Geological Survey Bulletin No. 817. Paper covers, 265 pages, illustrated, with maps. Price 50 cents. Washington: Superintendent of Documents.

A Graphic History of Metal Mining in Idaho. By C. P. Ross. Bulletin 821 -A of the United States Geological Survey. Contributions to economic geology, 1930, Part 1 (pages, 1-9). Paper covers,

Price 10 cents. Washington : Superintendent of Documents.

Bituminous Sandstone near Vernal, Utah. By E. M. Spieker. Bulletin 822-C of the United States Geological Survey. Contributions to economic geology, 1930, Part II (pp. 77-98). Paper covers. Price 10 cents. Washington Superintendent of Documents.

Notes on the Geology of Upper Nizina River, Alaska. By F. H. Moffit. Bulletin 813-D of the United States Geological Survey. Mineral Resources of Alaska, 1928 (pp. 143-163). Paper covers. Price 15 cents. Washington: Superintendent of Documents.

Mineral Industry of Alaska in 1929 and Administrative Report. By P. S. Smith. Bulletin 824-A of the United States Geological Survey. Mineral Resources of Alaska, 1929 (pp. 1-109). Paper covers. Price 20 cents. Washington Superintendent of Documents.

Geologic History of the Yosemite Valley. By F. E. Matthes. Professional Paper 160 of the United States Geological Survey. Paper covers, 137 pages, illustrated, with maps. Price $\$ 1 \cdot 10$. Washington: Superintendent of Documents.

The Coal Fields of the United States. General Introduction by M. R. Campbell. Ohio, by J. A. Bownocker. Professional Paper 100 of the United States Geological Survey. Paper covers, 101 pages, illustrated, with maps. Washington: Superintendent of Documents.

Australia. The Manufacturing Industries of the British Empire Overseas. Part II. Paper covers, 43 pages, with 11 large diagrams. Price 2s. 6d. London: Erlangers, Ltd.

Studies in Industrial Relations. Part I. Siemens Works-Lens Mining Company-London Traffic Combine-Saar Basin-Bata Boot and Shoe Factory. Studies and Reports of the International Labour Office, Series A (Industrial Relations) No. 33. Paper covers, 263 pages. Price 5s. London: P. S. King and Son.

French - English and English - French Dictionary of Commercial and Financial Terms, Phrases and Practice. By J. O. Kettridge. Cloth, quarto, 647 pages. Price 25 s. London: George Routledge and Sons.

Francis J. Blight, Publisher, A biographical sketch. By George Hawker. Cloth boards, 198 pp., with 32 half-tone plates and a foreword by Dr. Ewing. Price 10s. 6d. London: Elliot Stock.

## COMPANY REPORTS

McCreedy Tins.-This company was formed in 1907 and works alluvial tin deposits in Swaziland. The report for the year ended June 30 last shows that $178,816 \mathrm{cu}$. yd. of ground was mined and sluiced during the year, yielding $46 \frac{1}{2}$ tons of tin concentrates. Operations were restricted owing to the price of tin during the latter part of the period under review. The working profit for the year was $£ 584$. The new power station has been completed and is operating satisfactorily.

Jos Tin Area (Nigeria)--This company was formed in 1910 to work alluvial tin deposits in Northern Nigeria. The report for the year ended July 31 last shows that $271 \frac{3}{4}$ tons of tin concentrates was recovered during the year, as
compared with $252 \frac{1}{4}$ tons in the previous year. The amount realized per ton, however, was only $£ 958 \mathrm{~s} .2 \mathrm{~d}$., as against $£ 14616 \mathrm{~s} .4 \mathrm{~d}$. The profit for the year was $£ 7,827$, which, added to the $£ 4,832$ brought in, made an available total of $£ 12,659$. After making various provisions and distributing $\notin 7,500$ as a dividend, equal to $10 \%$, there remained a balance of $\$ 3,879$ which was carried forward.

Broken Hill Proprietary Block 14.-This company, formed in 1887, works a lead-zincsilver mine at Broken Hill, N.S.W. The report for the half-year ended September 30 last shows that during the period 10,600 tons of ore was mined and treated at the Sulphide Corporation's Mill. The total tonnage treated was 11,059 tons averaging $13.72 \%$ lead, $13.12 \%$ zinc and $12.39 \%$ silver per ton and it produced 2,114 tons of lead concentrates, assaying $65.87 \%$ lead, $8 \%$ zinc and 53.65 oz . silver per ton, together with 2,119 tons of zinc concentrates, assaying $50.45 \%$ zinc, $3 \cdot 12 \%$ lead and 6.09 oz . silver per ton. A small working profit was made over the period, but, after making various allowances, there was a net loss of $£ 3,171$

Penawat (Malaya) Tin Dredging.-Formed in 1927, this company works alluvial tin property in the Kinta district, State of Perak, F.M.S. The report for the year ended August 31 last shows that the dredges treated $2,318,458 \mathrm{cu}$. yd. of ground and recovered 828 tons of tin concentrates, which realized $\$ 831,193$. The working profit was $\$ 272,750$ and the net profit $\$ 139,661$, of which, after making various allowances, $\$ 5,239$ was carried forward.

