The Mining Magazine

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EDITORIAL

THE Rosenwald Industrial Museum of Chicago is appealing for information as to the location of any ancient engines or other machines now disused and for which a home will be found in this the first industrial museum in America.

SIR Alfred Ewing, the retiring Principal of Edinburgh University, when receiving the freedom of that City recently, announced the gift by Sir Alexander Grant of £25,000 for a new department of geology, to which object a like sum would be contributed in a year's time.

SETTLEMENT of a long-standing dispute between Peru and Chile is announced. This concerns the provinces of Tacna and Arica, the former of which is to go to Peru and the latter to Chile. The territory concerned is situated between the Bolivian rail centre La Paz and the sea.

AS in previous years the Camborne School of Mines is holding its holiday course in economic geology, under the direction of Mr. E. H. Davison, from July 8 to August 16. Many mining men home on leave have in the past found this a valuable "refresher," if only on account of its field work.

SIR Thomas Holland is relinquishing his appointment as Rector of the Imperial College of Science and Technology in order to take up the Principalship of Edinburgh University. May we express the hope that his successor will be one who is sympathetic to the ideals of technological education so long upheld by the Royal School of Mines and the Royal College of Science.

THE future of East Africa is felt to be better left to rest awhile pending the mission of Sir Samuel Wilson, the Permanent Under-Secretary of State for the Colonies. Meanwhile it will be gratifying to many, who remember his work in South Africa as the agent of the Government of India, to learn that Mr. Sastri has accepted Mr. Amery's invitation to visit Kenya and elsewhere.

LENGTHY negotiations between the Palestine and Transjordan Governments and the concessionaires, Major Tulloch and Mr. Novomeyski, for the exploitation of the supposedly rich mineral region of the Dead Sea have resulted in the grant of a concession by the Crown Agents for the Colonies. Among a considerable number of interests supporting the concessionaires the names of Messrs. C. Tennant, Sons, and Co., Ltd., and of Mr. Leslie Urquhart are especially interesting. Lord Lytton's name has been mentioned as first chairman of the company to be formed.

A SERIOUS view is taken of the unrestricted export of scrap iron and steel from this country resulting in a severe shortage. The fact is that "scrap" is a very important factor in steel manufacture, much more being used in modern practice than formerly. Continental steel-producing countries either prohibit or limit the export of scrap. The position is aggravated by the fact that, while British pig iron is subject to import duty in most European countries, scrap is duty free, so that steel makers there can afford to pay a good price for it.

COMMENT in these columns in our issue of January last, *à propos* future Empire mining congresses, on the non-existence of a Malayan Society devoted to mining has brought us a communication from the F.M.S. Chamber of Mines, published elsewhere in this issue. We quite agree that the Chamber is doing good work, but our desire is to see in Malaya a purely technical institution on the same lines as those at present existing in Canada, Australia, and South Africa, and, as we have already stated, the local engineers should be helped or encouraged in the formation of such an institution by the powers behind the Empire Mining Congress.

THE report of the Radium Sub-Committee of the Committee of Civil Research[1] contains a review of world resources and concludes that for present purposes the only feasible source of supply to meet urgent hospital requirements in this country is from Belgium, where the Congo ore is concentrated, in virtue of the vastly higher grade of that ore. There has been some disappointment that recommendations for attention to Empire (*e.g.*, Australian) and home sources were not made. The problem is a difficult one and the economic significance

[1] London : H.M. Stationery Office. Price 6d.

of a high-grade raw material is aptly crystallized by the following words taken from an article by the late J. S. McArthur in the MAGAZINE for February, 1916: "The figures involved in the radium industry baffle the imagination . . . to extract 10 milligrams of radium from 1 ton of ore is like selecting ten minutes out of the whole Christian era." Adverse critics of the report have, perhaps, overlooked, too, the fact that Sir Thomas Holland was a member of the committee.

The Institution Meeting

At the April meeting of the Institution of Mining and Metallurgy the Symposium on Geophysics was continued. Mr. Broughton Edge's paper on the general principles of electrical prospecting was taken as read, the author being again absent, and the proceedings commenced with the presentation by Mr. Karl Sundberg of two papers on prospecting by Swedish geoelectrical methods. The first paper, which had been compiled by Mr. Sundberg and Mr. Hans Lundberg, dealt with ore-finding methods and was exemplified and illustrated by the authors' experiences in Sweden, Mexico, and Newfoundland, where discoveries were made respectively of iron and copper, molybdenite and galena, and a lead-zinc orebody with copper, silver, and gold. The second paper exemplified practice in locating a salt dome in Texas. Two other papers were presented by Mr. H. B. Bateman, in the authorship of which he collaborated with Mr. Norbert Gella, the technical director of the Elbof Geophysical Company, Cassel, Germany. These were in the form of brief notes on an electrical and magnetic investigation of magnetite ores in North Sweden and on an electrical investigation for copper ores in Roumania. When introducing these papers Mr. Bateman ventured to parry the criticism levelled against geophysical prospecting companies by Dr. McLintock at the previous meeting by transferring the blame for secrecy to the individuals employing them.

Following these papers were demonstrations of a magnetometer and a seismograph. Instruments employed in geophysics have undergone very rapid development in recent years. The magnetometer shown, for example, represented a considerable technical advance on its predecessors and we hope to include a description thereof in our next issue. Elsewhere in this issue we publish as another example of such progress a description of the gravity gradiometer, which represents an important contribution to the improvement of gravimetric surveying instruments.

A feature of the meetings of the Institution which have earned it a well-deserved reputation among the technical and learned societies in London is the excellence of the discussions on subjects brought before them, and it was, perhaps, because of this very fact that some disappointment was felt that the length of the proceedings precluded the possibility of any extended talk. On the other hand, there were many who felt not unnaturally reluctant to embark on a subject so beset with mathematical and physical intricacies. It was thus with a doubly stimulated interest that the meeting heard the statement delivered by Mr. A. S. Fitzpatrick, which, as the President remarked in his conclusion, made a fitting commentary on the two evenings' proceedings. Mr. Fitzpatrick, who is the technical liaison officer between the Commonwealth and Home Governments, gave chapter and verse about the work being done in Australia by the Imperial Geophysical Experimental Survey under the leadership of Mr. Broughton Edge. This commission has separate sections working on gravimetric, electrical, and magnetic methods, and another smaller section on the seismic method. From their work three important results may be expected: Stimulation of interest in geophysics itself, as a result of the data to be published; an opportunity for British manufacturers to design and make the requisite instruments, so many of which have originated on the Continent; and, finally, the stimulation of the mining industry itself in the Commonwealth. We might add here that elsewhere in this issue we publish the first part of an interesting review of the earlier history of geophysics by Dr. W. R. Jones.

Rio Tinto

Erratic movements in the price of copper on the one hand and the interest aroused a few months ago in what was thought to be a serious disagreement between the Rio Tinto Company and the Spanish Government on the other have combined to invest the proceedings of the annual general meeting of this great undertaking with peculiar significance. In these circumstances it is perhaps particularly fortunate that the Chairman's speech at that meeting should

have been one of the most important and interesting that has ever been made to the shareholders of the company. Sir Auckland Geddes told a plain and simple but illuminating story which so admirably reflects some of the many aspects of mining as to be well worth a little consideration.

He dealt first with the settlement of the differences with the Spanish Government already alluded to and confessed frankly that in the past there had been understatements of the copper content of some of the pyrites exported and that, as a result of the underpayment of export taxes, the profits shown in the balance sheets for the years in question were greater than they should have been and the dividends correspondingly too high. Additional payments have been and are being made, and the Spanish Government's facilitation of a settlement is, not unnaturally, much appreciated. Still on the subject of the relationship between a mining company and the government and peoples of the country of operation, he told of commendable social services for the welfare, education, and recreation of the mine workers and their dependents, which was by way of answer to a criticism lately heard from an influential Spaniard to the effect that foreign companies mining in Spain cared nought for the peoples employed.

Concerning mining and milling operations, the Chairman revealed that the average copper content of the massive pyrites being worked was tending to fall, while that of the porphyritic ores was maintained, for the treatment of which a new concentrator is to be in operation soon. Of this porphyritic ore very little has been heard before. He went on to speak of the work of the company in other parts of the world through its various subsidiaries, and in particular of the Pyrites Company's work at Wilmington, Delaware, and elsewhere, which led up to disclosures as to their interest in silica gel, which has lately culminated in the formation of an organization with world-wide ramifications, with himself as president. Silica gel is a chemical product resulting from the treatment of sodium silicate (water glass) with sulphuric acid produced from Rio Tinto pyrites. This material has a remarkable adsorption power and is rapidly finding considerable industrial uses on this account. Notably has it already been employed successfully for air conditioning, and in particular the dehydration of air for blast furnaces, for refrigeration of railway freight cars and for the refining of motor benzol.

Apart from its subsidiary companies, the Chairman made disclosures of outstanding importance with regard to the interest which the Rio Tinto Company has acquired in what threatens to become its most serious rival as a copper producer, indirectly through its association with Minerals Separation, on the Board of which they are already and will be further represented, and directly through its interest in Rhodesian Congo Border Concessions, the Board of which he himself expects to join.

As we have already seen, this wide and comprehensive survey presents us with an image of the many-sidedness of the business of mining. There is the relationship between the mining company and the government of the country of operation, for the maintenance of the friendly character of which the engineers and other executives of the company are more often than not responsible. That mining engineers should become diplomats is hardly necessary, but the ability to exercise tact is invariably a commanding asset. Similarly in the labour relations, proper attention to housing, sanitation, infant welfare, recreation, and education will go a long way, if not actually all the way, to creating a loyal and hard-working force.

Turning to the more material side, the success of a mining enterprise will depend on the efficient disposal of its products. The main or primary products do not present much difficulty, except when owing to over-production or other causes there is a falling market. In such a case restriction of output seems the only remedy, especially when research into methods of effecting a better or cheaper concentration or for finding new uses for the particular material have failed to produce any considerable result. Many of the other products are usually dumped until uses are found for them, and it is here particularly that the value of research comes in. Uses must be found for as many of these as possible. Also important in this connection is the broad outlook of those in supreme control of the company.

The finance of mining operations is not a subject for us to delve into, principally because it does not differ greatly from that of any other industrial undertaking. Thus it is at the dictates of good sense, in response to long vision, rather than to any specialized knowledge that those in control spread

their capital assets and acquire interests in other mining, metallurgical, or cognate enterprises and particularly those which promise on the one hand to become good allies or on the other serious rivals.

The Institution Annual Dinner

Time did not permit more than a bare reference in our last issue to the proceedings at the Annual Dinner of the Institution of Mining and Metallurgy. The speeches delivered were particularly interesting and may suitably be dealt with further. Especially impressive were the weighty words of warning uttered by Sir Halford Mackinder as to the responsibilities which devolve on those who control the output of the mines. As he pointed out, there is a danger of this becoming too monopolistic and passing out of the control of governments into the hands of a few powerful industrial groups. Our British civilization, covering as it does a fourth part of the world, has the task of developing a vast estate which should be done not only in our own interests but in those of the whole of humanity.

Sir Godfrey Fell, who was charged with responding to this statesmanlike appeal, fell back at first on witticisms, making invidious comparisons between precious and base metals, but recovered himself to utter a plea for stabilization in the prices of metals. If to the uncertainties of mining were added those as to the price at which the hard-won product was to be sold, the investor was bound to be discouraged from giving his aid to the exploitation of the world's mineral resources. We can hear many an answering Aye !

In proposing the toast of the Institution, Sir Richard Gregory was pleased to see that the contact between the purely scientific worker and the industrial technologist was being maintained and in fact strengthened and he chose two happy examples to illustrate his point. In geophysics there is the application of purely physical principles to the location of underground masses and in the older flotation there is the application of another physical phenomenon to the concentration of metalliferous materials.

Professor Truscott, in responding to this toast, made his theme the position of the technical man in industry. He holds that management and labour are the two factors in industry, preferring to regard " capital and labour " as having more of a political significance. Thus under the heading of " management " he groups the manager and his technical staff as well as the directors, both business and technical. Good management can make good labour and is responsible for the prevention of waste. For these arduous and onerous duties it must be scientifically organized and the practical man must be displaced, for he it is who has been responsible for the haphazard ways and backward equipment of the past. Much of this, we feel, is profoundly true, and yet the remedy, if literally interpreted, must surely be worse than the disease. He went on to say that as a nation we have a great natural ability and that our ideals of education, inasmuch as they are largely a matter of moral discipline, have made us honest and fair above other nations. We must strive to maintain this and set our face against the tendency to praise " artistic indolence," which is one of our other and less worthy national characteristics. By reason of the former and removed from the sphere of influence of the latter British enterprise is especially successful abroad. In so far as mining is concerned, the Rio Tinto Company, the Mysore goldfield, and the Transvaal industry are shining examples. When, however, we turn and look at similar non-ferrous industries at home we do not find such an entirely happy picture with respect to the metallurgy of the major base metals—copper, lead, and zinc. He thinks that the loss of these industries is due to " unenlightened " management. With modern management and in virtue of our geographical position, our technical genius, our business honesty, our good labour, and our cheap power we should be able to compete for these and other mineral products. In spite of the impressive character and undoubted sincerity of these well-chosen words Professor Truscott left upon his hearers a sense that there was something missing, and would probably have sent them away happier if he had defined " management." Many, for example, will not be disposed to admit his contention that certain metallurgical industries have been lost through bad management of the past, preferring to regard these losses as consequences of changed economic conditions.

Sir Auckland Geddes, who spoke a few words at the end on behalf of the guests, reiterated the first speaker's plea for placing the mineral and other resources of the world at the disposal of humanity at large.

REVIEW OF MINING

Introduction.—In view of the General Election this month and the uncertainty which usually precedes the appeal to the country business has kept quite good. Copper and tin are lower, but both are well supported at current prices, deliveries of tin in the United States for April reaching the new high record of 8,435 tons.

Transvaal.—The output of gold on the Rand for April was 836,474 oz. and in the outside districts 35,649 oz., making a total of 872.123 oz. The natives employed on the gold mines at the end of the month totalled 197,412, as compared with 197,646 at the end of March.

The net profit of the Central Mining and Investment Corporation for 1928 was £725,677, approximately the same as for 1927. The payment of a final dividend of 8s. and a bonus of 4s., together 12s. per share, free of income tax, is recommended, making the total distribution for the year 20s. per share, free of income tax, the same as for the previous year.

The 1928 reports of the mines controlled by the Anglo-American Corporation were issued last month. At the Brakpan, although a record tonnage was milled, the profit was not quite up to that for the previous year, owing to a lower yield being obtained. Working costs, however, at 19s. 9d. showed a reduction of 7d. per ton milled as compared with 1927. The company's operations were also adversely affected by a decrease in native labour during the final quarter of the year, but for which the profit would, it is stated, have exceeded that for the previous year. The total working profit was £639,755, against £643,470, dividends totalling 9s. 9d. per share absorbing £497,250. The ore reserves at December 31 last were estimated at 2,938,050 tons, a decrease of 131,570 tons, but the value at 8·21 dwt. is 0·28 dwt. better, whilst the stoping width is 57·61 in. against 60·34 in. In the middle western area development operations met with a fair measure of success and a considerable tonnage of good grade ore from this section was included in the reserves.

As in the case of the Brakpan, Springs Mines had a record tonnage for 1928—830,600 tons, against 799,000 tons—and the yield at 41s. 4d. against 38s. 7d. showed a satisfactory improvement, for which the reduction in stoping width was mainly responsible. Working costs, however, were somewhat higher. The working profit was £853,852, against £727,603 for 1927, and dividends totalling 6s. 9d. per share were paid, absorbing £506,250. At the end of last year the reserves were estimated at 3,008,641 tons, value 9·10 dwt. over a stoping width of 52·50 in., as compared with 3,198,420 tons, value 8·58 dwt. over a stoping width of 57·39 in. at the end of the previous year.

On the West Springs the working profit for 1928 was £260,565, against £343,847 for 1927, although a considerably larger tonnage was milled—647,300, against 587,700. The falling-off in the yield of over 3s. per ton milled was due to the inclusion of a large tonnage from the old development dump, which is of low grade. The reserves at the end of last year were 2,695,520 tons, value 6·80 dwt. over a stoping width of 61·16 in., an increase of 57,300 tons as compared with the end of 1927, the value at 7·23 dwt. showing a decrease of 0·43 dwt., whilst the stoping width of 61·16 in. compares with 61·55 in.

The Union Corporation report for 1928 shows a net profit of £428,582, as compared with £386,160 for 1927, the total dividends of 5s. 6d. per share taking £385,000, as against £350,000 for the preceding year. The reserve account has been substantially increased and now stands at £630,570. The company, as in previous years, has derived much of its revenue from its holdings in Modderfontein Deep Levels and Geduld Proprietary Mines, whose reports were summarized in our last issue, and also from its interest in the San Francisco Mines of Mexico. The report states that interests have been acquired in certain of the companies which are exploring and developing the Northern Rhodesia copper deposits.

For 1928 the General Mining and Finance Corporation showed a profit of £90,293, against £325,187 for 1927, and as the dividend paid in December last took £63,228 no final distribution for last year was forthcoming. The corporation, however, carried forward £120,257, against £102,489 brought in.

With regard to the New Steyn Estate, a deep level in the western Rand belonging to the General Mining and Finance group, it was stated a year ago that an amalgamation with the neighbouring Durban Roodepoort Deep was under consideration. The report for 1928 says that it has not yet been found possible to arrive at a satisfactory basis for this.

Owing to a substantial increase in the working profit for last year—which jumped from £42,537 for 1927 to £96,344 for 1928—the East Rand Proprietary Mines were able to clear off the balance of the debenture debt. The improvement was due to an increase in the supply of native labour and to additional hoisting facilities underground, which enabled a greater tonnage to be milled. Whilst the working revenue was 3d. per ton milled higher, working costs were reduced by 5d. per ton milled, the working profit therefore showing an increase of 8d. per ton milled, which accounts for the satisfactory increase of nearly £54,000 shown in last year's total working profit.

Rhodesia.—The gold output of Southern Rhodesia for March was 47,388 oz., as compared with 44,551 oz. for February. Other outputs for March were: Silver, 6,783 oz.; coal, 72,053 tons; chrome ore, 9,852 tons; asbestos, 3,604 tons; and mica, 15 tons.

The proposal to increase the capital of the Roan Antelope to £1,250,000 by the creation of a million new shares of 5s. each was approved at the meeting last month. From the remarks of Mr. Chester Beatty reported elsewhere in this issue it will be seen that the mining and financial position are equally satisfactory.

In February last reference was made in this column to the negotiations for financing the N'Changa, when it was pointed out that a strong group—the principal names of which were given—was prepared to submit more advantageous terms than those offered by the American Smelting and Refining Co., whose offer was thereupon withdrawn. Arrangements have now been made increasing the capital to a million sterling by the creation of 400,000 new ordinary shares of £1 each, which will enable the Rhodesian Congo Border Concession, Ltd., as the parent company, more actively to finance the N'Changa.

The policy of pushing development drives into unexplored ground was continued last year on the Lonely Reef with very satisfactory results. The extension of the 11th and 12th levels south exposed a lens of high-grade ore, which has so far been proved from the 13th upwards to the 9th level. In view of the success met with in extending these levels the policy of pushing development into other unknown areas is being continued. Last year the company milled 62,330 tons for 35,030 oz. of gold, whilst the 148,415 tons of accumulated slimes treated yielded 11,064 oz., bringing the total to 46,094 oz., as compared with 31,140 oz. for 1927. On mining operations the net profit was £83,196, against £22,535 for the previous year. Dividends totalling 5s. per share absorbed £72,324. The reserves at December 31 last were 96,215 tons, value 15·19 dwt., as compared with 87,195 tons, value 11·36 dwt., at the end of 1927, there being in addition over 800,000 tons of accumulated slimes also available for treatment.

Nigeria.—The Nigerian Electricity Supply Corporation, Ltd., has been formed under the auspices of the Anglo-Oriental and General Investment Trust to carry through the construction and equipment of a hydro-electric installation for the utilization of the important Kurra Falls to supply cheap power to the tin mines on the Bauchi plateau. The capital is £650,000 in 450,000 preferred ordinary and 200,000 ordinary shares of £1 each. Messrs. J. M. Smyth, M.Inst.C.E., and C. F. Mackness, M.I.E.E., are the consulting engineers and Messrs. Foley, Boyes, Butler, and Peek the Nigerian managers.

Like all other tin mining companies, the Kaduna Syndicate profit for the year to October 31 last was adversely affected by the low price of the metal. For the period mentioned 382½ tons was produced, against 414 tons for 1926–27, the net average price realized being £140 1s. 9d. per ton, against £180 8s. 4d. The profit at £17,201 compares with £35,068, whilst the dividends total 20 per cent., against dividends and bonus of 55 per cent. for the previous year.

Owing to an increased output—310 tons against 191½ tons for 1926–27—the profit of the Kaduna Prospectors for the year to October 31 last was £10,085, as compared with £9,771 for 1926–27, and dividends totalling 20 per cent. have been paid, as compared with 30 per cent. The price realized for its product was £145 11s. 1d., against £181 13s. 7d.

Australia.—It is satisfactory to learn that the suggestion of the Broken Hill companies that the present working arrangement should continue until determined by either party giving three months' notice of the desire to terminate same has been approved by the unions.

New Zealand.—The Waihi report for 1928 states that owing to deterioration at successive levels it has been decided not to do any

further exploration at depth, whilst laterally exploration has led to the conclusion that the orebodies are confined within the block which has been hitherto worked by the Waihi and Waihi Grand Junction companies through so many years. For last year 228,749 tons was treated for gold and silver realizing £376,685, the gross profit being £116,825. Dividends totalling 2s. per share have been paid, absorbing £99,182. The ore reserves at December 31 last were 408,829 tons, a decrease of 80,524 tons as compared with the end of 1927. The Waihi, in conjunction with the Tronoh Mines, Ltd., are acquiring a tin dredging area in Siam covering about 650 acres, in which the former will have a two-thirds interest and the latter a one-third interest.

Cornwall.—Although for the year to March 31 last the Geevor Tin Mines produced 123 tons of black tin more than for the previous year, the amount realized only showed an increase of £654, due to the average price obtained being nearly £26 a ton less than for 1927–28. Had the average price for 1928–29 been the same as for the previous year the total amount received by the company for its product would have been nearly £20,000 more.

Panama.—The new concession recently secured by the Panama Corporation, which adjoins the Veraguas concession on the west, is some 2,000 square miles in extent and trebles the area previously held by the corporation in the western portion of its territory. The mining operations now being carried out are mainly in the Veraguas concession and the richest discoveries are stated to have been made within the western boundary.

Spain.—The Rio Tinto report states that last year operations at the mines continued in a satisfactory manner, the mineral shipped being in excess of that for 1927. The profit for 1928 was £1,669,783, against £1,016,840 for 1927, and, after payment of the preference dividend, the ordinary received 40s. per share, which absorbed £750,000, this comparing with 50s., taking £937,500, for 1927, the decrease being due to the company having to meet heavy demands for arrears of taxes in Spain, in addition to which it decided to place £200,000 to an emergency account. In order to finance the company's interests in Northern Rhodesia it was decided at an extraordinary general meeting on the 9th inst. to increase the capital by 50,000 Ordinary shares, which are to be offered to the Ordinary shareholders.

The Tharsis profit for 1928 of £122,029 was well ahead of that for 1927 and after placing £25,000 to a general reserve account, to which the sum of £10,000 standing to the credit of reserve insurance fund account has also been transferred, enabled a dividend of 10% to be paid, as against 8¾% for the previous year, the carry forward at £82,139 being about the same as the amount brought in.

Amalgamated Mining Trust.—For the year ended March 31 last the Amalgamated Mining Trust showed a net profit of £196,360, as compared with £72,151 for the previous twelve months. The final dividend of 2s. and a bonus of 1s. brought the total for the year to 4s., or double that for 1927–28, the carry forward being £34,970, against £24,896 brought in.

Zinc Manufacturing Company.—In November last some particulars were given of the Coley Zinc Process, in which Messrs. Stewarts and Lloyds are largely interested. The Zinc Manufacturing Company, which has a capital of a million sterling, in 1,800,000 "A" ordinary shares of 10s. each and 200,000 "B" ordinary shares of 10s. each, takes over certain rights of manufacture and sale under the process and last month 1,275,000 of the "A" shares were offered to the public at par.

Anglo-Oriental Mining Corporation.—The report for the period to February 28 last, covering approximately the first year of the corporation's operations, shows a profit of £220,228. After meeting the preference dividend of 7½ per cent., a dividend of 9d. on the ordinary and a final dividend of 3d. on the preference have been paid, the carry forward being £83,493. An investment reserve of £60,000 has been created by transferring thereto the sum of £29,731 8s. 11d. standing to the credit of the share premium account and an appropriation of £30,268 11s. 1d. from the profits of the past year. The corporation is mainly interested in tin-producing companies, the aggregate output from which has for some months past exceeded the figure quoted in its prospectus by more than 50 per cent. Having regard to the conditions existing during the period covered by the report, the result of the corporation's first year's operations cannot be regarded as other than satisfactory. At the meeting last week Mr. John Howeson dealt fully with the tin position and his remarks will doubtless receive the careful consideration of those interested.

EARLY GEOPHYSICAL PROSPECTING

By WILLIAM R. JONES, D.Sc., D.I.C., F.G.S., M.Inst.M.M.

The author gives a valuable historical record of the work of British pioneers in establishing principles.

A hundred years ago, as the result of numerous experiments conducted in Cornish mines, Robert Were Fox established, for the first time in the history of science, that electrical potential differences exist between different parts of ore in various lode formations, and it can be claimed for him that he is the father of geoelectrical prospecting.

His experiments are described in the Philosophical Transactions of the Royal Society of London for the year 1830, and the results of further experiments are recorded in the Proceedings of the Geological Society, pages 755 to 757, vol. iii, 1842. The simple apparatus he employed " consisted of copper wires from $\frac{1}{16}$ to $\frac{1}{20}$ inch in diameter, and plates of different metals, with other contrivances for varying the methods of producing contact with the ore-points selected in the veins. The galvanometer had only one needle $2\frac{1}{2}$ in. long, $\frac{1}{5}$ in. wide, and $\frac{1}{20}$ in. thick, having an agate cup and moving on a steel point. A fine brass wire was coiled 48 times round the box which contained the needle."

In the Pennance Mine, near Falmouth, with this very simple apparatus, by connecting ore-points separated from one another by distances varying from 36 to 600 feet, he obtained galvanometer deflections of from 20 to 80 degrees and, " in the eastern portion of the six-fathom level the needle traversed completely round and continued to revolve a short time after the circuit was broken." The lodes subjected to these experiments " abound with arsenical and iron pyrites interspersed with oxide of tin and sulphurets of copper and lead." He obtained the greatest deflections when connections were made between two ore-points of copper, arsenic, and iron minerals ; no deflections were obtained between two ore-points of galena, his explanation being that " sulphuret of lead is much more electro-positive than arsenical copper or iron pyrites."

His results " were not apparently modified by the method of making the contact, or by the method employed to effect it, provided an adequate degree of pressure was employed. For instance, a point of a copper wire, pressed against a given ore-point was mostly as effectual as a plate of that metal similarly treated ; and when zinc and platinum were successively substituted for copper no change was produced." He concluded, therefore, that " the electric currents were independent of extraneous causes, and were derived from the veins only."

The natural current obtained, in one case, was sufficient " to render a short bar of iron of a horse-shoe form, with several coils of copper wire around it, feebly magnetic." This pioneer proceeded to prove also that electro-chemical effects could be obtained from this natural current. He substituted the electro-magnet in the circuit for a " V " shaped glass tube " having moistened clay at the bottom," and with water in one limb and copper sulphate solution in the other. " Small cylinders of copper pyrites, taken from the same piece of ore, were employed to connect these liquids respectively with the opposite wires, the ore at the positive end of the wire having been dipped in water, and that at the negative end in the solution of copper sulphate. The apparatus remained undisturbed for three days when the column of the solution of sulphate of copper was found to have increased in height at the expense of the water in the other branch, the difference being about $\frac{1}{10}$ in. On the copper pyrites in the solution of sulphate of copper being examined, it was found to be partly coated with metallic copper." Fox remarked that these effects were produced solely by

means known to exist in the earth, and he added " that the experiments seemed, therefore, to have a direct and unequivocal bearing not only on the decomposition of metallic salts under the surface, but on the causes which effect the different levels of subterranean springs, and the purification of water from bodies which it may hold in solution."

Bennets [1] in 1833 conducted experiments which led him to the conclusion that the natural electric effects increased with the copper content of the ore; and in the year 1841 Henwood, who was then Secretary to the Royal Geological Society of Cornwall, submitted a very interesting communication [2] to the Royal Society, the Marquis of Northampton, the President, being in the chair. The paper was entitled " Experiments on the Electric Conditions of the Rocks and Metalliferous Veins (Lodes) of Longclose and Rosewall Hill Mines in Cornwall."

It was explained that the experiments were undertaken with the object of determining the reasons why the experiments of R. W. Fox and others had been unable to detect the presence of electricity in the tin veins of Cornwall (as apart from the lodes carrying a high content of copper, arsenic, and iron minerals where Fox had proved electro-potential differences). The methods used by Henwood were similar to those of Fox, and the tabulated results obtained by Henwood show that " both the granite and the tin vein in Rosewall Hill mine, and also the greenstone and the copper vein in that of Longclose, present unequivocal traces of electric currents, whether different parts of the same veins or various portions of the same rocks were examined." Henwood claimed that his experiments showed also that " the nature and position of the small metallic plates employed materially affect, not only the intensity, but in some cases also the direction of the currents; and also that there is a considerable difference in the results when the same plates of metal are placed on different ingredients in the veins, even though these may be in immediate contact with each other."

[1] J. Bennets, *The London, Edinburgh, and Dublin Philos. Mag. and Journal of Science*, London, vol. 3, p. 17, 1833.

[2] W. J. Henwood, *Proceedings of Royal Society, London*, Series A, p. 315, 1841.

Fox had come to the conclusion [1] that the electro-potential differences in orebodies were due to electrolytic processes which actually accounted for the deposition of the ore. Henwood disagreed with this view and contended that thermo-electric effects played an important part. A third Cornishman in the person of Robert Hunt, who was then Secretary of the Cornwall Polytechnic Society, and who had been " recently engaged in an experimental inquiry into the electricity of mineral veins, and being desirous of examining all the phœnomena which have any bearing on this most interesting subject," was induced to institute some experiments " on the influence of electric currents upon the copper pyrites, which is a bisulphuret of copper and iron." He communicated papers on this subject between the years 1841 and 1846 and in the one entitled " On conversion of the Bisulphuret of Copper (Yellow Copper Ore) into the Sulphuret (Vitreous Copper) by Electricity " he states " I must be excused from remarking that it appears to me evident that the change of bisulphuret of copper into the sulphuret is explained in the preceding experiments and shown to depend upon the decomposing power of the electric currents which circulate through metalliferous veins as was discovered by Mr. Robt. Fox, and the decomposing agency of which I have proved much to my satisfaction in some experiments conducted in East Pool copper mine." [It will be noted that in 1847 East Pool, now a famous tin mine, was then a copper mine.—W. R. J.]

It is extremely interesting to find that it was after he had confirmed the experiments of Fox and Henwood and other British investigators, that Reich [2] was led, in Germany in the year 1844, to consider the possibility of applying what are now known as geoelectrical methods to the search for unknown ore deposits.

One of the methods of geophysical prospecting—the Geothermic—depends for its data on the distribution of temperature in the earth's crust, and on the heat conductivity of rocks. D'Aubuisson had drawn attention as early as 1801 to the increase of temperature with depth, and had made an attempt to measure it; von Trebra in 1818 had also carried out certain experiments, but

[1] R. W. Fox, *Reports of Meeting of Brit. Assoc. for Adv. of Science*, London, 1835.

[2] F. Reich, *Berg-und Hüttenmännische Zeitung*, Nordhausen u. Leipzig, pp. 342–346, 1884.

it would appear that John Forbes,[1] yet another Cornishman, was the first to prove experimentally, in the year 1822, that this increase of temperature could not be caused by blasting operations in the mine, to lights used, nor to the presence of man, but was entirely due to heat in the earth's crust, and he calculated this increase. Comparing independent results of these three early workers, it is found that D'Aubuisson gave an increase of 1° C. for every 29·5 to 39·5 metres; von Trebra for every 31·3 metres; and Forbes for every 27·5 to 33 metres. That old genius Robert Were Fox, who had for the first time established the existence of electrical potential differences in orebodies, also conducted experiments on the geothermal gradient. In his 'Report on some Experiments on the Electricity of Metallic Veins and the Temperature of Mines'[2] in 1837, he describes how, in Skeers lead mine in Durham, he found "feeble electrical action" in a lead vein; and it occurred to him that the question of increase of temperature with depth might be decided "by burying the bulbs of different thermometers at various depths below the deepest excavation of the mines," and states he is indebted to the agents of Levant Tin and Copper Mine and of the Consolidated Copper Mines for having carried his plan into effect in their respective mines. He used a thermometer four feet long enclosed in a brass tube, had the bulb sunk in a hole three feet beneath the 'sump,' or bottom of the deepest shaft, whilst another shorter thermometer was placed near it with its bulb inserted in a hole only an inch deep. Both thermometers had previously been compared with a standard thermometer and corrections were applied. The deeper thermometer registered 78° F. as against 72·5° F. by the shorter thermometer. A reference is also made to an experiment of his at Tresavean Copper Mine, which gave an increase of 1° F. for 48 feet of depth. Fox's results averaged 1° C. for every 27·5 metres of depth, which he considered to represent the average geothermal gradient, and he was one of the first experimenters to point out that important variations existed in some mines and that these abnormal differences were due to many causes.

The Seismic Method, which is fast becoming one of the most important of geophysical prospecting methods, depends for the interpretation of the data obtained, on the different rates of propagation of elastic waves through different rocks. Just as Robert W. Fox is the father of geo-electrical prospecting, so is Robert Mallet the father of the Seismic Method of geophysical prospecting, for it was he who proved, for the first time, not only that the rates of propagation of elastic waves varied in different rocks, but also that the rates varied in different directions in the same rock. He was, moreover, the first to employ artificially produced earth tremors for the investigation of the propagation of elastic waves.

In his "Second Report on the Facts of Earthquake Phenomena" to the British Association in 1851 "the transit velocities were experimentally determined of waves of impulse produced by the explosion of gunpowder, and these velocities shown to be—

In wet sand	. .	824·915 ft. per sec.
In discontinuous granite	1306·425	,, ,,
In more solid granite	. 1664·574	,, ,, ."

In a later paper, namely the "Report of the Experiments made at Holyhead, North Wales, to ascertain the Transit-Velocity of Waves, analogous to Earthquake Waves, through the local Rock Formations," by command of the Royal Society,[1] he points out that the results given above "produced some surprise on my own part, as well as on that of others, the transit-velocities obtained falling greatly below those which theory might have suggested as possible. . . ." Mallet suggested as the explanation of the low velocities obtained, that the media of the ranges (like all the solids constituting the crust of the earth) were "not in fact united and homogeneous elastic solids, but aggregates of solids more or less shattered, heterogeneous, and discontinuous; and that to the loss of *vis viva*, and of time in the propagation of the waves from surface to surface, was due the extremely low velocities observed." Dr. Jakob Noggerath in 1846, and J. F. Schmidt in 1858, showed the correctness of Mallet's theory, and also of the results of his experiments, by observations of the transit-velocities of natural earthquakes in the superficial formations of the Rhine

[1] John Forbes, *Trans. of Royal Soc. Cornwall*, vol. 2, pp. 159–217, 1822.

[2] R. W. Fox, *Report of the British Association for Advancement of Science*, 1837, pp. 133–137.

[1] *Reports of the British Association for Adv. of Science*, 1861, pp. 201–236.

country of Hungary ; and Mallet himself did so in Southern Italy.

In his earlier paper Mallet suggested the need of extending the experimental determinations of wave-transit to stratified and foliated rocks, and to shattered granites ; and it appeared to him that the operations then in progress in the Government quarries at Holyhead, where large masses of granite were being dislodged by means of gunpowder for harbour construction, would present a favourable opportunity of making some experiments upon the stratified rock formations of the locality. " Instead of the usual method of blasting by means of small charges fired in jumper-holes bored in the rock, occasional explosions of large mines, containing at times as much as nine tons of gunpowder lodged in one or three or more separate foci deep within the surface of this cliff," were effected. The gunpowder, well tamped, was exploded by an " electric current from a powerful Smee's galvanic battery, a small piece of platinum wire adjusted within the charge became heated, and ignited the powder." The shock propagated in all directions outwards as " an elastic wave of impulse, was at an early stage of the operations remarked to be so powerful that it could be felt distinctly in the quaking of the ground at distances of several hundred yards, and was sufficient even to shake down articles of delf ware from the shelves of cottages a long way off from the quarries."

(*To be continued.*)

THE GRAVITY GRADIOMETER

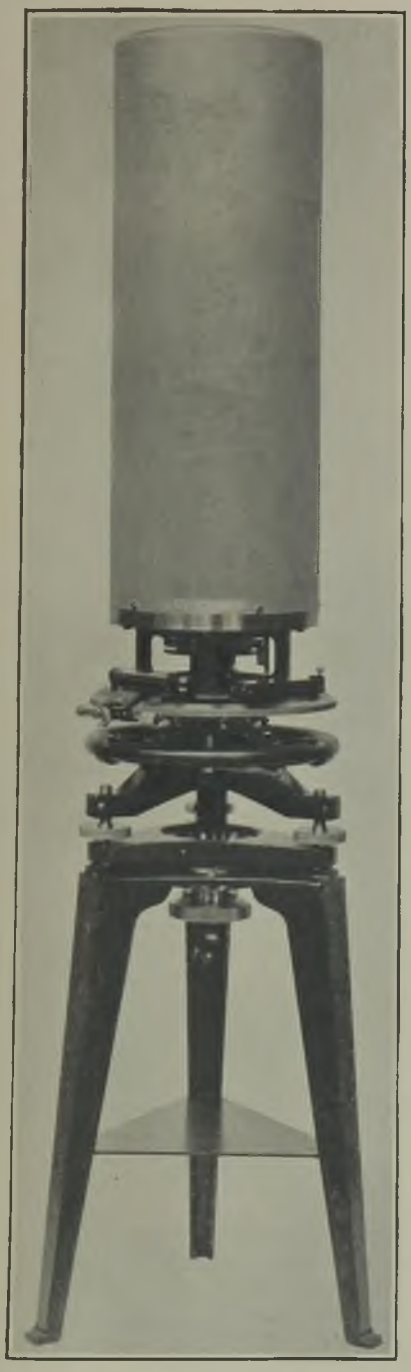
By Captain H. SHAW, M.Sc., and E. LANCASTER-JONES, B.A. (Cantab.)

The authors describe a new design of torsion balance for gravitational surveying and one effecting a great economy of time, labour, and cost.

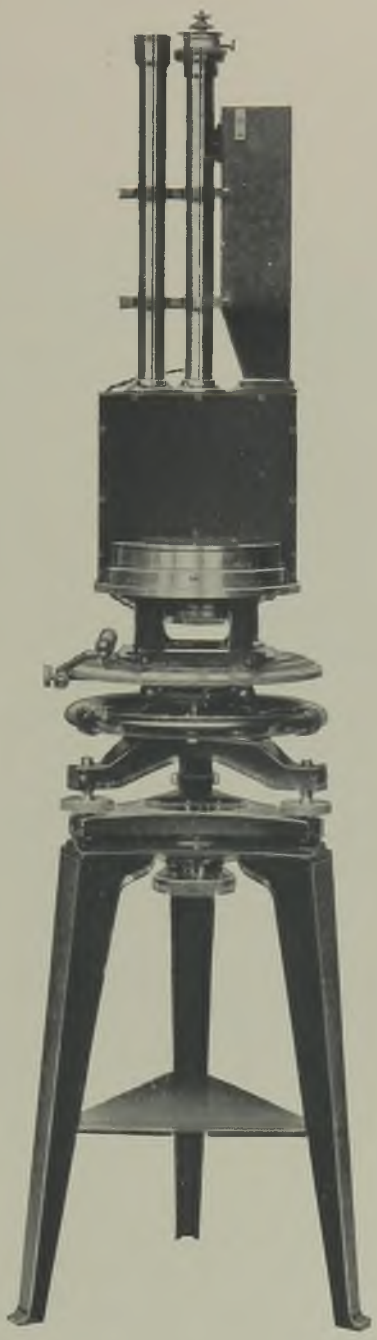
It is now generally recognized that the gravitational method of prospecting has been definitely established as a valuable aid to the mining engineer and geologist in locating and elucidating subterranean structures such as faults, anticlines, synclines, etc., by the success achieved in all the principal oil-producing areas of the world, and in important metalliferous regions. In an article which appeared in The Mining Magazine of April, 1927, the photo-visual type of Eötvös torsion balance was described, and its construction explained. The theory of the instrument and the procedure of operating it in the field were given, while the method of conducting the observations and interpreting the results was also outlined. Experience has shown that only the comparative slowness of the method and the lack of portability of the apparatus have limited its application to regions of fairly simple geological structure and small topographical relief. With the advent of the new design of instrument, of which a brief description is given below, the practical disability under which, owing to bulk and slowness of operation, the torsion balance has hitherto laboured, now disappears, and an extensive field of investigation previously beyond the economic limits of employment of this method of prospecting is opened up.

The Eötvös torsion balance in its usual form measures certain gravity values, from which we are able to determine the direction and magnitude of the " gradient of gravity," and also the " curvature value." Under simple conditions of terrain and topography both of these quantities are capable of furnishing information which is useful in the interpretation of the gravitational anomalies. The occurrence of large surface irregularities however is to some extent obstructional to the use of the curvature quantity, as it renders necessary an excessive amount of levelling and computation, while even after these corrections have been applied the resulting value of the curvature quantity is liable to a considerably larger error than the gravity gradient.

The new instrument, which is a single-beam type, measures the gradients of gravity only, and determines these gradients with an accuracy adequate for all practical purposes. The curvature values of gravity are not measured, the instrument being designed so as to be completely irresponsive to these quantities. It has long been recognized by practical gravity surveying

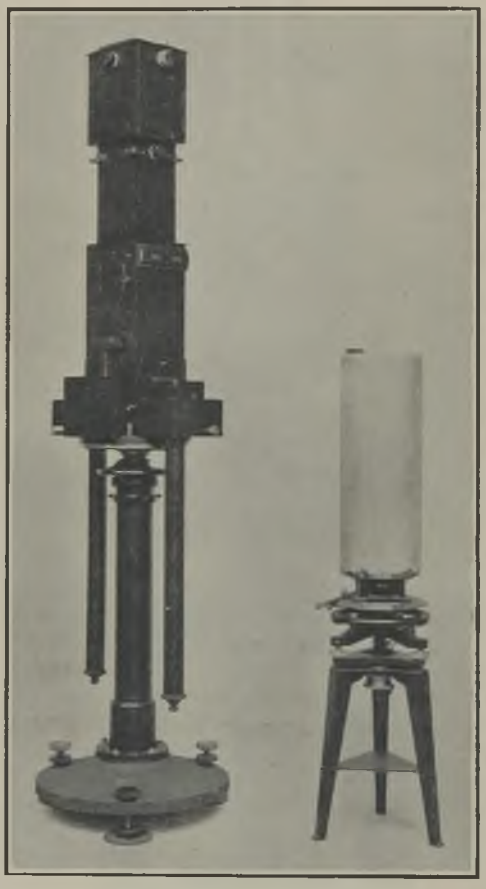


EXTERIOR VIEW OF GRADIOMETER.



GRADIOMETER WITH COVER REMOVED.

experts that the curvature magnitudes measured with the ordinary Eötvös torsion balance are not often employed, their computation and interpretation being possible and justifiable only in specially favourable localities. By ruling these values from consideration, the design of the instrument is rendered more efficient and its operation simplified, for the observations previously necessary for the determination of the curvature value are now eliminated, and it becomes possible to obtain the "gradient" of gravity with a fewer number of instrumental settings.



TORSION BALANCE COMPARED WITH GRADIOMETER.

CARRIED BY HAND.

INSTRUMENTAL DETAILS.—The instrument, when closed up for operation, presents a simple and compact appearance contrasting strikingly with the complicated structure of the ordinary torsion balance. The lower part is a simple tripod stand surmounted by an ordinary tribrach and rotating circle of standard theodolite construction. Above this is the balance proper, completely enclosed in a simple cylindrical metallic cover. On removing this outer cover, the internal protecting cases are revealed. These consist of double walled metallic casings, comprising the beam box with removable lids, the mirror box with removable doors, the central torsion-wire tube and the eccentric tube containing the upper rod and weight, which, in this instrument, replaces the customary lower wire and weight. By adopting the system of a rigid upper rod instead of a flexible lower wire to support one of the masses on the beam, space has been economized and the vital protection of this sensitive part of the apparatus from eddy currents due to

temperature fluctuations, has been rendered simple and effective. In addition, the balance can be mounted in closer proximity to the ground than is possible with the standard type, since the centre of gravity of the suspended system is now well above the beam, instead of about a foot below it, as formerly.