Rambutan.--This company was formed in 1905 and works alluvial tin deposits in the Kinta district, State of Perak, F.M.S. The report for the year ended June 30 last shows that 122 tons of tin concentrates was recovered from the treatment of $777,300 \mathrm{cu}$. yd. of ground. The working profit was $£^{2,327 \text {, which was carried forward. }}$

San Francisco Mines of Mexico.-This company was formed in 1913 and works lead-zinc deposits in the State of Chihuahua, Mexico. The report for the year ended September 30 last shows that 337,480 metric tons of ore was treated by the mill and 36,259 tons of lead concentrate produced, assaying $59 \%$ lead, $12.83 \%$ zinc, $2.88 \%$ copper, and 1237.8 gms. in silver and 3.734 gms. gold per ton, together with 35,960 tons of zinc concentrates, assaying $54.66 \%$ zinc, $1.67 \%$ lead, $1 \cdot 30 \%$ copper, and 245.8 gms . silver and 1.014 gms . gold per ton. For a short period zinc concentrates were not produced owing to the fall in metal prices and during this time there was produced an additional 7,512 tons of lead concentrates, averaging $57.55 \%$ lead, $13.80 \%$ zinc, $2.87 \%$ copper and 1217.5 gms. silver and 3.845 gms . gold per ton. The ore reserves at the end of the year were $1,763,600$ tons fully blocked and 552,900 tons partly blocked, but this does not include ore in the Clarines mines. The extension of the milling programme was not proceeded with beyond the erection of one of the milling units. The working profit was $£ 165,359$ and a dividend of 1s. per share was paid.

Apex (Trinidad) Oilfields.-This company was formed in 1919 to acquire oil rights in the Fyzabad district, Trinidad. The report for the year ended September 30 last shows that 425,036 tons of oil was produced, as compared with 414,328 tons in the previous year. The continued general fall in the market value of oil resulted, however, in a considerable reduction in revenue. The oil profits for the year amounted to $\neq 330,128$, and $\notin 125,000$ was distributed as dividends, equal to $25 \%$.

## DIVIDENDS DECLARED

Anaconda Copper.-62 $\frac{1}{2}$ cents, payable February 16.

Apex (Trinidad) Oilfields.-6d., less tax, payable February.

Ayer Hitam Tin.- $1 \frac{1}{2} d$. , less tax, payable January 30.

British South Africa Co.-1s. 3d., less tax, payable March 5.

Consett Spanish Ore.-2s., less tax, payable February 16.

Gaika Gold Mining.-3s., payable January 31. Jos Tin Area (Nigeria)-6d.
Rezende Mines.-2s. 6d., payable February 18.

## NEW COMPANIES REGISTERED

Asturias Minerals Corporation.-Registered January 20. Capital: $£ 50,000$ in $£ 1$ shares. Objects: To acquire mines, mineral and other rights. Directors : W. F. Jackson and C. Baker.

## British Oilfields Development Syndicate.-

 Registered as a private company December 23. Nominal Capital: $£ 1,000$ ( $500 \not £_{1}$ Ordinary and $10,0001 \mathrm{~s}$. Ordinary). Objects: To acquire mines, oil wells and refineries, and to carry on the business of producers and refiners of petroleum products.Consolidated Gold Alluvials of British Columbia. Incorporated in British Columbia. Capital: $\$ 2,500,000$ in $\$ 1$ shares. Objects: To acquire and develop a section of Lightning Creek, British Columbia. British address: Finsbury House, Blomfield Street, E.C. Directors: H. Darling, H. Brown, O. B. Allen, W. R. Beldam, D. Barron, H. W. Hamlett, H. J. Hardy, P. A. Ivanoff, R. M. Reid, and W. J. Yappe. H. J. Hardy is chairman of the London committee.

Gold Coast Mines.-Registered January 14. Nominal Capital: $£ 1,000$ in 4 s . shares. Objects To adopt an agreement with Yelnut Syndicate, Ltd., to search for gold and other minerals and precious stones, and acquire mining and other rights in West Africa or elsewhere. Office : 224-5, Moorgate Station Chambers, E.C. 2.

Isamungu Gold Mine.- Registered January 10. Nominal Capital: $f 100$ in 1s. shares. Objects To acquire and turn to account any oil or mineral bearing lands, mining rights, etc., and to adopt an agreement between Oilfields, Ltd., and its liquidator of the first part, Platinum Areas, Ltd., and its liquidator of the second part, and this company of the third part. Office: 14 Union Court, Old Broad Street, E.C. 2.

Mepale (Burma) Oil.-Registered as a private company January 21. Nominal Capital : $\AA_{\AA 75,000}$ in $\neq 1$ shares. Objects: To adopt certain agreements and to search for oil shale, mineral oil and other products. Directors: S. R. Hodge and J. W. Gregory. Office: 46, Basinghall Street, E.C. 2.

Swithin's Investment.-Registered December 15. Nominal Capital: $£ 125,000$ in $£ 1$ shares. Objects: To acquire the assets of the West African Nigerian and General Trust.

Yelnut Syndicate.-Registered as a private company, January 14. Nominal Capital: f100 in 4s. shares. Objects : To adopt an agreement with J. Tunley, to search for gold and other minerals and precious stones, and acquire mining and other rights in West Africa or elsewhere. Office : 224-5, Moorgate Station Chambers, E.C. 2.


[^0]:    * Oz. gold. + Oz. silver.