The tube enclosing the upper-rod is balanced by a casing containing the optical

Protecting hut.

system, which is considerably reduced in extent and simplified in arrangement without sensible reduction in efficiency. On opening up the boxes, the suspended system is seen to consist of a circular beam, carrying a number of lower masses, and supporting the upper rod which carries the remaining mass at a height of about 45 cm. above the beam. The radial distance of each mass from the centre of the beam is less than one quarter of that of the standard Eötvös torsion balance, and to compensate for this reduction in dimensions, a specially sensitive wire is employed, having a torsion coefficient less than 0·1 C.G.S. unit. Important consequences of the reduction of the lateral dimensions of the beam system are the gain in symmetry and compactness, and the great increase in speed of operation. The beam is fitted with a special damping device, which brings it to rest in about 20 to 25 minutes, after each change of azimuth.

General Arrangement.—In its new form the instrument consists of a single beam of an entirely new design so arranged as to eliminate the curvature effects completely and to give the gravitational gradient at any station from observations in 3 azimuths, instead of 5 azimuths, which were previously necessary with the single beam instrument. It has been shown theoretically that this desired arrangement can be obtained by any design of beam system in which the masses are so arranged that the $\int(a^2-b^2)dm$ is always equal to zero. A number of experimental beams satisfying these conditions have been tried, including beams having 2 masses, 3 masses, and 4 masses, so disposed as to make the above integral always equal to zero, but the beam system fitted with 3 masses has so far proved

Metal protecting hut.

the simplest and most acceptable arrangement in practice.

With such a beam system the gradient at any station can be obtained from three readings taken in azimuths 120° apart, but in practice it is usually desirable to repeat one or more of these observations so that four or sometimes five readings are usually taken at any station. In cases where

rapidity of operation is of supreme importance an instrument having two beams set with their principal axes at right angles to each other may be employed. In this case each of the beams gives the gradient component in one of two perpendicular directions and these values are obtained theoretically from observations in two azimuth settings of the instrument placed 180° apart. In practice repeat observations are necessary, although in this case one repetition will usually suffice making a total of three observations.

THE SUSPENDED SYSTEM.—The suspended system in this instrument consists essentially

SHOWING SOFT NATURE OF TERRAIN.

of a number of masses arranged in plan at the apices of an equilateral polygon, the simplest case being that of three masses situated at the apices of a triangle. Two of these masses are mounted directly on the beam but the third mass instead of being suspended below the beam by means of a flexible wire as in the standard type of torsion balance is mounted well above the beam by a rigid yet light supporting rod projecting vertically from the beam. The beam thus assumes an L shape or a Y shape according to whether the elevation or plan view is considered. As a result of this modification, it is possible to reduce the vertical dimension of the suspension wire and beam system to one-half of its previous value, with a consequent gain in compactness. The centre of gravity of the mass system is now located at a considerable distance above the beam, instead of well below it as in previous models, so that the instrument may be operated nearer to the ground, without increasing the errors due to terrain and topographical effects. The overall height of the instrument is thus reduced from 6 ft. 3 in. to approximately 4 ft. with consequent gain in rigidity, lightness and portability.

In the normal torsion balance the masses are carried at a distance of 20 cms. from the axis of suspension but in the gravity gradiometer this distance (usually called l) has been reduced to less than one-fourth of this value, as a result of which certain important advantages are obtained. Firstly there is a great increase in the speed of operation due to the reduction of the free period of swing of the suspended system in the ratio of the square roots of these distances. On this account the beam can be brought to rest in a shorter time than is possible with the large instrument, and there is likely to be less disturbing effect from the variation of temperature, in the short interval between observations. Furthermore there is considerable gain in simplicity and symmetry of construction of the instrument, which thus lends itself to easier and more adequate protection against radiation effects, temperature effects, and other disturbing influences. The diameter of the outer protecting cover has been reduced to 7 in. and although the lower portion of the apparatus has a width somewhat greater than this, the instrument has now been reduced to a very convenient and handy size.

The instrument is extremely robust, and capable of standing up to any ordinary treatment in the field, while the weight of the whole instrument, complete with base and tripod is less than 100 lb. The balance proper, with base and tribrach, is quickly detached from the tripod and, as it weighs only 65 lb., can be transported conveniently by one man, without undue effort, for short shifts. For shifts longer than a few hundred yards, a simple form of transport is desirable.

When properly damped, the suspended system is found to come to rest in about 20 minutes so that it is possible to take readings at intervals of 25 minutes, while with a slightly decreased sensitivity it is possible to reduce the observation interval to 20 minutes. Three readings are essential

with the single beam instrument to complete a station, but it is always preferable to take four or even sometimes five readings. In general five settings are ample, so that a total working time of about 2 hours should suffice per station. Allowing 15 minutes for changing stations, it is thus usual to complete a station in well under $2\frac{1}{2}$ hours; when four settings prove sufficient it is possible to reduce this time to 2 hours.

The beam system is protected from extraneous disturbances by a three-walled metal enclosure, while if it is desired, a supplementary outer jacket of insulating material, can be easily fitted. Additional protection is provided by a compact and efficient hut which has been specially designed for use with the instrument, to protect it from solar radiation, wind, etc. This hut is just sufficiently large to permit the observer to move around the instrument and to take visual observations from the inside, while it can be dismantled or re-assembled in under 2 minutes. A still smaller hut is also available which closely surrounds the instrument and permits observations to be taken from the exterior, through a window in the roof of the hut. This hut is very light and convenient, as it weighs only about 90 lb. and can be readily transported.

So far the instrument has only been designed for visual observation, for, now that the period of observation has been so greatly reduced, it is doubtful whether much advantage would be gained by fitting up the instrument for automatic rotation and photographic recording, but should this be required, there will be little difficulty in doing so. Observations can be taken by day and night, and no difficulty has been experienced in taking observations on a normal summer day.

As its more massive portions are near the base, the instrument is extremely stable; the reading remains particularly steady during observation, and only on very exceptional occasions does any vibration occur, while the risk of disturbance of the suspended system due to the approach of the observer or passing vehicles is reduced to a minimum. The suspended beam is also so closely confined within its chamber that risk of breakage of the torsion wire is very small, and the instrument will stand up to heavy usage without damage.

On account of its small size and its rapid speed of operation the gradiometer is admirably adapted for use in confined spaces such as underground mine galleries which have hitherto been regarded as unsuitable on account of their inaccessibility, or in places which are only accessible for short periods, such as tidal areas. In fact the instrument can be transported and used wherever a normal precise theodolite could be used.

One of the most important features of the instrument is the torsion wire, which is of special form, and although it has a tensile strength at least equal to that of wires used in the standard form of torsion balance, it is approximately 10 times as sensitive to torsional forces. It is prepared by taking a wire 0·04 mm. diameter and rolling it into the form of a ribbon, a process which increases the torsional sensitivity very greatly, while the tensile strength remains unchanged. The preparation of these wires requires great care, and only a small percentage of those which are prepared are eventually found to be suitable for use in the instrument, after they have passed through the process of "ageing."

Damping and Arresting Devices.—In order that the beam, when disturbed by a change of azimuth, may be brought to rest within the requisite period of 20 or 25 minutes, it must be strongly damped—almost to the critical point—when the oscillations become nearly aperiodic. To effect this damping, a special form of adjustable damping has been introduced which has proved entirely satisfactory. With this new arrangement adequate damping is obtained with ample clearance between the beam and the surrounding walls, while even the minimum amount of damping available suffices to bring the beam to rest in 30 minutes, so that no great skill on the part of the observer is necessary to make the necessary adjustment to ensure efficient damping with absolute freedom from risk of contact during the oscillations. The damping is rendered adjustable by the movement of the base of the beam box which may be raised or lowered by an elevating screw, the graduations of which correspond to a change of elevation of the platform of one-thousandth of an inch. This platform may be raised sufficiently to come into contact with the undersurface of the beam and so take the load from the torsion wire, while a further elevation serves to clamp the beam up against the roof of the beam box so that it is held rigidly in position and may be transported with safety. An additional arresting device is fitted at the

upper end of the tube surrounding the upper mass. By a half rotation of the cap of this tube (which may be operated from the outside of the instrument cover) a clamp is brought into action, locking the upper mass in position, and thus protecting it from damage or disturbance due to vibrations experienced during transport. Special stops are provided to restrict the amplitude of swing of the beam system to a suitable amount, thus assisting the beam to come to rest at the earliest possible moment. The length of the torsion wire is about 30 cms. so that the torsion tube and the tube surrounding the upper weight are of approximately the same length thus giving a reasonably compact design. With a torsion wire of this length the sensitivity of the instrument to gravitational gradients is somewhat greater than one-half of that of the standard type of instrument, a sensitivity which is regarded as adequate for all practical purposes and enables gradient determinations to be made with an accuracy not less than that with which the terrain and other corrections can be calculated in practice.

Field Work with the Gradiometer.—The area selected for the first field tests with this instrument was a sandy foreshore, which was totally submerged by the tide twice daily, and many of the stations that were occupied were only available for a few hours between tides. Hence only a rapidly operating and readily transportable instrument could be worked economically in this region. The nature of the ground surface, which was rather clayey sand, hard enough in some parts, but slimy and treacherous in others, provided an admirable test of the stability and rigidity of the instrument. As a result of an extensive series of tests the gradiometer was proved to possess stability to an extent which we had not anticipated, while the tests have also demonstrated that it is a thoroughly robust design, requiring only the minimum of attention to maintain it in efficient working order.

As compared with the standard Eötvös balance, the beam system is more delicately balanced but shows no tendency to get out of adjustment once it is properly adjusted. In general, during this series of tests the operations were conducted only during the day-time, when it was easily possible to complete five or six stations per day. In one continuous test, eleven stations were actually occupied and observed in twenty-four hours, and extending the test to 36 hours enabled seventeen stations to be completed, giving an average of a little over 2 hours per station. In many of the slimy and muddy parts of the shore area surveyed, it proved desirable to employ small pickets to support the base on which the instrument rests, since the sand was, for the most part, softened by the admixture of clay, giving a yielding, rather elastic bed. In spite of this it was not found necessary to take any special precautions to ensure stability of the instrument. When taking readings the observer merely exercised ordinary care in entering the protecting hut and approaching the instrument. Occasionally, in the very clayey ground, as also in a swampy area adjoining, his approach would set the beam system quivering slightly, but no difficulty was experienced in reading the definite equilibrium position of the scale, and no case was recorded of the instrument moving out of its level position. Over a test survey of several hundreds of stations the reliability of the balance proved to be extremely good, and the gradients could on the average be considered accurate to within 1·5 Eötvös units. Only in exceptional cases did the probable error exceed 2 Eötvös units.

Summary of Advantages.—The advantage resulting from the increased portability and speed of operation evident by the characteristics of the new instrument specified in the foregoing review, may be summarized as follows:—The instrument can be employed with economy on any survey where the larger type of balance is used. The new type can be used to gain rapidly a general idea of the distribution of gravity in the whole area under investigation, whilst the larger type may be employed to focus upon selected localities which are revealed by the reconnaissance with the smaller instrument. One of the chief difficulties in torsion balance surveying is the detection and elimination of local disturbing affects due to shallow deposits in the neighbourhood of a station. The new balance may advantageously be used for this purpose. In particular, regions characterized by glacial overburdens, hitherto considered an insuperable obstacle to efficient gravity surveying, need no longer be regarded in this light. A close network of stations is quite an economical proposition for an instrument of the new type, and by averaging the values at neighbouring groups of stations

the irregularities due to hidden boulders, etc., may be eliminated. Regions of fairly pronounced topographical relief are no longer barred to gravity surveying, since the effect of neighbouring topography on gravity gradients is rarely excessive and as an extra precaution, the number of stations can be increased in difficult areas. The new balance can be employed in sites where for any reason the time or space available is limited, for example in mine galleries where interruption of the normal working routine is undesirable for any great length of time, and space is limited. Another instance is a region which is covered by the tide for many hours of each day. An instrument of the new design has actually been employed on sites which were only uncovered by the tide for some two and a half to three hours per tide.

KILLIFRETH MINE, CORNWALL

By ERNEST R. BAWDEN, M.I.Min.E., Assoc. Inst.M.M.

The author describes one of the county derelicts which he considers is worthy of resuscitation.

Killifreth Mine is situated in the parish of Kenwyn in the county of Cornwall. It is approximately 6 miles west of Truro and 2 miles east of Redruth. It is bounded on the north by Great Wheal Busy Mine, on the south by Wheal Unity Wood Mine, on the west by the boundary between the parishes of Gwennap and Kenwyn, and on the east it is bounded by a line passing through the west end of the village of Chacewater.

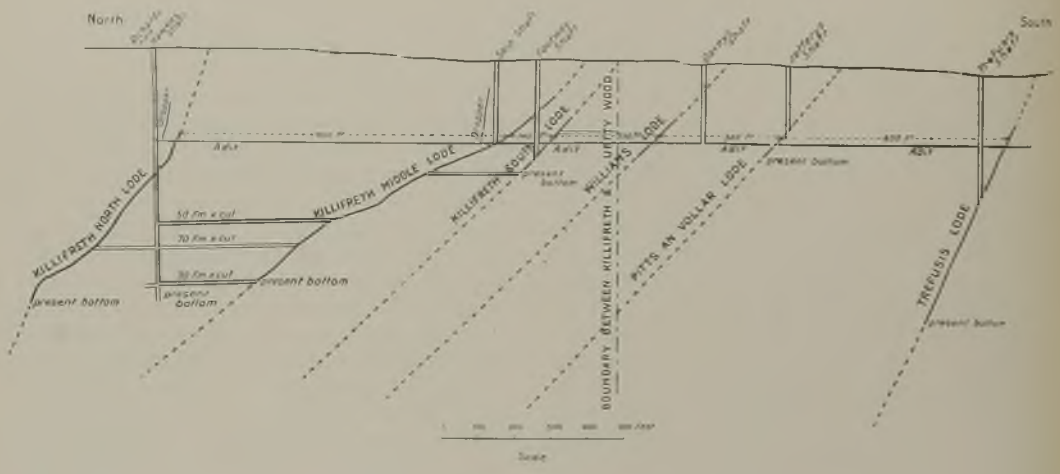
HISTORY.—A map dated 1828 shows the area now known as Killifreth Mine divided into smaller areas or tin bounds. They were West Good Fortune Tin Bounds, Good Fortune Tin Bounds, Lane Tin Bounds, Wood Tin Bounds, Wheal Fat Mine, and Wheal Union Mine. At some time between 1828 and 1860 Killifreth Mine was worked for copper but apparently did not develop into much of a copper producing property. In 1864 it was re-opened by a Cost Book company, who, according to J. H. Collins mined ore from which 4,060 tons of black tin were sold for over £190,000, besides the ores of copper and arsenic. This company mined and milled ore having a general average assay value of 47 lb. of black tin to the ton. Excepting one quarter's crushing of a grade of 30 lb. of black tin to the ton, which was the lowest grade ever mined or crushed in its history, the lowest monthly average was 38 lb., the highest monthly average being 56 lb. During the last six months this Company worked the mine, the average grade of ore sent to the mill assayed 42 lb. of black tin to the ton. It is of interest to observe that during these last few months of working some rich pillars were mined. [On opening the mine in 1918 the author found the grade of ore to be 39 lb., this being the average value of the ore sent to the mill at that time.] This mine had to be abandoned in 1897 as a consequence partly of a policy of extensive development which proved beyond the financial resources of the adventurers, and partly because of the failure to make a satisfactory conversion of the undertaking into a limited liability company.

In October, 1912, a company was registered having a capital of £100,000, of this amount £60,000 was paid in shares as purchase consideration leaving £40,000 as working capital. On the outbreak of the Great War mining operations were suspended until October, 1918, when pumping operations were resumed. The mine was then drained to the 70 fm. level and closely sampled. The old stope faces as left by the former proprietors in 1897 were re-worked, 3,000 tons of ore were hoisted by a small improvised hoist and sent to the mill, which gave a milling result of 39 lb. of black tin to the ton. No ore was mined at this time below the 40 fm. level for the reason that the main hoist was not in commission to deal with it. Towards the end of 1920 the price of tin had fallen considerably, while the price of arsenic had risen very high indeed. It was decided therefore to acquire the Great Wheal Busy Mine and to work it for arsenic.

Pumping operations on Killifreth were accordingly suspended and all future efforts were concentrated on the production of arsenic from Great Wheal Busy Mine and the capital of the Company was increased to deal with this added area.

Ore Bearing Zone.—The geological formation is composed of sedimentary rocks belonging to the Falmouth and Mylor Series. These overlie the granite which in the western part of Killifreth lies at a depth of approximately 1,200 ft. from surface. The junction of the sedimentary series and the granite has been observed in Ting Tang, East Wheal Damsel, Wheal Jewell, Wheal Unity Wood, Poldice and Treskerby Mines. In Killifreth at the 40 fm. level west of the Middle lode there is unmistakeable evidence of the proximity of the granite. This formation is traversed by felspar porphyry dykes (locally termed "elvans") which, together with the cross-courses are nearly always associated with the deposition of cassiterite in enriched zones along the contact of the tin lodes and cross-courses. This applies also to copper. It has been observed in the district under consideration that without the accompanying elvans and cross-courses the lodes are not as productive. Also, if a lode passes through the elvan in the direction of its dip the under portion of the lode has seldom been profitable. It will be seen that Killifreth is situated in a metamorphic aureole in which have been discovered and worked some of the richest deposits in Cornwall. In all the mines of the locality the ore deposits occur at and above the junction of the granite with the Mylor series. This junction is deeper towards the east than it is in the western parts of the mines, which explains why, Poldice, West Poldice, Consolidated and United Mines are worked deeper towards their centre and eastern ends.

Four main lodes traverse the property. They are Main or North lode, Wheal Vor lode, Middle lode, and the South lode. There are two cross-courses having a northerly direction and a dip east of 80 degrees. Most of the cross-courses and flucans in the district dip east. These cross-courses heave the lodes a distance of from one to twelve feet. In Killifreth they heave the lodes to the left. The cross-courses are composed of slatey clay and granular quartz; sometimes they contain small quantities of minerals not common to the district. The author has obtained specimens of cobaltine from the main cross-course at the adit level on the Middle lode. The walls of the cross-courses exhibit the usual evidence of movement. There are two elvans known respectively as the North and South elvan. They have a strike of nearly due east and west, they dip north at an angle of 40 to 50°. On the surface and in Higgins crosscut the outcrops of these elvans have in places decomposed into a good fireclay. Other elvans in the neighbourhood have similarly



Rough transverse section through Richards (now Hawkes) and Trefusis Shafts.

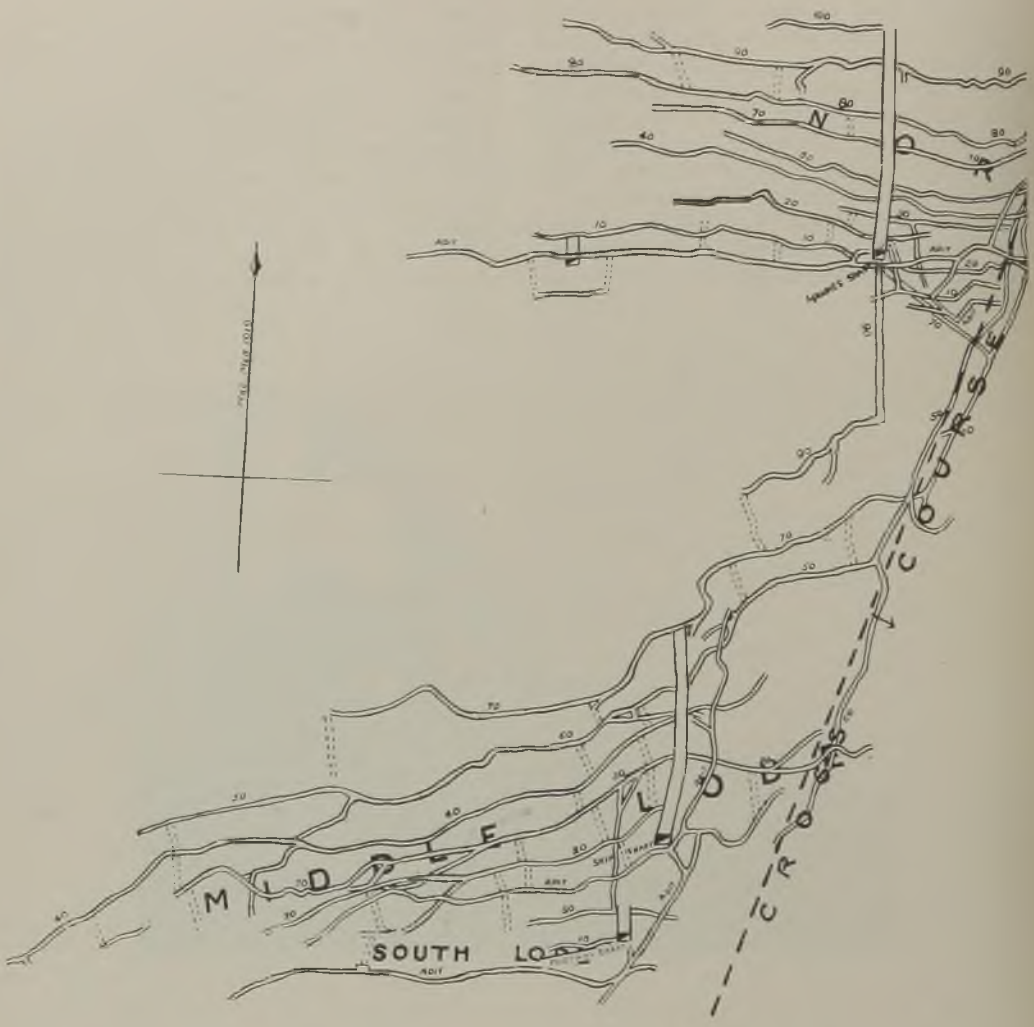
decomposed and have been quarried for fireclay, while others have in places been worked for road metal.

North or Main Lode.—This is the most important lode traversing the property. It has a strike of 77° north-west and dips north at an angle of 50°. It has been worked extensively from the adit to the 70 fm. level, and below the 70 fm. level to the 90 fm. level on the ore course at Hawkes shaft. Three main productive courses of ore have been discovered and worked. The first and most westerly is that at Hawkes shaft, which is the resulting enrichment at the point of intersection of the lode by the main cross-course. The middle course of ore is around the junction of the lode with Wheal Vor lode. The third and most easterly course of ore is at Tregonings shaft and is the enrichment resulting from the junction of the lode with what the author considers is the Middle lode. East in virgin ground a cross-course is known to exist, which in Great Wheal Busy and Creegbrawse Mines favourably influenced the lodes. It is an interesting speculation as to whether it favourably affects the Killifreth lodes and thus afford another illustration of the miners' dictum "ore against ore." The old pumping plant on the engine shaft was not equal to its task. Hawkes pumping plant could not deal with the water below the 70 fm. level on this lode, though it could do so on the 90 fm. level Middle lode. Therefore the bottom levels on the Main lode were under water which prevented working the ore courses in the bottom levels and also further sinking. The Company were crosscutting towards the lode at the 100 fm. level crosscut with the object of draining the water via Hawkes shaft and also to work the ground already blocked out. The failure to do this proved in time a contributory cause of the Company's failure.

Headgear, pumping engine, and winder at Hawkes shaft as at present.

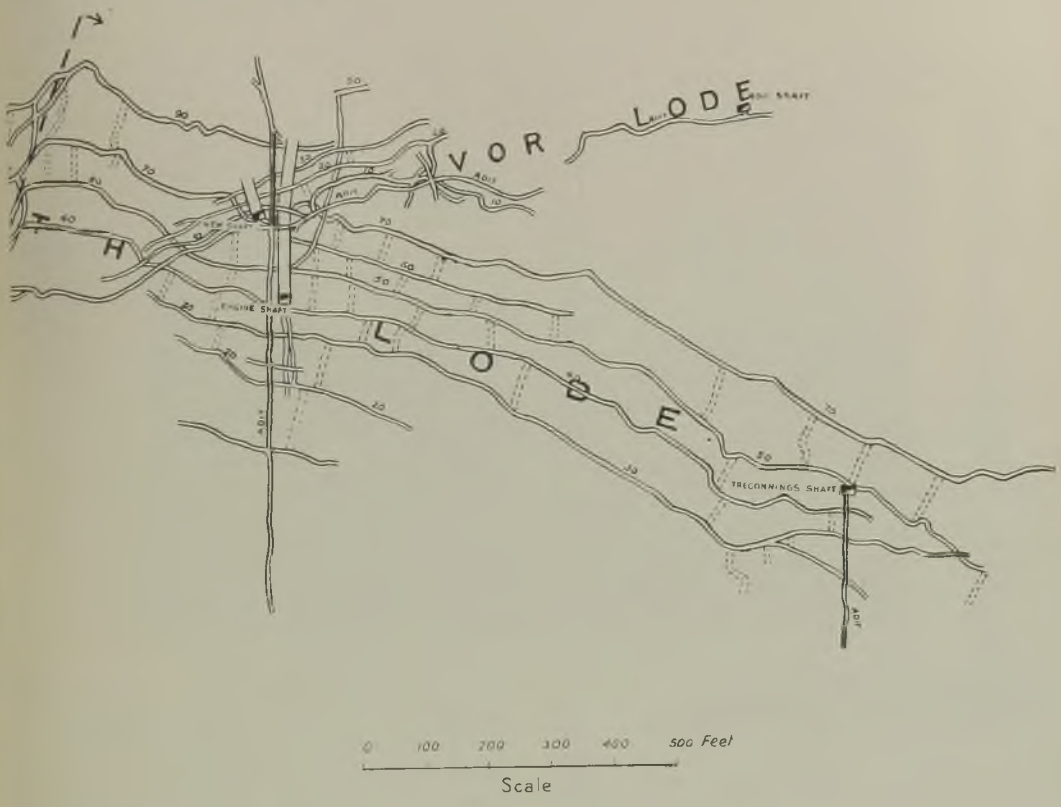
Middle Lode.—This lode is south of the North lode. It strikes 77° N.E. and dips N. 33°. It has not been worked east of the main cross-course. Insufficient crosscutting has been done to locate it eastwards of this fault, between which and Tregonings shaft there is a length of unexplored ground which deserves further prospecting at or above the adit level, in case it cannot be carried out at a deeper level. At the 70 fm. level the drive

PLAN OF THE UNDERGROUND

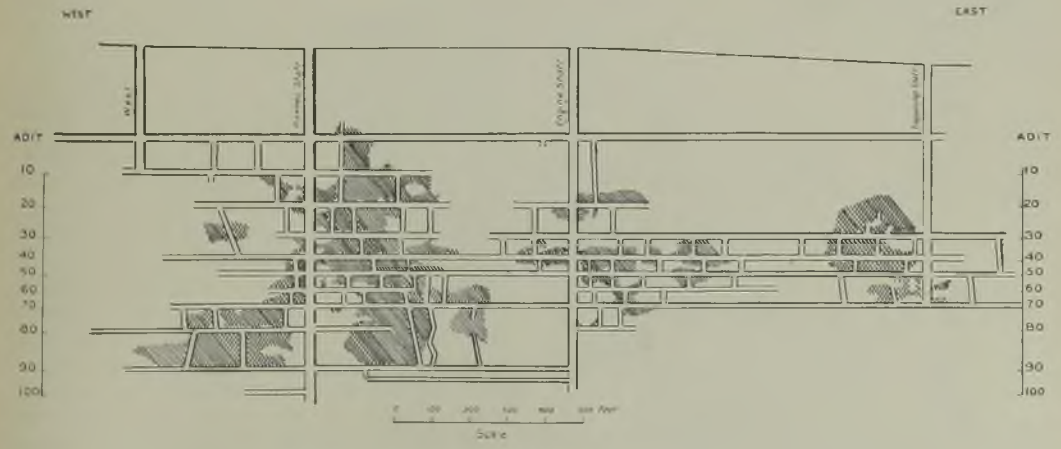


west has entered the elvan; by continuing the drive the lode will again be picked up. The lode at the 50 fm. level in the vicinity of the Skip shaft has been disturbed and split by the elvans. But westward it forms again and the level has for a considerable distance been driven on a strong lode carrying very good values. At the 30 and 40 fm. levels and in the extreme west of the mine the lode has entered a greenstone. On passing into the greenstone the lode shows a tendency to break up into numerous stringers of pure cassiterite. The well-defined character of the lodes and walls disappears. The nature of the occurrence of the cassiterite is such that on mining the soft tinstone breaks down into fines enabling the larger and harder portions of waste to be separated and packed into stulls. The present face of the 40 level is within 200 or 300 ft. of the western boundary. The lode should form a junction with the Main lode in depth at a point 90 fm. below the present bottom of Hawkes shaft. It has been worked extensively westward on the 20, 30, 40, and 50 fm. levels. For a distance of 600 ft. west from the main cross-course, the cassiterite is not associated with wolfram, beyond this point wolfram makes its appearance in appreciable quantities. Molybdenite occurs as a

Workings Killifreth Mine.



mineralogical specimen, but not in sufficient quantities to regard it as of commercial value. The lode which varies in extreme cases from 1 to 12 ft. wide, but normally is about 4 to 5 ft. wide, exhibits very erratic values. One pillar left in position by the former proprietors assayed 1,080 lb. of SnO_2 to the ton; naturally they left a very small pillar. Another pillar assayed 39 lb. to the ton. The accompanying table giving particulars of sampling serves to illustrate the patchy nature of the lode.



Longitudinal section North lode.

Location.	*Width.* ft.	in.	*Value.* lb. SnO_2 per ton.
40 *fm. Level West.*			
45 ft. west of No. 9 rise	2	6	79
48 ,, ,, ,,	2	0	77
51 ,, ,, ,,	2	0	28
54 ,, ,, ,,	2	0	21
57 ,, ,, ,,	3	3	114
60 ,, ,, ,,	2	0	56
63 ,, ,, ,,	2	0	224
66 ,, ,, ,,	2	6	84
69 ,, ,, ,,	2	0	420
72 ,, ,, ,,	2	0	152
75 ,, ,, ,,	4	0	88
80 ,, ,, ,,	Record missing.		
85 ,, ,, ,,	3	6	64
100 ,, ,, ,,	4	0	23
103 ,, ,, ,,	3	0	16
20 *fm. Level West.*			
7 ft. west of rise.	3	0	7
10 ,, ,,	3	0	14
13 ,, ,,	3	0	2
16 ,, ,,	3	0	2
19 ,, ,,	3	0	7
22 ,, ,,	2	6	Trace.
50 *fm. Level West.*			
Samples taken at 3 ft. intervals.			
	3	6	47
	3	6	56
	3	6	60
	4	0	132
	4	0	33
	4	0	18
	4	0	28
	4	0	20
	4	0	49
	4	0	42
30 *fm. Level east of Skip shaft.* No. 1 Winze		6	6½
3 ft. down	1	0	42
6 ,, ,,	1	0	102½
9 ,, ,,	1	0	98
12 ,, ,,	1	6	182
15 ,, ,,	1	6	107
18 ,, ,,	1	3	9
Adit level crosscut.			
0 ft.	4	6	10
5 ,, East	4	0	23
10 ,, ,,	2	0	5
15 ,, ,,	1	0	3
20 ,, ,,	2	0	3
25 ,, ,,	1	6	5
5 ,, West	1	0	30
10 ,, ,,	2	6	5

The lode in places had to be worked on the tribute system. One particular case may be cited as an illustration. Eight men were put stoping between the 30 and 40 fm. levels on contract, the average of the ore broken by them assaying 9 lb. SnO_2 per ton, and no foot or hanging wall rock was mined. It was decided to let the stope on tribute to the men, paying a standard price of £85 per ton for black tin, and a tribute of 10s. in the £, out of which the men paid the cost of materials. Under this system the ground produced from 2½ to 3 tons of black tin every four weeks; by any other system this particular stope could not be mined profitably. The tributors mined the waste first, leaving the richer portion standing which was subsequently broken down very carefully on bags, which had been previously laid on the floor. Discontinuous as the lode undoubtedly is, these small patches occur with sufficient regularity to enable a fairly uniform grade of ore to be mined and milled. The old Cost Book company usually mined 7,000 tons per quarter, their working costs being in the neighbourhood of 13s. per ton, which costs include every conceivable item. In latter years the whole of the production came from the Middle lode.

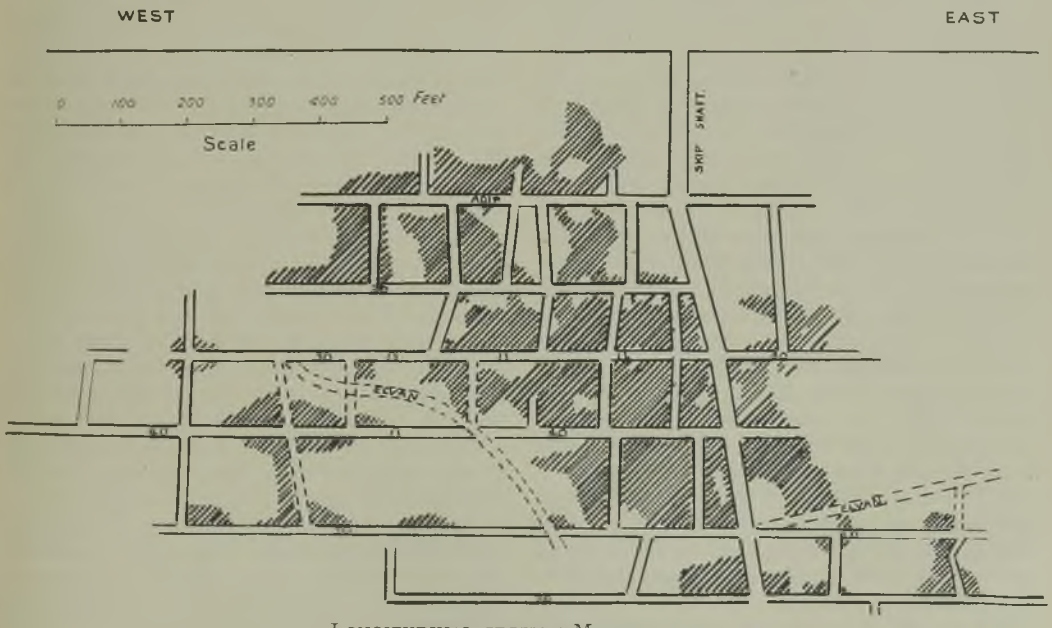
South Lode.—This lode is south of the Middle lode and at the adit is distant 140 ft. A good deal of stoping has been done around the adit by the earliest miners. The lode is about 4 to 6 ft. wide, and easily mined. Its value is low, running about 7 to 14 lb. of tin to the ton. This lode has not been tested by crosscuts from the levels below the 50 fm.

Hawkes shaft, also known as Richards shaft.—Hawkes shaft is the main shaft of the property. It is 12 ft. by 6 ft. 6 in. within timbers. It is vertical to the 100 fm. level below adit. It was originally a compound shaft following the dip of the lode from the 20 fm. level at which depth the shaft intersected the lode. The shaft is equipped with an 18 in. diameter Cornish pump having one pole set at the adit and another 50 fm. below the adit. The bucket lift which drained the mine to the 70 was withdrawn when pumping ceased. This pump is driven by an 80 in. Cornish pumping engine having a 10 ft. stroke in the cylinder and a 9 ft. stroke in the shaft. It is capable of dealing with 750 gallons of water per minute, easily and cheaply. The coming water in the mine is approximately 350 gallons per minute. The vertical shaft is connected to the Main lode at the adit, 20 and 70 fm. levels, and to the Middle lode workings on the 70 and 90 fm. levels by means of crosscuts. The incline

TREFUSIS SHAFT IN THE WHEAL UNITY WOOD SECTION, WHICH GIVES ACCESS TO A BRANCH OF THE ADIT WHICH DRAINS THE LODES SOUTH OF AND INCLUDING THE MIDDLE LODE TO A DEPTH OF APPROXIMATELY 36 FATHOMS FROM SURFACE, ACCORDING TO THE CONFIGURATION OF THE COUNTRY.

portion is connected to all levels on the Main lode and to the Middle lode by the 50 and 70 fm. level crosscuts.

The bottom crosscut (N) to the Main lode has not been driven the necessary distance to effect communication between the vertical



LONGITUDINAL SECTION MIDDLE LODE.

shaft and lower workings. All stopes on the Main lode down to the 70 fm. level are filled with waste rock, and the levels are narrow, tortuous, and low, being quite unsuited for trucking purposes, and having no doubt been driven when wheelbarrows were in vogue. The engine shaft is a compound shaft badly out of line and useless for hoisting purposes in its present state. Tregonings is a good but small shaft.

On the Middle lode the stopes are open and the levels are in good condition suitable for modern requirements. The Skip shaft is a compound shaft, faulty in alignment, and partially caved, it cannot again be used as a shaft beyond the adit level. Footway shaft is a compound shaft to the 30 fm. level on the South lode, and communicated to the Middle lode by means of a crosscut. This shaft is suitable as a footway but not for hoisting.

Situated between Great Wheal Busy Mine which has been worked to a depth of 1,320 ft. below adit (adit being 240 ft. from surface) and Poldice worked to a depth of 1,260 ft. below adit, Killifreth's deepest workings of 600 ft. below adit seem shallow in comparison. The greater part of this area is undeveloped as may be seen by the accompanying plans. Up to the time of writing no level has been driven to boundary on any of the lodes. Williams lode in Unity Wood Mine dips into Killifreth at a shallow depth. The Unity Wood and Killifreth lodes converge eastwards and should form a junction near Chacewater. For stretches of several thousand feet these lodes stand intact from surface, they can easily be prospected. The future of mining in this district depends upon the discovery of profitable deposits of tin in the unworked ground situated at or near the junction of the sedimentary rocks with the granite. Without the necessity of pumping any water there are several lodes traversing the area under consideration which at a depth of 240 ft. can be developed by levels and crosscuts.

A REVIEW OF THE CONTINENTAL DRIFT HYPOTHESIS

By ARTHUR HOLMES, D.Sc., A.R.C.S., F.G.S.
Professor of Geology, The University, Durham.

The author discusses the Wegener hypotheses and some possible causes of continental drift.

(*Continued from April issue, page* 209)

It may be objected that in the north the Hercynian tin ores of Cornwall are not repeated in the Appalachians. But here a little reflection shows that the apparent exception is hardly one for surprise. The Caledonian ranges are everywhere practically devoid of tin, and if the earlier Palæozoic magmatic activity failed to concentrate the element, then a later Hercynian reworking of the same belt could hardly be more successful. Tin occurs in Europe where the Hercynian ranges stand alone, but as soon as the older mountains are crossed it is found no more. The case of pitchblende provides a contrasted example. The Hercynian pitchblendes of Joachimstal and St. Ives are mirrored across the Atlantic by the uraninites of Connecticut and the Carolinas. But the uraninites of Connecticut are of two different ages, one corresponding to the Hercynian of Cornwall and the other to an earlier, probably Lower Devonian, period of ore-genesis.

Where ranges approach and cross, it is not to be expected that the later tectonic structures and magmatic accompaniments will be exactly of the same age, type or composition as those found well away from the earlier site of orogenesis. Moreover, the earlier structures will necessarily be strongly modified by the passage across them of a second earth storm. These reflections are occasioned by Krenkel's recent declaration that the mountain systems of South America and South Africa differ both in tectonic arrangement and age (9). The detailed reply to this criticism may safely be left to du Toit, but it may be pointed out that for still another reason the criticism cannot be fatal to the drift hypothesis, for successive stretches of the Alpine-Himalayan system differ in structure and age just as widely and yet are visibly continuous.

Among radioactive minerals possibly the most significant coincidence of occurrence is displayed by thorianite. The name immediately suggests Ceylon, and according to Wegener's reconstruction of Gondwanaland,

Ceylon formerly lay to the east of Madagascar. Thorianite, as it happens, is known to occur only in Ceylon and in one other place. That place is Madagascar! If Fig. 1 is to be believed in principle then some day the mineral may also turn up in Western Australia and Antarctica.

Crustal Structure and Isostasy.—In Professor J. W. Gregory's contribution to the Symposium (**1**) he does not positively object to the drift hypothesis, but he maintains his long-held opinion that the main cause of the present distribution of land and sea is to be found in uplifts and subsidences due to the shrinking of the earth, the latter process being only in part a consequence of cooling. This is, of course, the view of the older orthodox geology, and it should be clearly realized that those who hold it must be prepared to face geophysical difficulties just as serious as any with which the advocates of continental drift can be confronted.

The comparative study of seismograms, and especially the outstanding work of Dr. Harold Jeffreys in this difficult field (**10**), has shown that in addition to the veneer of sediments over the continents there are three layers to be considered in connection with the propagation of earthquake waves beneath the continents. These are :—

(*a*) *The upper layer*, identified with granite and gneiss, and having a normal thickness of about 10 km.

(*b*) *The intermediate layer*, having a normal thickness of about 20 km. or a little more. Jeffreys cautiously favours an identification with tachylyte, a suggestion which I have adversely criticised, pointing out that quartz-diorite or diorite would be equally consistent with the seismic wave velocities (**11**).

(*c*) *The lower layer*, or *substratum*, continuing downwards with no important break to a depth of 2,900 km. It forms by far the greater part of the shell of the earth (surrounding a probably metallic core) and it is everywhere present beneath the higher layers of both continental and oceanic regions. Its nature is in doubt. It has been regarded, by different authors, as crystalline or glassy dunite, or as eclogite passing down into peridotite. It may be added that it is probably for the most part in a glassy state ; that its temperature is such that although it is rigid, it is devoid of permanent strength except possibly near the top ; and that it is and has been the main source of basic and ultrabasic magmas, including the plateau basalts.

Observations on the Pacific floor are few, but they are consistent with the presence of an outer layer of gabbro. A recent analysis of data made by Hiller (**12**) gives for certain surface waves the following velocities : 3.69 km./sec. through the Pacific floor ; 2.87 through Eurasia ; and 3.58 through the Atlantic floor. In the Atlantic swell the velocity is 2.9, but elsewhere the Atlantic floor is clearly far from continental. The supposedly sunken lands are not there, except for a thinned-out layer of sial that is probably very variable in thickness, reaching its maximum in the central swell. Yet now there is undoubtedly ocean floor where once there was land, and the former sial of that area must still exist somewhere.

The physical conditions that would bring this picture into harmony with the view that the Atlantic has been formed by inbreaking involve : (*a*) An increase in density of the former sial from 2.7 to 3 (in round figures) in order that it could sink in accordance with isostasy ; and (*b*) a change of mineral facies to one which would act towards seismic waves nearly as gabbro would do—these changes not affecting the adjacent lands.

We know of no kind of process, metamorphic or otherwise, that could lead to such results. The alleged tachylyte layer of Jeffreys could do a good deal in this direction by crystallizing in the heavy eclogite facies, but as the seismic evidence for the Atlantic speaks for the presence there of a floor of gabbro, a solution on these lines appears to be ruled out. Moreover the association of island volcanoes and plateau basalts with the formation of the Atlantic and Indian oceans suggests deep-seated conditions of fusion rather than of crystallization.

There is, however, one process by which continental sinking could be brought about. This involves removal of the intermediate layer and of much of the granitic layer by magmatic currents initiated in the still deeper substratum. A kind of magmatic denudation acting on the lower surface of the former continent is visualized, the material being sufficiently fused or otherwise capable of flow to be transported partly under America and partly under Europe or Africa. To a limited degree this may be a genuine process, especially in generating geosynclines ; but by itself, it leaves all the collateral problems of mountain-building and climatic changes unsolved. Moreover, if it be a real

method of sinking former continents, then it implies a process capable of stretching and transporting the continents themselves. Van der Gracht (1) hints at this when he asks, "Is not possibly the whole process [of continental drift] more similar to ice floating on flowing water than to a raft sailing over a currentless pool?" Apart from this, and a suggestion by the same author of "a plastic outflow of the interior continental masses toward their margins," the possibilities arising from currents in the substratum appear to have been entirely overlooked during the Symposium.

(To be continued.)

REFERENCES.

(9) E. KRENKEL. *Geologie Afrikas*, vol. ii, Berlin, 1928.
(10) H. JEFFREYS. See various papers in Vol. I of the Geophysical Supplement of the Monthly Notices of the Royal Astronomical Society; and particularly the forthcoming second edition of *The Earth*, Cambridge.
(11) A. HOLMES. "The Structure of the Continents." *Nature*, Oct. 23, 1926, p. 586.
(12) W. HILLER. "Über die Geschwindigkeit der seismischen Oberflachen wellen." Gerlands *Beiträge z. Geophysik*, vol. xvii, 1927, p. 279.

LETTER TO THE EDITOR

The F.M.S. Chamber of Mines

The Editor:

SIR—The attention of the Council of this Chamber has been drawn to a statement in the January issue of your Magazine (page 4) that "Malaya is entirely lacking in cohesion among mining men" and that there is no society devoted to mining.

I am instructed to correct this statement and to inform you that close co-operation exists amongst mining men in Malaya, both European and Chinese. The interests of the industry are well cared for by this Chamber in the East and by the Malayan Chamber of Mines in London.

I would add that the Perak Chamber of Mines was founded in 1907 and incorporated as the F.M.S. Chamber of Mines in 1914, and that its present membership is 69 companies and 225 individual members.

A copy of the Year Book for 1927 is being forwarded under separate cover.

Yours faithfully,

A. C. J. TOWERS,
Secretary,
F.M.S. Chamber of Mines.

Ipoh, Perak, F.M.S.
March 9.

BOOK REVIEWS

An Introduction to the Study of Ore Deposits. By F. H. HATCH, O.B.E., Ph.D. Cloth, octavo, 117 pages + 31 figures. Price 7s. 6d. London: George Allen and Unwin, Ltd.

Dr. Hatch is well known as a successful author of text-books which, while elementary, are nevertheless accurate and reliable. Short books on big subjects are far more difficult to write than those who have never tried their hand may imagine. Dr. Hatch has the admirable knack, invaluable to students, of summarizing a subject with a masterly sense of proportion, and of stimulating an interest which leads many of his readers to more detailed studies. Once again, by writing this short treatise, he has laid students of geology and mining under a debt of gratitude.

The book is based on a course of lectures given at Cambridge some years ago—now suitably revised in accordance with modern views and instances—and on a Presidential Address dealing with theories of ore-deposition given in 1912 to the Institution of Mining and Metallurgy. An historical summary of theories of ore-genesis is followed by a general survey of the nature and classification of deposits. Successive chapters then deal with ore formation by differentiation in basic magmas; by gaseous emanations from granitic magmas; by gaseous emanations connected with volcanic eruptions; by thermal waters; by mechanical agencies; and by chemical precipitation in seas, lakes, and swamps. Finally the forms of ore deposits are simply but effectively discussed.

A detailed series of references is given to the sources of information on which the first—historical—chapter is based. Thereafter references are few, and most of these are to old papers which Dr. Hatch probably thinks should not be overlooked or forgotten. One is tempted to suggest that references to recent work might have been preferable, but, so vast is the modern literature, that it would be difficult to know where to stop if this field were seriously invaded. The same comment confronts almost every suggestion of criticism; the book could be improved only by its indefinite extension, and that would, of course, destroy the particular virtues of its unique individuality. Only in one particular would I suggest a slight addition: The diamond might receive a paragraph or two. It is at present given

two words only, one of which is in the index. But the answer to this might quite well be that diamond is not an ore.

The book is well printed and clearly illustrated, and it is a pleasure to recommend it cordially to all who are beginning the study of ore deposits and their genesis.

ARTHUR HOLMES.

Geology of Gold. (South Africa, Australia, New Zealand.) 1929. By E. J. DUNN. Cloth, octavo, 303 pages and 82 plates. Price 35s. London: Charles Griffin and Co., Ltd.

Mr. E. J. Dunn, who gave the name of Dwyka to the glacial conglomerate of South Africa, has had a very wide experience as a mining geologist in that country, in New Zealand, and Australia, and it has been his privilege to examine professionally many historic mines of special geological importance. Mr. Dunn has kept careful and systematic records of his observations and a representative collection of material, and this book states his conclusions as to the processes of ore formation and illustrates them by an atlas of excellent photographs and diagrams. The records of mines now closed are especially valuable since it is the illfate of successful mining to destroy the material worked, and thus the mining geologists of one generation often find difficulty in obtaining accurate information about well-known mineral occurrences worked out by their predecessors. This collection of data selected from the notebooks of so acute an observer as Mr. Dunn will be of permanent value as a contribution to the history of ore genesis. Mr. Dunn in 1872 gave the name of the Lydenburg Beds to the rocks at Pilgrim's Rest in the Transvaal, and expresses (p. 22) his regret that this name has been dropped, he thinks unnecessarily, from South African geology in favour of the Pretoria Series. This date shows in what an early stage of modern metal mining Mr. Dunn took part, and it helps to explain why in some cases he expresses views on the origin of rocks which have been generally abandoned. He is thus conservative as regards the origin of granite from sedimentary rocks and the features which he illustrates by a beautiful photograph of a Victorian granite as the frontispiece, and in the first two figures of his collection of photographs, would not be regarded as convincing evidence of a sedimentary origin. The author's conclusion as to the influence of granite on lode formation is however supported by much recent opinion, and in this view he was ahead of contemporary opinion. He concludes: "there appears to be no grounds for assuming that granite has generally had any direct influence on determining the presence of auriferous lodes in sedimentary or other rocks, except where special varieties are present."

Mr. Dunn uses the term indicator in a sense which would render it unnecessary. The term was used for a structural feature in some slates which explains why the gold was concentrated along particular lines in that slate. Mr. Dunn adopts a use of the term indicator which applies it to the whole of a band of slate in which gold ore occurs; and he extends the use of the term to various fields where the gold has been deposited in bands of slate, but not in the interbedded sandstones. This condition is well known in many gold fields, and is similar to cases where gold occurs in a dyke and not in the rocks into which the dyke is intrusive. If the term indicator be extended to any band of rock containing gold, it becomes meaningless, for such a band as in the author's diagram 19, might be called "a productive zone."

The chief value of the book is in its collection of 172 diagrams illustrating important mines and modes of ore occurrence, and its excellent photographic illustrations (more than 250) of gold ores, country rocks, and specimens of alluvial and other gold. In a series of interesting chapters Mr. Dunn describes and discusses various modes of occurrence of gold, the features of lodes, the source and solubility of gold, the associated mineral species, the distribution of gold in lodes and in various alluvial deposits. The chapters contain much valuable information based on personal observations in historic mines at an important stage in their development, as in his account of Mt. Morgan. In the chapter on that mine, as also in the references to the Bendigo Goldfield, in the investigation of which the author was the leading pioneer, the chapters are rather a contribution to the history of the field than a full account of it, as they do not give reference to later work. As already indicated, the book is a collection of selected extracts from a mining geologist's notebooks, and its value is as a personal record of observations and impressions rather than as a guide to current theories on the formation of gold ores.

J. W. GREGORY.

The Principles of Subsidence and the Law of Support in Relation to Colliery Undertakings. By W. T. LANE and J. H. ROBERTS. Cloth, octavo, 319 pages, illustrated. Price 18s. London: Alfred A. Knopf, Ltd.

Mining Subsidence. By HENRY BRIGGS. Cloth, octavo, 215 pages, illustrated. Price 14s. London: Edward Arnold and Co.

It is curious to note that amongst the voluminous mass of British mining literature there have hitherto been no works on the extremely important question of Mining Subsidence. It may fairly be said that the first work devoted to this subject was really the Final Report of the Royal Commission on Mining Subsidence, published in 1927, and it may also fairly be surmised that both of the works now under review owe their origin to the incentive of this report; they are certainly both largely indebted to it, and the publication of these two works within a month of each other may be taken as evidence that British mining engineers are at last being aroused to a sense of the importance of the subject. Both books necessarily cover the same ground, but in very different fashion. The first named book is divided into two entirely independent parts, of which the second and larger part, occupying some 180 pages, is devoted to the Law of Support, a subject which Professor Briggs dismisses in some half-dozen pages. The latter, however, is all and indeed more than is needed, because the whole subject, at any rate as far as mining engineers are concerned, is clearly and authoritatively stated in the Final Report of the Royal Commission. The much lengthier review of the law by Messrs. Lane and Roberts really carries the matter no further; it is not sufficiently precise and does not convey a sufficent amount of detail for the use of the lawyer, who will always prefer his own legal text-books, whilst it contains far too much detail for the use of the mining engineer, who, as already pointed out, will find in the Final Report of the Royal Commission all that he really needs.

As regards the physical problems involved in mining subsidence, the two books again are entirely different; the work of Professor Briggs contains much orginal matter and much careful thought, which even those engineers who may not agree with his views will certainly find deserving of full consideration. The work of Messrs. Lane and Roberts, on the other hand, contains nothing original at all. As the authors themselves frankly and freely admit, the book is merely a compilation of the work of others. Such a compilation would no doubt be very valuable, especially having regard to the fact that much of the information is scattered in British and foreign technical journals and in the publications of many technical societies, but for a compilation to be of real value it must of necessity be complete and up-to-date, and unfortunately the present work cannot fairly claim to be either the one or the other. Necessarily both works contain summaries of the views held by previous writers on the subject, a historical review of the theories of subsidence being indeed no unimportant portion of the whole subject, but the treatment of the historical review by both writers is thoroughly characteristic. Thus whilst Briggs gives proper weight to the work done by the Dortmund Board of Mines, Lane and Roberts never mention the work, important though it was. On the other hand the above authors devote some ten pages to a description of Fayol's theory, which Briggs dismisses in less than half of that space. The former authors state the theory without comment or criticism and upon the whole leave the reader under the impression that they are inclined to accept his theory. Briggs, on the other hand, analyses the theory scientifically and states his own opinion of it, namely that it contains a useful half-truth inasmuch as it gives a correct indication of what takes place in the preliminary stages of subsidence. Opinions such as these, based on careful reasoning, are necessarily valuable; Lane and Roberts either have no opinions of their own, or, if they have any, they have taken care not to express them in this book. It is not unfair to say that the work of Lane and Roberts is valuable chiefly for the bibliography which it gives upon mining subsidence, though it would have been far more valuable had that bibliography included the important German works on the subject. It is tolerably significant that the only reference they give to the important work of Hausse is to a brief abstract in the Transactions of the Institution of Mining Engineers (incorrectly quoted in the book as the Institute of Mining Engineers, a mistake which is repeated in several places). The work of Briggs on the other hand, whilst at the same time ably

summarizing the views of previous workers, will probably be valuable chiefly for his own contributions to the theory of subsidence. The subject is a very complex and a very difficult one, and no one can claim to-day to have put forward anything like an opinion on the rationale of subsidence which finds general acceptance among mining engineers, but the fact that it is a subject bristling with difficulties should not deter men from attempting to grapple with these to the best of their abilities, and it is far better to put forward imperfect theories, such as those of Briggs confessedly are, rather than to put forward no views at all, which it must be admitted is the position which Lane and Roberts have taken up.

HENRY LOUIS.

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

NEWS LETTERS

JOHANNESBURG

April 4.

NAMAQUALAND DIAMONDS.—It is officially announced that the total production from the State diggings in Namaqualand up to the end of March, 1929, is approximately 600,000 carats worth about £6,500,000. The Government has sold 205,000 carats, for £2,450,000, or an average of £11 19s., per carat, and there remain in hand 395,000 carats roughly valued at £4,000,000. It would be interesting to know what the Merensky portion of the field has yielded in carats and cash, but there is at present no indication that this information will ever be published. Mr. S. B. Joel stated at Capetown, on the eve of his departure for England, that "in the Merensky portion of the fields all the diamonds have been extracted, and the Government has nearly exhausted the State diggings portion by hand picking. The Government has still to recover a certain percentage by machinery, but nothing of a serious nature; and the diggings will yield only a small proportion compared with what has already been extracted. The Government realizes the position and will maintain control of the diamond market." Namaqualand's average value of £11 19s. per carat for alluvial diamonds is £2 17s. higher than that of the rest of the Cape Province, which is £9 2s. The Free State's average for 1928 is £8 2s. 6d. per carat, and the Transvaal's is £2 9s. 5d. Last year's average values per carat for mine stones are: Cape, £3 5s. 4d.; Free State, £3 1s. 9d.; and Transvaal (Premier Mine), £1 1s. 4d. It has been stated that the average value of the alluvial diamonds found by the Consolidated Diamonds Co. on the north bank of the Orange River is over £10 per carat.

RAND REFINERY'S RECORD.—A record amount of precious metal was received and handled at the Rand Refinery last year—11,982,348 bullion ounces. This is an increase of 266,590 ounces compared with the figure for 1927. The Refinery was originally designed to treat 10 million ounces annually, and to have refined nearly an extra two million ounces, without any undue tax on the plant, is a very satisfactory state of affairs. Additional producers from Rhodesia are sending their output to the works for refining, showing that non-members are satisfied with the advantageous results obtained. The disposal of fine gold for the year was as follows:—Sold to South African Reserve Bank, 9,539,216 fine ozs.; shipped to London, 2,271 fine ozs.; sold to India, 1,000,017 fine ozs.; sundry local sales, 1,876, fine ozs. The gold sales to India showed an increase of 61,807 fine ozs. over the 1927 figures. The fine silver shipments to India direct amounted to 1,018,986 fine ozs.

ASBESTOS FINDS ON THE RAND.—The fact has just been brought to light that chrysotile asbestos has been found on the northern highlands of the Rand where there are remnants of the Swaziland system with schists and serpentines. It is not possible to say much about this discovery at present because the extent and economic value generally of the occurrences are still a matter of enquiry. Asbestiform material, probably tremolite, is said to have been mined not far from the Johannesburg Municipal boundary, and to have been an interesting little local industry in association with the making of asbestos-cement boards. In a patch of amphibolites, serpentines and talcose schists in the Rietfontein-Modderfontein area, west of the main road to Pretoria, asbestos is also said to have been found. It is hoped that asbestos mining

also may be a feature of other Rand activities in a not distant future.

UNION'S COAL RESOURCES.—South African coalowners are watching with considerable interest the progress through the House of Assembly of the Fuel Research and Coal Bill which provides for the constitution of a corporate body to be called the Fuel Research Institute of South Africa with the head office in Pretoria. On the commencement of the Act the board will take over all the rights, assets and liabilities of the coal grading committee. The objects of the institute will be:

"(a) To study and investigate the fuel resources of the Union.

(b) To undertake scientific and technical research on all matters relating to fuels in general and to fuel by-products.

(c) To grade and classify coals.

(d) To investigate any other matter which the Minister, after consultation with the board, may refer to it.

(e) To establish such laboratories and testing stations as it may deem necessary; and

(f) To publish from time to time in such form as it may deem suitable, particulars of the grades of coal available in South Africa and any other such information concerning the objects referred to as it may deem suitable."

The board will consist of five members appointed by the Governor-General, two of whom shall be appointed on the recommendation of at least three-quarters in number of registered companies producing coal. One member of the board will be a person highly qualified in fuel science and experienced in methods of research work. The members of the board will act in an honorary capacity and will hold office for three years. The board will formulate and control the policy of the institute, determine in what directions research should be undertaken and generally act in an advisory capacity to the Minister. The institute will be responsible for the grading of coal in a manner to be prescribed by regulation, and any member of the institute or its representatives will have the right of entry to a colliery at any time to inspect, test and take samples of coal. The export of ungraded coal will be prohibited, but a colliery may appeal to the Minister if it is refused a grading certificate, and his decision shall be final. In the event of a real or apprehended scarcity of coal for consumption within the Union the Minister may temporarily restrict or prohibit export. The expenses of the institute will be financed from an annual levy to be imposed by the Governor-General, not exceeding one-eighth of a penny per ton on coal sold during the preceding year. The institute shall create a capital fund with moneys voted by Parliament and from fees charged by the board. The Coal Act of 1922 is repealed. The Bill has been submitted to the Colliery Owners' Associations, and they have approved of it, subject to certain amendments.

PROSPECTING IN ZULULAND.—During the past two months a good deal of prospecting work has been done in Northern Zululand, and it is reported that promising mineral discoveries have been made there. Information regarding these discoveries is meagre, but it is believed that gold and asbestos occurrences are being opened up.

NEW USE FOR CINEMA CAMERA.—In order primarily to facilitate the complete study of large winding engines, Mr. L. B. Woodworth, of the Engineering Department of Rand Mines, Ltd., has developed a method of grouping a large number of electrical and mechanical indicating instruments and photographing them at such intervals as may be desirable, with either an ordinary or a cinema camera. The films, when developed, can be projected on a screen one by one, or examined with a magnifying glass and a complete timed record obtained. The camera method was developed with special reference to winders, but is capable of extension to many other forms of testing, and the effect of Mr. Woodworth's paper, read before the South African Institute of Electrical Engineers, is to put the method freely at the disposal of engineers the world over for application to their particular problems. The Victoria Falls Power Co. has already begun experiments with a view to applying the camera to the study of the occurrence and development of fault conditions on its network.

CHAMBER OF MINES LABORATORY WORK.—In the course of its annual report the Executive Committee of the Transvaal Chamber of Mines says that during the year 1928 the Chamber's Laboratory experimental work was continued, principally in connection with the ignition in a gas muffle of konimeter slides made of various materials. It had been previously demonstrated that the carbon particles contaminating a

konimeter spot could be entirely eliminated by igniting the slide, such carbon being not always completely removed by means of the immersion method of acid treatment. Konimeter slides of Chance's " heat-resisting glass " have been specially manufactured in England, and are proving most suitable.

BRISBANE

March 18.

Royal Commission on Mining.—The Royal Commission promised by the Premier of Queensland, to enquire into and report on the mining industry of this State, has been appointed. It consists of Mr. T. A. Ferry, member of the Queensland Board of Trade and Arbitration, as chairman; Mr. A. A. Boyd, M.Inst.M.M., for several years General Manager of the Mount Morgan Gold-Mining Company, in liquidation; Mr. C. F. V. Jackson, B.E., M.I.C.E., Queensland State Mining Engineer; and Dr. H. C. Richards, Professor of Geology and Mineralogy, University of Queensland. The Commission is to inquire exhaustively into the mining industry of the State from an administrative, economical, and labour point of view, from a geological standpoint, and in relation to any other matters connected with the industry which may be considered helpful in extending mining in Queensland, in widening the sphere of employment, and in the effective utilization of the mineral resources of the State. The personnel of the Commission is free from the political element which too often enters into the constitution of such bodies, and as such as should inspire confidence.

The Coal Crisis.—The coal position seems to have reached a dead end. Following on the dismissal, on February 15, of some 10,000 or 11,000 men from the associated collieries of the Newcastle and Maitland districts, a conference was held between the Prime Minister (Mr. Bruce), the Premier of New South Wales (Mr. Bavin), and representatives of both the mine owners and miners. It was there stated by Mr. Bavin that the profits of the owners on coal production did not exceed 2s. a ton, and a tentative agreement for settlement was reached whereby the men would agree to a reduction of 1s. a ton in wages if it was shown, by an approved accountant, that Mr. Bavin's figures were correct. It was apparently arranged that the accountant should be one of three to be submitted by the president of the Accountants' Institute, but subsequently, on behalf of the miners, it was demanded that the accountant should be left to the unrestricted choice of the unions concerned, and that his duties should not be confined to the simple question involved. This demand, the Prime Minister definitely stated, could not be acceded to, and thus the matter stands at present. If the miners had agreed to bear their quota of the proposed reduction of 5s. per ton in the cost of coal, Mr. Bruce was ready to renew his offer of a Federal bonus on coal, but wisely decided that it should apply to coal produced in any State, instead of being confined to the output of New South Wales. Fortunately the unassociated collieries have not been closed, and it would seem that their output is sufficient to meet all supplies required for the present, so that the chief sufferers are the men who have lost their jobs in the associated mines.

Mount Isa Progress.—Latest official news from the Mount Isa field is that Davidson's shaft has reached a depth of 340 ft., and is still being sunk. Two smaller shafts are being put down, to be used in the future for ventilating purposes. In the four-week period ended February 14, the amount of diamond drilling carried out totalled 142 ft. on the Rio Grande lode and 709 ft. on that of the Black Star. Progress is being made with the erection of the power plant, a portion of which was expected to be put in commission a week ago. Part of the spillway at the Rifle Creek dam has reached the required height of 50 ft. above the creek bed, and good progress is being made with the wings, which will be about 10 ft. higher. Private advices are that there has been practically no rain at Mount Isa since early in December, when there was 18 ft. of water in the new reservoir, but it is possible there will be further falls before what is known as the wet season is finally ended. It is estimated that the dam, when full, will contain about four-and-a-half years' supply. The railway from Duchess to the mines, 54½ miles in length, is nearing completion, and a considerable portion of it is already being used with the aid of ballast trains. The Minister for Railways says the line should be finished by the end of this month.

Queensland Antimony.—Many deposits of antimony are known in Queensland,

particularly in the north, inland from Cairns, but, owing to the low price of the metal usually prevailing and the uncertainty of the market, these have been exploited only to a very small extent. There have of late, however, been inquiries for the metal both from Europe and America. The Commissioner for Australia in the United States has reported that there is an assured market there for supplies, to the extent of 5,000 tons a year, of 60% stibnite (antimony glance). A representative of southern mining investors has lately been in North Queensland inspecting some extensive deposits on the Mitchell River, whence has been obtained about 60% of the antimony as yet produced in this State. He is said to have been favourably impressed, and to be taking steps which will lead to a revival of this branch of mining in that locality. Enquiries are also being made for molybdenite and bismuth, of which very little has been mined in this State since the war.

The Whitworth Corporation.—The English company, the Whitworth Mining and Finance Corporation, which lately acquired several tin-mining propositions in the Cairns hinterland, North Queensland, has begun operations on the Governor Norman mine, at Irvinebank. The various tunnels of this old mine are being cleaned out and put in working order. The district inspector of mines (Mr. O. M. Williams) gives some interesting particulars of this property. The orebodies consist of two major and one minor shoots of ore, which occur along the strike of a very well-defined master joint at the point of intersection of other master joints. In the vicinity of the major intersections there has been very extensive and intensive alteration of the country rocks. The large open cuts that have been made in the past denote the major shoots of ore to have been of unusually large dimensions, and a considerable tonnage of low-grade ore is said to be still available. It is quite obvious, Mr. Williams says, that in each case the shoot worked represents one of a series; and, with the knowledge now available as to the genesis of the tin deposits in these districts, there should be no undue difficulty in locating further rich and extensive shoots of ore. Three block shafts have been started at sites in the general direction of the pitch of the various shoots of tinstone. The same company has also a few men already employed at the Vulcan, notable for being the deepest tin mine in Australia, its workings being down to 1,400 ft. Arrangements have been made for the company to take over from the Government the tin treatment works at Irvinebank, which have been almost idle for several years.

Oil Prospecting.—The Federal Government Geologist (Dr. W. G. Woolnough), after a brief visit to the Roma district, in Queensland, lately furnished to the Minister for Home and Territories a report on oil prospects both in that locality and other parts of Australia. While light oil and petroliferous gas have been unmistakably found at Roma, what is wanted, as Dr. Woolnough has before pointed out, is crude oil. He now states it is by no means improbable that such crude oil may exist in the vicinity of Roma, and that strenuous efforts are being directed along admirable lines to find it, although adding that many of these are in the direction of "wild cat" drilling. This latter statement has been sharply denied by the Queensland Minister for Mines and by Dr. Jensen, a well-known geologist, at one time on the Queensland Geological Survey, on whose reports and recommendation a number of the prospecting schemes now in full swing have been launched. The Federal Geologist also states that chemical and physical investigations indicate that the light oil found at Roma can almost certainly be regarded as a condensate from the gas, and that consequently doubts are entertained in some quarters as to the existence of any near-by source of normal crude oil. That such oil may, however, exist in the vicinity is considered by him as by no means improbable. Dr. Woolnough's general conclusion is that, in spite of many disappointments and many false trails, there seems to be a very reasonable chance that Australia may yet enter the ranks of the oil producing countries.

VANCOUVER

April 9.

The Kootenays.—The Victoria Syndicate, of London, which acquired the Hewitt, Carnation and Wakefield groups in 1926, extended the bottom adit of the Carnation through the hill, a distance of 2,800 feet, connected the southern portal by a 10,000 ft. aerial tramway with the Hewitt mill, and then, last summer, dropped its options on the Carnation and Wakefield, and concentrated development on the Hewitt,

because it was considered that the opportunities there were much greater. It has now consolidated its holdings at the Hewitt with those of Galena Farm Mines, acquired the Hazard group lying between Galena Farm and Hewitt, and formed Galena Farm Consolidated Mines to take over and operate the properties. Both Galena Farm and Hewitt are old mines with good records of production, but like so many old mines in the Kootenays, until recently no attempt has been made to exploit the mines to anything like the extent of their possibilities. The Hazard group, which contains the same shear zone, is practically virgin ground. The three properties, which contain 27 claims and fractions, has a length of three and a half miles on the shear zone. Recent development on the Galena Farm is reported to have exposed a continuous ore-shoot for a length of 1,200 ft. on the bottom level. The Hewitt, which has been under development by the Victoria Syndicate for three years, was brought to production early in last year, and yielded the syndicate an operating profit of $170,000 by small-scale operations. The lead concentrate averaged 300 oz. silver per ton. The new company will build a new mill on Slocan Lake and a tramway to serve the three properties. The old mills and old tramways will be dismantled and such parts as are available will be used in the new mill and new tramway. The Victoria Syndicate and Galena Farm Mines are taking stock in the new company for their properties, and 400,000 shares are being offered to the public to provide funds to further development and new equipment. The products of the mill will be shipped by barges to bins at the Canadian Pacific Railway track and thence to Tadanac. Lieut.-Col. H. H. Yuill, British Columbia representative for the Victoria Syndicate, is president and managing director of the Consolidated company.

The Consolidated Mining and Smelting Company of Canada has brought the capacity of its Sullivan mill up to 6,000 tons per day. During last year the mill treated 1,484,487 tons, as compared to 1,248,500 tons in the previous year, and the St. Eugene mill treated 17,856 tons of Sullivan ore and 219,339 tons of old tailing. The company estimates that there still is some 60,000 tons of old tailing to be pumped from Moyie Lake, and that when this has been treated the earnings from the treatment of the old tailing will have paid for the plant and yielded the company a profit of half a million dollars to boot. The St. Eugene mill, which was closed for several weeks on account of the severity of the weather, is again running at capacity on Sullivan mine ore. When the ice on Moyie Lake has melted, treatment of the old tailing will be resumed.

The Consolidated Company's annual report, which was tabled at the annual general meeting on April 10, is replete with interesting information about the doings of the company in British Columbia, and elsewhere in Canada. At the smelter, the company added an electrolytic gold refinery, and now separates the platinum and palladium metals, thereby getting a slightly higher price for its gold and at the same time making a small production of platinum and palladium metals. In December it made its first production of bismuth, and this metal which in the past has been found objectionable will in future constitute a valuable by-product. The electrolytic cadmium plant was brought to production and 246 tons of bars and pencils of high-grade cadmium were produced. The market conditions, the report states, warrant an extension of the plant, which now has a capacity of $\frac{3}{4}$ ton daily. The company already is producing superphosphate fertilizer, and now it is turning its attention to the various processes for making ammonia from atmospheric nitrogen and is searching for a deposit of potash with a view to producing a series of balanced fertilizers. It is providing prospectors with samples of the common potassium-bearing minerals, and offers to make analyses of any samples sent in without charge. A small amount of exploration in the Rossland mines failed to discover any new ore. The withdrawal of pillars and clean up of old stopes in the Le Roi resulted in the production of 13,886 tons of smelting grade of gold-copper ore. At the Coast Copper property development by drifting, cross-cutting, and diamond drilling on the 1,200 and 1,000 ft. levels was continued with satisfactory results, though work on these levels north of the main winze failed to indicate the downward continuation of the north ore-shoot to those levels. The south drifts on both levels found commercial ore-shoots, which, however, have not yet been correlated with those on the 800 ft. level. The power plant at Raging River was enlarged by the addition of a 150 kw. 2,200 volt generator ; a new double-drawn

electric hoist was erected at the mine, and electric hauling equipment was transferred from Rossland mines. At the Big Missouri mine the Province tunnel was extended 2,155 feet and 476 feet of cross-cutting and drifting was done from it. The main tunnel and diamond drilling indicate a sheared zone some 500 ft. wide, carrying a large number of quartz and calcite stringers with a variety of disseminated mineralization, including iron, copper, lead, and zinc sulphides, with occasional free gold. A prominent stringer with a fair average but very variable gold values was found at approximately 1,700 ft. from the portal. Drifting north and south on the stringer showed the same mineralization and some spectacular gold specimens, but no well-defined shoot was opened. Free gold has been found in several sections in the crosscut between footages 1,630 and 1,809, but further development is necessary before tonnage and grade can be determined. Surface exploration on the Providence claim indicated commercial ore at several points, but it has been impossible to correlate these with discoveries in the tunnel. At the George group diamond drilling failed to find the downward extension of veins opened at the surface, but holes from a new station found copper values, but no gold, over mineable width. During the current year it is hoped that this vein may be traced further down the mountain, where it can be opened by adit or tunnel. Hydraulic work at Boulder Creek, near Atlin, indicated the approach of the heading to pay gravel and contact with bed-rock, so the prospects for profitable operation during the current year are few. Development was continued with promising results on the group of claims located last year on Bower Creek, a tributary of the Finlay River. Ores of lead, zinc and copper were found over a large area. The snowfall is light, and, with the exception of the long distance from transportation, conditions for mining are favourable. Of the several prospects under option, the most promising seems to be the Emerald group, on Sibola Mountain, which originally was located by the late James Cronin. The Cronin adit was extended 160 feet, and a cross-cut at the face exposed 11 ft. of ore without defining the walls. The values are in lead and zinc, with copper here and there. Zinc predominates on the hanging and lead on the footwall. Surface trenching located the vein 400 ft. below the Cronin tunnel, and an adit was started at this point, but a heavy fall of snow put an end to operations before any definite result was obtained. Development will be continued this year. Exploration will be continued on about a score of other properties that the company has under option. The fact that the value of the company's output for 1928, $34,426,849, was more than half of the mineral production of British Columbia, is sufficient excuse for this lengthy review of the report.

Mr. Lewis P. Larsen, president of the Pend Oreille Lead & Zinc Company, has announced that, subject to ratification at an extraordinary general meeting to be held on April 30, the company is to be re-organized under the name of Pend Oreille Mines & Metals Company, and that financial arrangements have been made for the erection of a 2,000 ton concentrator and an electrolytic zinc plant, for which the rights of the Tainton process have been secured, to treat Pend Oreille and Reeves McDonald ores. The present company has 1,000,000 common and 400,000 7% preferred shares outstanding. The preferred stock will be retired for $475,000 cash. The owners of common are to receive share for share for their stock and each share will have the right to buy one share of new stock at $5. The new company also will acquire 1,200,000 shares of Reeves-McDonald in exchange for shares in Pend Oreille Mines and Metals. The sale of those shares that are not taken by present shareholders has been guaranteed. The first 1,000-ton unit of the concentrator will be in operation by September, 1930. Tests that have been made indicate that ores from Pend Oreille and Reeves-McDonald will yield 150 lb. of zinc and 50 lb. of lead per ton. Mining and milling cost is estimated at $2 per ton, and the treatment of the resulting zinc concentrate at $15 per ton. After allowing for freight and marketing, the promoters estimate that, with a 1,000-ton mill, the profits of the company will reach $3,106,000 per year. The provisional directors of the new company are Lewis P. Larsen, president, and J. Jenson, secretary-treasurer of Pend Oreille Lead & Zinc Company; U. C. Taunton, director of Evans-Wallower Lead Company; Duncan McIntosh, president of Sally Mines; Lieut-Col. H. H. Yuill, president Reeves-McDonald Mines; and W. A. Witherspoon, president Union Securities Company, of Spokane. At the time of the promotion of Reeves-McDonald Mines by Victoria Syndicate, of

London, L. P. Larsen acquired for the Pend Oreille Lead & Zinc Company 1,200 shares at 33⅛ cents per share, and set aside 40,000 shares in Pend Oreille, at a nominal value of $10, to pay for them. These evidently are the shares now to be exchanged.

TORONTO

April 18.

PORCUPINE.—The output of bullion from this field during March was valued at $1,587,601, showing a gain as compared with February, although lower than the January production. The output of Hollinger Consolidated continues low, both as regards the tonnage treated and the recovery. Its mill is equipped to handle 8,000 tons a day, but that objective has never been approached. In 1928 the average daily tonnage was 5,081, with a recovery of $5·98, a considerable falling off from the previous year when an average of 6,050 tons were handled with an average recovery of $6·64. The McIntyre Porcupine is making good headway with its comprehensive scheme of development between the 3,000 and 4,000 ft. levels. The plan has been adopted of driving from the south-west to the north-east corners of the property, and to prospect the ore zone by crosscuts and diamond drilling from the main shaft. This is being done on every third level, main drifts being 375 ft. apart. Favourable results of underground development in the greenstone formation at depth have considerably improved the position of the Dome Mines. Production is increasing, the output for March being $361,767 as compared with $316,143 in February, and $310,362 in March, 1928. The mill of the Vipond treated over 9,000 tons during March, with a recovery of slightly over $75,000. The new orebody which was discovered on the seventh level last summer, and has since been cut on four other levels, is developing satisfactory. On the 200 ft. level a crosscut is being run towards the Hollinger boundary to pick up a rich vein coming in from that property. The Rypan Porcupine Mines, Ltd., which owns a property three miles south-east of the Hollinger, has let a contract for extensive diamond drilling.

KIRKLAND LAKE.—The yield of the Kirkland Lake area shows a steady increase each month. The March output of bullion being $1,196,959. The Lake Shore is preparing to increase the capacity of its mill, at present 1,200 tons a day, to at least 2,000 tons. The mill building will have to be enlarged to permit the installation of new tube mills and filters and several surface changes will be necessary, and it will be a year or more before the enlarged mill will be ready for operations. In view of the results of recent underground developments the official estimates of the value of the ore reserves at $125,000,000 made some time ago is regarded as considerably below their present value. At the Teck-Hughes the shaft is being put down to the 3,000 ft. level, and six new levels are being opened up at depth. Sinking is being continued to a depth sufficient to permit the running of five additional levels. With the increased tonnage rendered available by this development it is understood that an enlargement of the mill is contemplated, although no definite decision has been announced. Production at present is being maintained at $100,000 a week. The Wright Hargreaves has considerably improved its position by important discoveries of high grade ore on the east claim at the 1,250, and 1,375 ft. levels. Two new veins at the 1,750 ft. level are being opened up and promise to yield a large tonnage of medium grade ore. The Sylvanite will sink a shaft near the Wright Hargreaves boundary about 2,000 ft. from the main shaft to encounter a rich vein crossing in from Wright Hargreaves at a depth of 850 feet, which shows ore bearing from $10 to $14 per ton over a width of over 12 feet. At the Telluride preparations are going forward for the installation of the new mill, machinery for which has arrived on the ground. The power transmission line is under construction and electric energy will be available by the time the mill is completed. The Amity Copper mine, which has been making shipments of ore to the Noranda smelter, has opened up a vein of medium grade on the 600 foot level. Work is being actively carried on at the Barry-Hollinger, Bidgood, Ritchie, Murphy and other properties which have not yet reached the production stage.

SUDBURY DISTRICT.—It has been definitely decided that the copper customs refinery to be built by the Consolidated Mining and Smelting Co. and the International Nickel Co. of Canada in conjunction with other interests will be erected at Copper Cliff and not in the Province of Quebec as originally proposed. Its cost is estimated at $4,000,000, and it will have an initial capacity for refining 120,000 tons of copper annually. It will

employ about 600 men and utilize 6,000 h.p. electric energy. Construction will be started at once, and the new refinery will be completed and operating in eighteen months. Steady progress is being made with the development of the Frood mine, and with the construction of the mill and new Copper Cliff smelter of the International Nickel. The mill is being designed for a capacity of 5,000 tons; in addition 3,000 tons of smelting ore will be mined, making a total of 8,000 tons of ore a day to come from the mines. The mill will be designed to permit of the easy separation of the parts of the copper ore, which will be converted directly into blister copper, instead of into matte, as at present. The Treadwell Yukon is carrying out an extensive development programme, which includes the sinking of the three shafts to the 1,500 ft. level, and connecting the tops of these shafts, with a surface electric railway, with the mill, and other surface plants. During the year 1,081 tons of copper concentrates were produced. Preparations are being made to deepen the Levack Mine of International Nickel by sinking the shaft to the 840 ft. horizon giving two additional levels. The McVittie-Graham, the shaft of which has reached the 250 level, is installing a new mining plant. The Falconbridge is rapidly pushing development, and the shaft is now down 627 feet, and lateral development is going forward. Diamond drilling during the winter on the Vermillion Lake property of the Sudbury Basin has proved up an orebody 1,500 ft. in length, by a width varying from 20 to 100 feet, with a downward continuation of 500 feet. Two diamond drills will be kept in operation during the summer to determine the extent of the deposit. The Sudbury Nickel and Copper Co., a subsidiary of the Sudbury Basin, which has 10,000 acres of land in the district, has let several contracts for diamond drilling.

ROUYN.—The annual report of the Noranda Mines, Ltd., for 1928 show operating profits of $3,018,247, the smelter treated 271,926 tons of ore flux and concentrates, and produced 33,307,937 lb. of blister copper. The ore reserves as of January 16 are estimated at 3,097,000 tons with a gross value of $99,340,000. The programme of expansion includes the sinking of the 4th shaft to 1,000 ft. level, in connection with which a complete crushing plant will be installed, and other additions to the equipment which it is expected will put the mine and smelter in condition to handle between 1,600 and 2,000 tons per day. The Waite-Montgomery is shipping an average of about 4,000 tons a month to the smelter. Operating profits during February amounted to $62,896. The Granada Rouyn has encountered rich ore at the 625 ft. level, and a test mill will be installed. The Aldermac has opened up two important lenses of ore on the 500 foot level. An electric hoist has been ordered capable of carrying operations to a depth of 2,000 feet. The Amulet which has made considerable additions to its ore reserves by recent development will erect a concentrating mill with a capacity of 300 tons daily. A campaign of surface exploration and diamond drilling on sections of the property where geological conditions are favourable has been arranged. The Thompson Cadillac has encountered good ore on the 150 ft. level which had been opened up for 48 feet. Number 2 shaft is being deepened, and will be connected with Number 1 shaft at the 150 ft. level.

PATRICIA DISTRICT.—There will be much activity in this field during the coming summer, as many companies have brought in large quantities of machinery and supplies over the winter roads. Interest is mainly centred on the Shoniah area, where several old-established companies have secured claims. The Sudbury Basin has secured several groups of claims, and the Lindsley interests of New York have taken over 40 claims or about 1,500 acres. Some further rich discoveries have been made on the property of the Northern Aerial Mineral Exploration Company, on which the original Shoniah find was made. At the Bathurst in the Woman Lake area a small test mill is in operation, and some further discoveries of high grade ore have been made. The Howey Gold Mines, Ltd., of Red Lake, which is preparing to install a 500 ton mill, has closed an advantageous contract for power with the Ontario Hydro Electric Power Commission. It will receive a minimum of 2,000 h.p. for the life of the mine, at the annual rate of $25 per h.p. It will take about a year to have the mill ready for operation, by which time the power will be available.

THE SILVER MINES.—Silver production has been on the decline for some time as most of the Cobalt mines have been exhausted, and there have been but few new discoveries. The Nipissing of Cobalt however maintained production on a large scale during 1928, its net income being $404,440, the highest

figure since 1925. Its output amounted to 1,909,882 ounces, an increase of 19,613 ounces over the output of the previous year. The ore reserves are becoming rapidly depleted, at the close of the year they were estimated at 596,000 ounces, and in default of further important discoveries this year's estimates will show a further decline. The company has taken options on several properties on other mining fields. The Paramount Syndicate operating in the Elk Lake area has begun production, and is shipping high grade ore for treatment. The shaft has been put down for 45 feet, encountering two veins, and the results have been sufficiently encouraging to induce the syndicate to order a mining plant capable of operating to a depth of 400 feet.

CAMBORNE

May 2.

In Memory of Richard Trevithick.—It will give much pleasure to the large number of Trevithick enthusiasts to learn that a statue of this famous Cornish engineer, by L. S. Merrifield, the well-known sculptor, is to be erected in Camborne, the site chosen being the open space in front of the free library. Full details of the unveiling, which will take place in the autumn, are to be announced later.

Wheal Reeth.—The first unit of the new mill, situated in close proximity to the Lady Gwendolen shaft, and connected to Wheal Reeth proper by a tramway, is now in full operation on ore which is being obtained from development work in both the Wheal Reeth and Lady Gwendolen sections of the mine. The mill is unique, as far as Cornwall is concerned, in that the primary crushing is effected by means of a Colorado Ball mill, which, on the class of ore produced at this mine, is apparently proving entirely successful. Both sections of the mine are fully equipped with hoisting, air-compressing and pumping machinery, all electrically driven. The tin concentrates obtained are of a very high grade, the ore containing only a very small amount of copper pyrites and no mispickel, thus obviating the necessity of calcination. The writer hopes shortly to give a full description of the operations at this mine.

Wheal Vlow.—Great surprise has bee caused by the announcement of the suspension of work at this mine. It is about two years ago that the present operations were started by the London Tin Syndicate, and although much money must have been expended on surface plant and equipment it is evident that very little underground development has been carried out.

Argus Concessions, Ltd.—In last month's issue it was suggested here that the above company were proposing to work the Wheal Andrew mine. It is now ascertained that the company has taken up a fairly extensive sett in the vicinity of the famous old Gwennap United mines, and that this sett includes, among other lodes, those of Wheal Andrew. Work is not, however, being carried out, at present, in the Wheal Andrew section, but on a very large and interesting tin-bearing formation which comes to surface in another portion of the sett, and in which an old adit is being cleaned out with a view to examining the deposit at a little greater depth. Messrs. R. C. N. Robinson and Co. are the managers to the company.

Wheal Kitty.—Wheal Kitty must now be regarded as one of the chief producing mines in Cornwall; during the months of January, February and March of this year the sales of black tin amounted to 42 tons, 55 tons, and 51 tons respectively. This makes pleasant reading for those who believe in the future of the St. Agnes mining district.

Cornish Institute of Engineers.—The annual meeting of the Cornish Institute of Engineers was held at Camborne in April 6. Mr. Joseph Vile, of Troon, at one time connected with the Grenville United mines, was elected President for the ensuing year. It was announced, at this meeting, that the Mines Department had definitely refused the request of the Cornish Societies backed by the Institution of Mining and Metallurgy, for financial and other aid in the collection and storage of old mining records and plans. It is difficult to see the reason for the refusal particularly when one reads from the report of the "Departmental Committee on the Prevention of Dangers in Mines from Accumulation of Water" a sentence as follows: "It is seldom that records have been preserved to enable old plans to be checked and verified."

Castle-an-Dinas.—Mention was made of this interesting development in the Magazine for February. The sett is an extensive one, and is situated on Castle-an-Dinas hill in the parishes of Ludgvan and Gulval near Penzance. The present owners have carried out sinking and driving operations on a most promising lode on which the

" old men " worked to a very small extent in the early part of the last century. This lode is from 3 to 5 feet wide, and gives excellent assay values over the full width exposed.

REPORT OF THE RADIUM SUB-COMMITTEE, 1929.—The report of the Radium Sub-Committee which was appointed in July last year by the Committee of Civil Research, is now available to the public. The object of the Sub-Committee was " to examine the radium requirements of Great Britain in relation to the present sources of supply " After reading the report it becomes apparent that the Committee see no possibility of the Cornish radium supplies being developed. It is stated that the Cornish ores are of low grade and of insufficient quantity, but it seems remarkable that the total output of radium-bearing ore from Cornwall has been omitted. It might be interesting to point out that over 600 tons of uranium ore were actually sold from a few mines near St. Austell during the latter part of last century. In Cornwall, only the South Terras mine has been exploited solely for uranium ore, and from many other mines quantities of such ores were discarded as useless.

WRAY MINE, DEVONSHIRE.—Development work is being carried out at this micaceous hematite mine, situated near Moretonhampstead in Mid-Devon. It is understood that crushing and concentrating plant will soon be in operation. The local name for micaceous hematite is " shiny ore."

FALL IN PRICE OF TIN.—The fall in the price of tin is viewed with great anxiety in Cornish mining circles, it being evident that practically none of the local mines can be making a profit with the metal at £200 per ton. In the case of South Crofty, and of East Pool, the rise in the price of wolfram will, to a certain extent, counteract the adverse effect of the drop in the price of tin. Wolfram is now about £1 9s. per unit (WO_3), this being practically double the price obtaining six months ago.

WHEAL COATES.—This mine, which is situated on the cliffs between the Beacon and Chapel Porth in the parish of St. Agnes, is to be reopened. The last working was just prior to the war. The lode, or " mineralized zone " at Wheal Coates, although of low grade, is of considerable size and contains very little mineral which requires calcination. The ore should consequently be mined and concentrated cheaply.

PERSONAL

W. L. BAYLEY has been elected a director of the Balaghat and Nundydroog companies, with both of which he has been associated for many years.

F. O'D. BOURKE has left for Nigeria.

J. COGGIN BROWN is home from Burma.

EDWARD BUSHING is home from Nigeria.

HARRY BUSHING is home from Nigeria.

L. MAURICE COCKERELL has returned from Texas.

ARTHUR DICKINSON has returned from New Guinea.

A. G. GLENISTER is home from the Straits.

ROSS B. HOFFMANN has returned from California.

CHARLES JANIN is home from San Francisco.

F. H. B. LEGGETT has returned from Panama.

STANLEY LOW has returned from Panama.

MALCOLM MACLAREN has left for Bolivia.

JOS. MILLER has, owing to ill-health, resigned the management of the Story's Creek (Tas.) Tin and Wolfram mine, after a term of 14 years.

W. MURRAY has left for Burma.

N. E. ODELL will be here in June on his way to Scandinavia. His address during the period June-September will be c/o The Alpine Club.

C. E. PRIOR has left for Western Australia.

HORACE P. ROBERTSON and HUGH SANDYS have taken offices at New Broad Street House, London, E.C. 2, acting as consulting engineers.

CHARLES SALTER left Singapore early last month on vacation. Mr. Salter is travelling homewards via Canada and the U.S.A. and expects to arrive in London towards the end of June.

D. A. SUTHERLAND has returned from Egypt and the Near East.

W. W. VARVILL has been appointed lecturer on metal mining at Birmingham University.

BERNARD WILKINSON is here from the Straits, his London address being care of Harrisons and Crosfield, Ltd., 1 to 4, Great Tower Street, E.C. 3.

A. HOWELL WILLIAMS has left for Peru.

J. H. G. WILSON is leaving on the 18th for Colombia.

FELIX AVELINO ARAMAYO, the promoter of the Aramayo Company, has died at Biarritz.

HAROLD BENDIXSON died on April 19 at Willian, Herts, at the age of 71. He was formerly vice-chairman of Hambros Bank and chairman of Climax Rock Drill and Engineering Works, Ltd.

TRADE PARAGRAPHS

The old-established firm of **Cutten Brothers** has been taken over by John Duncan, who will continue to carry on the business as heretofore.

Robey and Co., Ltd., of Lincoln, issue a catalogue devoted to electric winding engines, which is fully illustrated with typical installations of their manufacture and emphasizes the special features that characterize them.

The Dorr Co., Ltd., have removed to Abford House, Wilton Road, London, S.W. 1 (opposite Victoria Station), where on one floor they have acquired offices sufficient for present and contemplated staff expansion consequent upon steadily widening activities.

The Stream-Line Filter Co., Ltd., of 45, Horseferry Road, London, S.W. 1, have secured an important order for filter plant to deal with

transformer and switch oils from the Central Electricity Board for use at each of the 13 stations included in the Central Scottish Grid Scheme. Readers will recall a description of this filtration principle which appeared in our issue of March, 1928.

Sandycroft, Ltd., of 4 Broad Street Place, London, E.C. 2, issue pamphlets Nos. 63/29 and 64/29. The first describes crushing rolls of their own special design with details of their duties and methods of drive; and the second jaw breakers, including Bigelow and Blake crushers, and sectionalized crushers of either design. These last are specially made for overcoming transport difficulties.

Crossley Bros., Ltd., of Openshaw, Manchester, have issued a leaflet describing their compressorless Diesel engines of 110 b.h.p., four cylinder vertical, and four stroke. A special feature is that the main moving parts, including all the valve gear, are totally enclosed, easy access to crankshaft and connecting-rod bearings being by way of large inspection doors, while, as to the top, large semi-hinged cover plates are fitted.

Askania-Werke A.G., Bambergwerk, 87 to 88, Kaiserallee, Berlin-Friednau, publish a booklet on Eötvös-Schweydar torsion balances with an ample and fully illustrated description of this instrument, together with some data as to the calculations involved in its uses and examples of its employment. Another booklet issued deals with flow meters for compressed air and gases of both fixed and portable types together with all accessory measuring instruments.

Sullivan Machinery Company, of Salisbury House, London, E.C. 2, have issued a catalogue of their diamond drill equipment and supplies which contains, with illustrations and tabular matter, full information as to all the requirements of the diamond driller. They also issue separately some particulars about the sale of these drills, which last year exceeded previous ones. A case is cited of a drill in Alberta which brought in an oilwell at a depth of 5,040 ft. against a pressure of 4,000 lb. per sq. in.

Hadfields, Ltd., of East Hecla Works, Sheffield, send us as usual a well illustrated reprint of their Chairman's speech at the Annual General Meeting, which publication ably reflects the manifold activities of this great firm. The report and balance sheet for the year to December, 1928, shows an increase by £4,000 in the carry over, although no increase in dividend rate was found possible. Sir Robert Hadfield, in his survey of the past year, dealt *inter alia* with trade conditions in the country, the development of the British Empire, peace in industry, scientific progress, the high-frequency electric induction furnace for steel making, developments in the firm's "Era" and "Hecla" heat-resisting steels, and Bean cars.

Menck and Hambrock, G.M.B.H., of Altona, Hamburg (London Office: 175/6, Windsor House, Victoria Street, S.W. 1), issue Bulletins 293 and 307 devoted respectively to quarry shovels and to universal steam shovels, models III–VII. The latter comprise shovels with capacities of $\frac{7}{8}$, $1\frac{1}{8}$, 2, 3, and $4\frac{1}{3}$ cu. yd. Excavators are also made for electric or Diesel motor drives. A feature is the comparative width of the caterpillar tracks for prevention of sinking in soft ground. An interesting comparison of specific pressures on the ground is furnished. Thus, a 3 cu. yd. machine when travelling exerts a pressure of 15 6 lb. per sq. in.; but with the boom over the corner of the caterpillar tread and the dipper working in the most advanced position, with the greatest pull on its teeth this figure becomes 35 lb. per sq. in. A list is furnished of some 470 users in a variety inndustries throughout the world.

International Combustion, Ltd., Grinding and Pulverizing Offices, of 11, Southampton Row, London, W.C. 1, report that new orders have been received for the following equipment: For England: One 8 ft., type 39, tandem Hum-mer screen and one 4 ft. by 5 ft., type 39, 1-surface Hum-mer screen for sand and gravel; one 8 ft., type 39, 1-surface tandem Hum-mer screen for ammonium sulphate; one 3 ft. by 3 ft. 6 in., type 39, 1-surface "Bulldog" Hum-mer screen for wet coal; one 4 ft. by 7 ft., type 39, single-body tandem Hum-mer screen for coal; one 4 ft. by 5 ft., type 37, 2-surface Hum-mer screen for limestone. For China: One 6 ft. by 48 in. Hardinge pebble mill, one Hardinge air classifier, one Andrews classifier, and one Hardinge thickener for limestone, etc. For Japan: Two 8 ft., type 39, 1-surface Hum-mer screens for tin ore. For Australia: One 4 ft. by 5 ft., type 39, 1-surface Hum-mer screen for lead-zinc ore. For France: One 5-roller Raymond mill for phosphate; one 2-roller Raymond mill for coal; two 6 ft. by 22 in. Hardinge ball mills for lead-zinc ore. For Italy: One 7 ft. by 36 in. Hardinge ball mill for coal; one No. 0000 Raymond pulverizer for levigated ochre.

A NEW LABORATORY ELUTRIATOR

A description was given in these columns in November, 1927, of the Andrews Hydraulic Classifier, the special application of which to mining classification was further alluded to in February, 1928. The principles underlying that plant have been successfully applied to the perfection of a laboratory elutriator for accurate and rapid classification (or size analysis) of fines, which is attracting a good deal of attention among metallurgists and chemists.

Kinetic Elutriators, Ltd., of 11, Southampton Row, London, W.C. 1, who are the manufacturers of the Andrews classifier, are also responsible for the design and construction of the apparatus described below and illustrated in the accompanying sectional sketch.

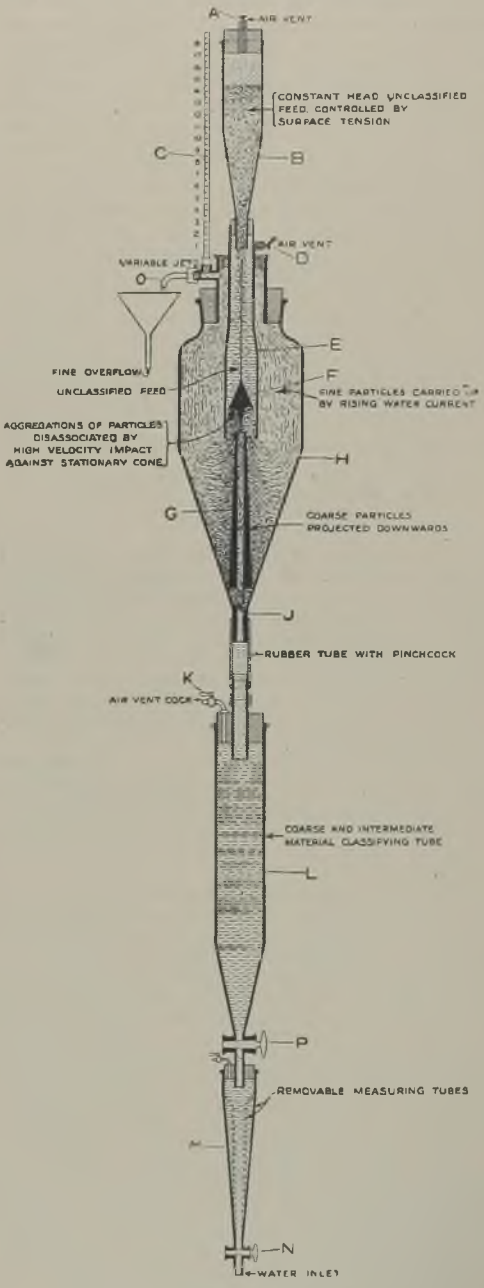
In Kinetic Elutriation the force of gravity is either supplemented or opposed, as desired, by imparting an initial velocity to the suspended particles. The resistance to the movement of a particle through a fluid is largely dependent upon the density of the fluid. Since the effect of this density may be controlled by the construction of the apparatus, this gives two separately controllable forces, density and variable acceleration, which, when suitably combined with the fixed force of gravity, may be used to cause particles of varying weight and size to move in any desired direction.

These general principles have already been applied to the Andrews classifier, and some of them are embodied in a new laboratory elutriator which has been designed with a view to overcoming the difficulties in ordinary gravity elutriators.

The feed tube "B" at the top of the instrument is charged with the sample of powders to be tested. This feed tube, which has a capacity of

approximately 60 cc. is completely filled so as to be entirely free of air bubbles. When placed in position with the bottom of the tube open and the air vent " A " at the top closed the solid particles are prevented from discharging by the surface tension film across the mouth of the feed tube and are so retained until the bottom of the tube is submerged.

The water flow is started by opening the inlet cock " N " at the bottom of the instrument, and



RAPID LABORATORY ELUTRIATOR.

the velocity is adjusted by means of a screw pinch cock on the rubber tube connection to the inlet cock. The correct velocity is indicated by the height of the water column in the piezometer tube " C." Three interchangeable bush nozzles are provided for the overflow outlet " O " which gives velocities in the upper vessel " H " ranging from 0·2 mm. to 2·0 mm. per sec.

When the pinch cock has been adjusted to give the required velocity the air vent " D " below the feed tube is opened momentarily, thus allowing the water to rise and submerge the bottom of the feed tube, thereby starting the feed. Since the upper end or mouth of the feed tube is sealed it must remain full of water or the original mixture of water and solid particles. Consequently for every particle that falls from the tube a corresponding volume of water must rise to take its place. This upward stream of water rising through the narrow outlet of the feed tube checks the downward descent of the solid particles causing them to fall in a slow even-flowing stream through the annular space between the top " F " of the central fitting " G " and the tube " E " into the large conical vessel " H " forming the upper classifying chamber.

So long as there are no solid particles in this chamber, the elutriating water flows partly through the narrow tube forming the axis of the central fitting " G," but mainly through the annular space between this fitting and the conical walls of the container. The accumulation of solid particles collecting in this annular space soon increases the density to such an extent as to cause practically all the water to flow through the tube in the central fitting " G." When this occurs the particles descend in a steady stream into the small space between the bottom of the central fitting " G " and the inlet " J " from the lower classifying vessel " L." They are prevented from descending through this inlet by the stream of water flowing upwards, and are instead immediately carried at a high velocity through the tube in the central fitting until, upon reaching the top of this tube, they impinge upon the under side of the umbrella-shaped top " F " of this fitting, thus effectively breaking up any aggregations of particles. The coarse and intermediate sized particles, with any fine particles still adhering to them, rebound from impact and are again projected *downwards* with considerable velocity into the annular space at the bottom of the conical vessel, whereas the released fine particles are carried *upwards* into the enlarged portion of the vessel, and upon reaching the top are carried out and collected as the fine fraction of the sample tested.

It will be noted that, in contrast to standard gravity elutriation, in the Kinetic Elutriator illustrated *all* coarse and intermediate particles, also all aggregations of particles, are repeatedly subjected to maximum impact velocity shattering blows. The liberated fine particles are immediately carried off to the fine overflow without having to pass through an eddying dense mass of unclassified material. The high velocity momentum, imparted to the coarse and intermediate particles after dis-associating impact, is in the opposite direction to the fine overflow carrying velocity. As a result of the continuous steady feed of unclassified material the density of the overflow is practically constant throughout the test, and it is unnecessary therefore to make any adjustments of velocity to compensate for changing density.

Having extracted the fine particles from the sample, it is usually required to sub-divide the residue. This is done by first closing the inlet cock "P," which allows the residue to descend into the smaller diameter classifying vessel "L." At the same time, the air vent "A" in the top of the feed tube is opened, which allows the water to descend washing out any stray particles that may have remained in this tube. As soon as the residue has settled, which usually takes two or three minutes, and may be accelerated by slightly opening the air vent cock "K" at the top of the small diameter classifying vessel, the inlet cock is reopened (without adjusting the screw pinch cock) and the test continued as before. The intermediate particles are quickly carried by the higher velocity in the small diameter vessel "L" into the upper conical vessel "H," where they are trapped and subjected to a final washing by continued circulation through and around the central fitting "G."

METAL MARKETS

Copper.—The great "copper bubble" was pricked during April and prices came down with a run, standard cash losing about £17 per ton in London, whilst in New York electrolytic slid from 24 cents to 18 cents per lb. Heavy re-sales by overbought consumers and operators undermined the market, which obviously had been pushed too high previously. Producers are still in a fairly strong position, but their output is increasing and is likely to expand still further in the immediate future. Meanwhile, many consumers have undoubtedly been frightened by recent price developments and have transferred to substitute metals such as aluminium where possible. Eventually, the copper-producing industry may feel the adverse effect of this movement.

Average price of cash standard copper: April, 1929, £81 2s. 7d.; March, 1929, £89 4s. 4d.; April, 1928, £61 14s. 1d.; March, 1928, £61 3s. 6d.

Tin.—Despite the operations of speculators credited with "bullish" opinions, prices lost about £20 during the past month. Consumption is excellent, but world production, stimulated by the previous price-advances, is obviously in excess of actual needs and this undermines confidence. It is rumoured that another group is prepared to take over the holdings of the present "bull group" which has been so active in this market during recent months, and as the price now looks fairly reasonable it is not out of the question that a new upward movement could be engineered. However, with supply in excess of demand and with large stocks, both visible and invisible, in existence it is obvious that the "bulls" would have quite a big task in carrying out any such plans.

Average price of cash standard tin: April, 1929, £206 19s. 7d.; March, 1929, £220 17s. 4½d.; April, 1928, £234 6s.; March, 1928, £232 16s. 5d.

Lead.—Early in April values developed considerable weakness, in sympathy with the general downward movement of non-ferrous metal prices. The drop was, of course, not unexpected, as the previous feverish advance was obviously unjustified by the position of the metal. Subsequently, consumers began to take more interest in the market, as prices looked fairly cheap, and a moderate recovery was witnessed. The undertone was strengthened by the falling-off in arrivals of fresh metal from producing countries due to various causes. It is possible that the gradual improvement in the basic position of this market, which was interrupted by the absurd speculative campaign during March, will now be resumed.

Average mean price of soft foreign lead: April, 1929, £24 11s. 10d.; March, 1929, £25 9s. 11d.; April, 1928, £20 8s. 8d.; March, 1928, £20 2s. 10d.

Spelter.—This market also declined during April, but the fall was not heavy. The output-restriction exercised by producers naturally gave the situation a certain amount of support, and the decision taken by the International Cartel during the month to reduce the rate of restriction from 7 to 5 per cent. revealed that in the opinion of most spelter producers the position was very healthy. Stocks, indeed, are low and makers are of the opinion that they could, with advantage, be increased, so as to obviate the risk of a sudden shortage, which might be the cause of an undesirable forcing-up of prices. At the present season of the year demand usually tends to expand, owing to an increase of activity in building.

Average mean price of spelter: April, 1929, £26 13s. 8d.; March, 1929, £27 3s. 5d.; April, 1928, £25 8s. 1d.; March, 1928, £25 0s. 5d.

Iron and Steel.—April was a good month for the Cleveland pigiron industry and a number of fresh furnaces were blown in. Quotations were advanced. Thus No. 3 foundry G.M.B. was unobtainable below 68s. 6d., and it was difficult for consumers to obtain early deliveries. Hematite was also a good market, with East Coast Mixed numbers quoted at 74s. As regards finished iron and steel, works were very active during the month, output approaching the rate witnessed during the busiest war years. Prices were well maintained. On the Continental iron and steel market prices experienced a setback towards the close of April. The International Tube Cartel, including European, American, and British makers, was established. The Americans joined the Rail Association during the month.

Antimony.—At the end of April English regulus was quoted about £50 to £55 per ton. Chinese material was dull, with spot priced at £37 10s. to £38 ex warehouse, whilst metal for shipment from China was valued at £33 to £33 10s. c.i.f.

Iron Ore.—A good demand has been seen for iron ore in April and with more blast furnaces being put into operation the output of Cleveland ironstone has been increased, whilst additional purchases of foreign ore were made. Prices are firm at about 23s. per ton c.i.f. for best Bilbao rubio.

Arsenic.—High grade Cornish white is still quoted at about £16 to £16 2s. 6d. per ton f.o.r. mines, demand being featureless.

Bismuth.—The official price remains at 7s. 6d. per lb. and demand shows little variation.

Cadmium.—Business is not, perhaps, quite as brisk as it has been of late, but a good turnover is reported and quotations are firm at about 4s. 1d. to 4s. 3d. per lb.

Cobalt Metal.—Sales have been fairly large recently, but the official price remains at 10s. per lb.

Cobalt Oxides.—Few fresh features are noticeable in this market, black oxide being quoted at 8s. per lb. and grey at 8s. 10d.

LONDON DAILY METAL PRICES

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

	COPPER.												TIN.				ZINC (Spelter).			
	Standard.				Electrolytic.				Wire Bars		Best Selected.									
	Cash.			3 Months.			Near.			Forward.			Near.			Forward.	Cash.			3 Months.			Near.			Forward.		
April	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.
10	79	2	6	77	2	6	85	0	0	95	0	0	95	0	0	—			—			209	0	0	209	5	0	26	13	9	26	8	9
11	84	0	0	80	12	6	85	0	0	95	0	0	95	0	0	—			—			210	10	0	211	0	0	26	15	0	26	10	0
12	80	10	0	77	5	0	88	0	0	91	0	0	91	0	0	85	10	0	86	15	0	206	0	0	206	15	0	26	13	9	26	10	0
15	76	15	0	77	0	0	85	0	0	89	0	0	89	0	0	—			—			203	17	6	204	2	6	26	12	6	26	8	9
16	77	0	0	74	5	0	80	0	0	84	0	0	84	0	0	79	0	0	80	0	0	205	2	6	205	17	6	26	10	0	26	6	3
17	77	10	0	75	12	6	84	0	0	85	0	0	85	0	0	—			—			204	17	6	205	10	0	26	13	9	26	11	3
18	78	10	0	76	7	6	84	0	0	85	0	0	85	0	0	—			—			203	15	0	204	10	0	26	17	6	26	13	9
19	77	10	0	75	0	0	83	0	0	84	0	0	84	0	0	81	0	0	82	5	0	200	0	0	200	12	6	26	12	6	26	8	9
22	77	15	0	74	10	0	83	0	0	84	0	0	84	0	0	81	0	0	82	5	0	200	15	0	202	15	0	26	13	9	26	10	0
23	77	15	0	74	10	0	83	15	0	84	15	0	84	15	0	81	0	0	82	5	0	202	15	0	204	10	0	26	11	3	26	8	9
24	77	12	6	74	12	6	84	0	0	84	5	0	84	5	0	—			—			203	7	6	205	0	0	26	6	3	26	3	9
25	77	7	6	74	7	6	83	15	0	84	5	0	84	5	0	—			—			199	15	0	201	15	0	26	0	0	25	17	6
26	73	15	0	72	15	0	83	0	0	84	0	0	84	0	0	78	5	0	79	10	0	197	15	0	199	5	0	26	10	0	26	8	9
29	75	15	0	72	12	6	83	0	0	84	0	0	84	0	0	—			—			198	0	0	200	0	0	26	15	0	26	10	0
30	78	0	0	74	0	0	83	0	0	84	0	0	84	0	0	78	5	0	79	10	0	198	15	0	201	5	0	26	13	9	26	13	9
May																																	
1	78	10	0	74	15	0	83	0	0	84	0	0	84	0	0	—			—			196	15	0	199	2	6	26	10	0	26	15	0
2	78	15	0	75	2	6	83	0	0	84	0	0	84	0	0	—			—			196	5	0	199	0	0	26	12	6	26	15	0
3	78	17	6	74	17	6	83	10	0	84	10	0	84	10	0	79	0	0	80	5	0	197	2	6	199	10	0	26	11	3	26	15	0
6	80	0	0	76	10	0	84	5	0	84	15	0	84	15	0	—			—			197	15	0	200	0	0	26	8	9	26	13	9
7	78	12	6	75	12	6	84	5	0	84	15	0	84	15	0	79	15	0	81	0	0	198	0	0	200	5	0	26	7	6	26	13	9
8	77	15	0	75	5	0	84	0	0	84	15	0	84	15	0	—			—			200	10	0	201	15	0	26	12	6	26	16	2
9	77	0	0	74	15	0	84	10	0	85	0	0	85	0	0	—			—			200	10	0	202	10	0	26	13	9	26	15	0

Platinum.—Rather quiet conditions have ruled recently and the general trading price is now about £13 10s. to £13 15s. per oz. for refined metal.

Palladium.—Little or no interest is evinced in this metal and there are now sellers at about £8 5s. per oz., while buyers are not inclined to pay much more than £7 5s.

Iridium.—Sponge and powder are somewhat easier at about £53 to £55 per oz.

Tellurium.—Demand is practically non-existent and quotations are nominal at 12s. 6d. to 15s. per lb.

Selenium.—The market is steady, with high grade black powder held for 7s. 8d. to 7s. 9d. per lb.

Manganese Ore.—Interesting features have been absent from this market during the last few weeks. Prices have not altered much, best Indian being about 1s. 2d. to 1s. 2½d. per unit c.i.f., with washed Caucasian about 1s. 1½d. to 1s. 1¾d.

Aluminium.—A very brisk demand developed during April, partly on rumours that prices were to be advanced. It has now been decided, however, that no change will be made in selling prices for the present and, although the volume of inquiry has lessened slightly, the market seems in a sound condition. Current quotations are £95 delivered for ingots and bars.

Sulphate of Copper.—Prices are easier in sympathy with copper, British material now being offered at about £29 10s. to £30 per ton.

Nickel.—Business is well maintained, the official price being unchanged at £175 per ton.

Chrome Ore.—A good demand continues in evidence, with quotations steady at £4 5s. to £4 7s. 6d. for 48 per cent. Rhodesian and £4 7s. 6d. to £4 10s. for 48 per cent. Indian.

Quicksilver.—Business is restricted to odd lots and prices are still about £22 2s. 6d. to £22 5s. per bottle for material on spot.

Tungsten Ore.—The worst stringency of supplies seems to be over, mainly owing to the lessened demand. For the present, however, prices remain rather high and Chinese ore for shipment is held for around 30s. per unit c.i.f.

	LEAD.							SILVER.		GOLD		
	Soft Foreign.						English.	Cash.	Forward.			
	Near.			Forward.								
	£	s.	d.	£	s.	d.	£	s.	d.	d.	d.	s.	d.	April
23	17	6		23	10	0	25	10	0	25 7/8	25 7/8	84	11	10
24	5	0		23	16	3	25	15	0	25 15/16	25 15/16	84	11½	11
24	10	0		24	2	6	26	2	6	25 15/16	25 15/16	84	11¼	12
24	7	6		23	16	3	26	0	0	25 15/16	25 15/16	84	11½	15
24	10	0		24	0	0	25	15	0	25 15/16	25 15/16	84	10½	16
24	15	0		24	5	0	26	0	0	25 15/16	25 15/16	84	10½	17
24	15	0		24	5	0	26	5	0	25 15/16	25 15/16	84	10½	18
24	15	0		24	5	0	26	5	0	25 15/16	25 15/16	84	10½	19
24	17	6		24	6	3	26	5	0	25 15/16	25 15/16	84	11¼	22
24	15	0		24	5	0	26	5	0	25 15/16	25 15/16	84	10½	23
24	13	9		24	2	6	26	5	0	25 15/16	25 15/16	84	10½	24
24	8	9		24	0	0	26	0	0	25 15/16	25 15/16	84	11	25
24	7	6		23	18	9	26	0	0	25 15/16	25 15/16	84	11¼	26
24	7	6		23	17	6	26	0	0	25 15/16	25 15/16	84	11¼	29
24	10	0		24	0	0	26	0	0	25 15/16	25 15/16	84	10¾	30
														May
24	8	9		24	1	3	26	0	0	25 15/16	25 15/16	84	11	1
24	10	0		24	2	6	26	0	0	25 15/16	25 15/16	84	11¼	2
24	8	9		24	6	3	26	0	0	25 15/16	25 15/16	84	11¼	3
24	8	9		24	5	0	26	0	0	25 15/16	25 15/16	84	11⅜	6
24	8	9		24	2	6	26	0	0	25 15/16	25 15/16	84	10¾	7
24	6	3		24	1	3	26	0	0	25 15/16	25 15/16	84	11⅛	8
24	3	9		24	1	3	25	15	0	25 15/16	25 15/16	84	11½	9

Molybdenum Ore.—Inquiry has broadened a little, but 85 per cent. concentrates are still priced at 34s. 6d. to 35s. per unit c.i.f.

Graphite.—The position of this article has not altered much and 85 to 90 per cent. Madagascar flake seems to be changing hands at about £27 to £29 per ton c.i.f., while high grade Ceylon lump realizes about £25 to £26 c.i.f.

Silver.—On April 2 spot bars stood at 25 15/16d. During the first half of the month India showed some buying interest, but supplies were plentiful and prices eased slightly to 25 3/4d. on 15th ult. Subsequently there was a general lack of interest and with a fair amount offering quotations declined, until spot bars closed at 25 3/16d. on April 30.

STATISTICS

PRODUCTION OF GOLD IN THE TRANSVAAL.

	Rand.	Elsewhere.	Total.
	Oz.	Oz.	Oz.
April, 1928	789,823	36,084	825,907
May	849,155	37,031	886,186
June	825,143	37,220	862,363
July	828,482	38,729	867,211
August	854,172	37,691	891,863
September	819,341	38,390	857,731
October	853,945	38,775	897,720
November	832,461	40,023	872,484
December	821,582	38,179	859,761
January, 1929	840,344	36,108	876,452
February	778,559	36,725	815,284
March	830,829	35,700	866,529
April	836,474	35,649	872,123

TRANSVAAL GOLD OUTPUTS.

	March.		April.	
	Treated Tons.	Yield Oz.	Treated Tons.	Yield Oz.
Brakpan	91,500	£148,025	89,000	£143,556
City Deep	87,000	24,126	95,000	25,848
Cons. Main Reef	58,300	22,246	58,500	22,343
Crown Mines	210,000	70,540	206,000	69,459
D'rb'n Roodepoort Deep	39,000	13,555	40,300	14,023
East Rand P.M.	142,500	37,430	143,000	38,196
Ferreira Deep	26,500	4,820	23,600	4,278
Geduld	85,000	26,588	83,000	26,074
Geldenhuis Deep	53,400	14,375	62,600	14,523
Glynn's Lydenburg	6,100	2,206	6,600	2,175
Government G.M. Areas	196,000	£373,760	202,000	£385,240
Kleinfontein	52,200	11,540	51,700	10,958
Langlaagte Estate	79,000	£110,287	81,000	£110,922
Luipaard's Vlei	22,500	5,682	22,800	5,723
Meyer and Charlton	17,300	£18,650	16,800	£20,039
Modderfontein New	144,000	73,842	146,000	72,856
Modderfontein B	69,000	25,739	69,000	25,487
Modderfontein Deep	43,000	22,727	44,600	23,346
Modderfontein East	63,500	19,865	67,000	20,546
New State Areas	75,000	£134,896	79,000	£138,555
Nourse	62,000	18,046	62,300	18,253
Randfontein	212,000	£200,872	205,000	£211,918
Robinson Deep	75,000	22,182	79,300	21,670
Rose Deep	56,000	11,915	57,500	11,997
Sabie	3,250	912	—	—
Simmer and Jack	76,500	18,745	73,000	18,192
Springs	67,000	£138,193	70,000	£142,907
Sub Nigel	23,400	20,769	22,800	19,937
Transvaal G.M. Estates	15,400	4,562	14,620	4,086
Van Ryn	38,000	£39,857	39,000	£38,452
Van Ryn Deep	62,000	£104,674	65,000	£105,514
Village Deep	58,000	14,994	58,500	15,078
West Rand Consolidated	85,500	£93,495	83,800	£91,659
West Springs	60,000	£75,996	62,600	£78,254
Witw'tersr'nd (Knights)	52,000	£45,695	52,500	£47,081
Witwatersrand Deep	45,000	9,839	46,000	10,377
Wolhuter	28,000	6,291	27,000	6,051

COST AND PROFIT ON THE RAND, Etc.

Compiled from official statistics published by the Transvaal Chamber of Mines.

	Tons milled.	Yield per ton.	Work'g cost per ton.	Work'g profit per ton.	Total working profit.
		s. d.	s. d.	s. d.	£
February, 1928	2,357,900	28 1	19 11	8 2	959,824
March	2,552,100	27 11	19 9	8 2	1,039,078
April	2,381,800	28 2	20 0	8 2	971,128
May	2,571,900	28 0	19 7	8 5	1,084,465
June	2,500,100	28 2	19 10	8 4	1,038,851
July	2,528,600	27 11	19 8	8 3	1,048,432
August	2,580,700	27 11	19 7	8 4	1,079,152
September	2,485,700	27 11	19 7	8 4	1,040,368
October	2,612,500	27 9	19 5	8 4	1,092,162
November	2,539,700	27 9	19 7	8 2	1,041,713
December	2,505,500	27 10	19 8	8 2	1,024,654
January, 1929	2,627,320	28 1	19 9	8 4	1,095,070
February	2,403,720	28 6	20 3	8 3	990,942
March	—	—	—	—	1,062,331

NATIVES EMPLOYED IN THE TRANSVAAL MINES.

	Gold Mines.	Coal Mines.	Diamond Mines.	Total.
April 30, 1928	199,820	16,696	5,664	219,700
May 31	198,461	16,943	5,742	222,172
June 30	197,186	16,870	5,650	222,340
July 31	194,584	16,695	5,189	220,345
August 31	194,788	16,553	4,839	218,578
September 30	194,936	16,724	4,535	215,843
October 31	193,147	16,767	4,807	216,362
November 30	190,870	16,803	4,880	216,628
December 31	187,570	16,059	4,444	208,473
January 31, 1929	192,526	15,845	5056	213,427
February 28	196,150	15,940	5,635	217,725
March 30	197,646	16,065	5,787	219,498
April 30	197,412	15,900	5,554	218,866

PRODUCTION OF GOLD IN RHODESIA.

	1926	1927	1928	1929
	oz.	oz.	oz.	oz.
January	48,967	48,731	51,356	46,231
February	46,026	46,461	46,286	44,551
March	46,902	50,407	48,017	47,388
April	51,928	48,290	48,549	—
May	49,392	48,992	47,323	—
June	52,381	52,910	51,762	—
July	50,460	49,116	48,960	—
August	49,735	47,288	50,611	—
September	48,350	45,838	47,716	—
October	50,132	46,752	43,056	—
November	51,090	47,435	47,705	—
December	48,063	49,208	44,772	—

RHODESIAN GOLD OUTPUTS.

	March.		April.	
	Tons.	Oz.	Tons.	Oz.
Cam and Motor	24,000	12,030	24,400	12,332
Globe and Phœnix	6,005	4,778	6,096	4,888
Lonely Reef	5,200	4,106	5,000	4,100
Rezende	6,400	2,980	6,400	2,950
Shamva	44,000	£22,236	46,000	£21,427
Sherwood Starr	4,800	£8,398	4,800	£8,537

WEST AFRICAN GOLD OUTPUTS.

	March.		April.	
	Tons.	Oz.	Tons.	Oz.
Ashanti Goldfields	9,214	9,876	9,206	10,256
Taquah and Abosso	9,460	£13,353	8,000	£13,360

AUSTRALIAN GOLD OUTPUTS BY STATES.

	Western Australia.	Victoria.	Queensland.	New South Wales
	Oz.	Oz.	Oz.	Oz.
April, 1928	36,487	2,811	846	318
May	29,264	2,990	321	397
June	39,449	3,932	498	487
July	29,399	3,208	772	154
August	37,991	2,637	690	3,447
September	32,397	3,366	644	364
October	36,565	2,632	820	256
November	31,466	3,111	865	—
December	36,097	—	—	208
January, 1929	27,384	—	—	—
February	28,177	—	—	—
March	25,848	—	—	—
April	39,166	—	—	—

AUSTRALASIAN GOLD OUTPUTS.

	March.		April.	
	Tons	Value £	Tons	Value £
Associated G.M. (W.A.)	5,201	9,130	4,657	9,448
Blackwater (N.Z.)	3,274	4,504	3,233	5,515
Boulder Persev'ce (W.A.)	4,448	14,788	6,196	14,342
Grt. Boulder Pro. (W.A.)	10,332	27,326	9,300	25,657
Lake View & Star (W.A.)	9,545	14,930	—	—
Sons of Gwalia (W.A.)	15,054	11,208	13,760	10,961
South Kalgurli (W.A.)	8,775	17,236	8,719	16,557
Waihi (N.Z.)	15,422	{ 5,041* / 30,500†	—	—

* Oz. gold. † Oz. silver.

GOLD OUTPUTS, KOLAR DISTRICT, INDIA.

	March.		April.	
	Tons Ore	Total Oz.	Tons Ore	Total Oz.
Balaghat	4,450	2,734	4,650	3,049
Champion Reef	8,865	5,269	7,820	4,721
Mysore	17,125	8,318	18,277	8,273
Nundydroog	11,010	6,663	11,005	6,666
Ooregum	14,000	7,446	14,000	7,378

MISCELLANEOUS GOLD, SILVER, AND PLATINUM OUTPUTS.

	March.		April.	
	Tons	Value £	Tons	Value £
Chosen Synd. (Korea)	7,760	12,105	7,970	12,543
Frontino& Bolivia (C'lbia)	1,900	7,570	1,710	4,207
La Noria (Mexico)	12,320	101,391*d*	—	—
Lena (Siberia)	—	20,757	—	16,430
Lydenburg Plat. (Trans.)	3,360	642*p*	3,500	616*p*
Marmajito (Colombia)	520	4,196	406	5,225
Mexican Corp. Fresnillo	77,795	131,740*d*	—	—
Onverwacht Platinum	2,317	463*p*	2,364	400*p*
Oriental Cons. (Korea)	—	32,500*d*	76,500*d*	—
St. John del Rey (Brazil)	—	32,300	—	41,500
Santa Gertrudis (Mexico)	49,052	145,013*e*	—	—

d dollars. *e* Profit in dollars. *p* Oz. platinoids.

PRODUCTION OF TIN IN FEDERATED MALAY STATES.

Estimated at 70% of Concentrate shipped to Smelters. Long Tons.

July, 1928	5,488	January, 1929	5,840
August	5,499	February	4,896
September	5,071	March	5,236
October	5,161	April	5,433
November	5,483	May	—
December	5,249	June	—

OUTPUTS OF MALAYAN TIN COMPANIES.

In Long Tons of Concentrate.

	Feb.	Mar.	April
Ampang	15½	14	21
Batu Caves	—	—	32
Changkat	60	60	53
Chenderiang	20	29	35
Gopeng	77½	80½	83½
Idris Hydraulic	35½	41¾	38¾
Ipoh	43½	51	42½
Jelapang	21	26½	23
Kamunting	63	93	81
Kent (F.M.S.)	51	57	58
Kepong	18	25	28
Kinta	30	27	30
Kinta Kellas	25	41½	59½
Kramat Pulai	22½	20½	19¼
Kuala Kampar	130	90	115
Kundang	32	33	35
Lahat	19½	18½	17¾
Larut Tinfields	70	85	84½
Malaya Consolidated	66½	54¾	73½
Malayan Tin	154¾	160¾	133
Meru	17½	16½	16
Pahang	208	222½	226¾
Pengkalen	51	65½	77½
Petaling	220	238	226
Rahman	56½	53½	59½
Rambutan	12	12	12
Rantau	55	50	44
Rawang	65	75	70
Renong	50¾	48½	50
Selayang	12½	22	—
Southern Malayan	95½	113	125
Southern Perak	47	66¾	86½
Sungei Besi	43	46	43
Sungei Kinta	33¾	31	20
Sungei Way	47½	62½	89¼
Taiping	41	48	53
Tanjong	24	24	24½
Teja Malaya	6	16	12
Tekka	50½	50½	43
Tekka-Taiping	45	54	—
Temoh	15¾	22	35
Tronoh	109¾	114	96

OUTPUTS OF NIGERIAN TIN MINING COMPANIES.

In Long Tons of Concentrate.

	February.	March.	April.
Amari	4¾	5½	6
Anglo-Nigerian	60	57	55
Associated Tin Mines	237	244	250
Baba River	4½	3½	3¼
Batura Monguna	3	4	—
Bisichi	56	58	61
Daffo	5	5	—
Ex-Lands	50	50	50
Filani	1½	1½	1½
Jantar	35	25	35
Jos	17	19¾	18½
Juga Valley	11	17½	9
Junction	20	14	6
Kaduna	30¼	28½	—
Kaduna Prospectors	18	17	—
Kassa	11	16	17
Lower Bisichi	4	5	5½
Mongu	35	30	35
Naraguta	16	12½	11½
Naraguta Durumi	9	9	—
Naraguta Extended	10	9	9
Naraguta Karama	18½	16½	19½
Naraguta Korot	15	15	15
Nigerian Base Metals	47	47	—
Nigerian Consolidated	20	20	20
N.N. Bauchi	150	150	160
Offin River	12	6½	6
Ribon Valley	18	17	14
Ropp	81	72	74
Rukuba	4	4	4
South Bukeru	12½	15	14½
Tin Fields	6½	7½	6
Tin Properties	27	26	19
United Tin Areas	4½	5½	4½
Yarde Kerri	15	15	—

OUTPUTS OF OTHER TIN MINING COMPANIES.

In Long Tons of Concentrate.

	Feb.	March	April
Anglo-Burma (Burma)	6	6	—
Aramayo Mines (Bolivia)	251	329	415
Bangrin (Siam)	41½	52½	66½
Berenguela (Bolivia)	27	32	—
Consolidated Tin Mines (Burma)	87*	91*	81*
Eastern Siam (Siam)	3½	4½	—
East Pool (Cornwall)	84	84½	—
Fabulosa (Bolivia)	145	154	—
Geevor (Cornwall)	68	73	70
Jantar (Cornwall)	13¾	19	—
Kagera (Uganda)	23	25	—
Polhigey (Cornwall)	—	—	20
San Finx (Spain)	27*	36*	—
Siamese Tin (Siam)	98	139½	120¼
South Crofty (Cornwall)	61½	66	65
Tavoy Tin (Burma)	44½	55	54
Theindaw (Burma)	4½	—	3½
Tongkah Harbour (Siam)	86	110	64
Toyo (Japan)	43	11	—
Wheal Kitty (Cornwall)	55	51	50

* Tin and Wolfram.

COPPER, LEAD, AND ZINC OUTPUTS.

		Mar.	April
Broken Hill Prop.	Tons lead conc.	1,298	—
Broken Hill South	Tons lead conc.	4,418	—
	Tons zinc conc.	4,538	—
Burma Corporation	Tons refined lead	6,602	6,554
	Oz. refined silver	628,211	625,327
Bwana M'Kubwa	Tons copper oxide	767	687
Electrolytic Zinc	Tons zinc	3,901	—
Indian Copper	Tons copper	78½	135
Messina	Tons copper	539	545
Mount Lyell	Tons concentrates	2,639	2,633
Namaqua	Tons copper	192	—
North Broken Hill	Tons lead conc.	6,990	7,560
	Tons zinc conc.	5,260	5,700
Poderosa	Tons copper ore	912	1,030
Rhodesia Broken Hill	Tons lead	345	210
	Tons slab zinc	1,007	835
San Francisco Mexico	Tons lead conc.	3,500	3,220
	Tons zinc conc.	3,900	3,800
Sulphide Corporation	Tons lead conc.	1,346	1,806
	Tons zinc conc.	2,657	2,770
Tetiuhe	Tons lead conc.	586	—
	Tons zinc conc.	1,628	—
Union Minière	Tons copper	10,800	—
Zinc Corporation	Tons lead conc.	5,331	—
	Tons zinc conc.	4,310	—

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

		February.	March.
Iron Ore	Tons	313,475	462,368
Manganese Ore	Tons	16,178	19,720
Iron and Steel	Tons	160,035	182,107
Copper and Iron Pyrites	Tons	29,522	25,466
Copper Ore, Matte, and Prec.	Tons	5,494	152
Copper Metal	Tons	9,888	14,541
Tin Concentrate	Tons	6,617	4,986
Tin Metal	Tons	1,051	1,261
Lead Pig and Sheet	Tons	19,246	21,579
Zinc (Spelter)	Tons	9,078	9,964
Zinc Sheets, etc.	Tons	1,755	2,005
Aluminium	Tons	1,627	1,844
Quicksilver	Lb.	—	19,224
Zinc Oxide	Tons	896	837
White Lead	Cwt.	12,150	14,721
Red and Orange Lead	Cwt.	3,232	3,449
Barytes, ground	Cwt.	38,967	44,442
Asbestos	Tons	1,889	1,666
Boron Minerals	Tons	1,005	493
Borax	Cwt.	5,467	12,317
Basic Slag	Tons	4,529	3,006
Superphosphates	Tons	18,856	26,984
Phosphate of Lime	Tons	25,579	28,197
Mica	Tons	216	264
Sulphur	Tons	10,507	3,089
Nitrate of Soda	Cwt.	286,630	416,539
Potash Salts	Cwt.	300,762	407,418
Petroleum: Crude	Gallons	28,689,716	51,192,683
Lamp Oil	Gallons	16,350,638	26,998,354
Motor Spirit	Gallons	70,407,029	84,508,954
Lubricating Oil	Gallons	7,685,750	7,594,244
Gas Oil	Gallons	5,804,516	11,615,855
Fuel Oil	Gallons	21,664,246	35,538,794
Asphalt and Bitumen	Tons	18,982	12,362
Paraffin Wax	Cwt.	104,146	115,719
Turpentine	Cwt.	18,353	10,078

OUTPUTS REPORTED BY OIL-PRODUCING COMPANIES.

In Tons.

	Feb.	March.	April.
Anglo-Ecuadorian	12,024	13,968	13,204
Apex Trinidad	31,880	37,210	35,820
Attock	7,135	6,457	5,241
British Burmah	5,016	5,440	5,223
British Controlled	31,528	32,795	—
Kern Mex	860	916	789
Kern River (Cal.)	3,226	1,183	3,827
Kern Romana	3,572	3,213	2,707
Kern Trinidad	3,733	3,610	3,086
Lobitos	25,268	27,629	26,899
Phœnix	32,516	41,007	34,048
St. Helen's Petroleum	11,214	7,762	5,198
Steaua Romana	50,390	63,100	61,850
Trinidad Leaseholds	28,800	32,300	32,500
Venezuelan Consolidated	—	2,143	2,157

QUOTATIONS OF OIL COMPANIES SHARES.

Denomination of Shares £1 unless otherwise noted.

	April 8, 1929	May 8, 1929
	£ s. d.	£ s. d.
Anglo-American	3 10 0	3 2 6
Anglo-Ecuadorian	1 2 0	1 2 0
Anglo-Egyptian B	2 17 0	3 0 0
Anglo-Persian 1st Pref.	1 7 0	1 7 0
" " Ord.	4 11 0	4 10 0
Apex Trinidad (5s.)	1 7 0	1 10 0
Attock	3 3 6	2 19 0
British Burmah (8s.)	7 0	7 0
British Controlled ($5)	5 6	5 0
Burmah Oil	4 8 9	4 6 3
Kern River, Cal. (10s.)	8 0	7 9
Lobitos, Peru	2 3 6	2 4 6
Mexican Eagle, Ord. (4 pesos)	13 4	14 0
" " 8% Pref. (4 pesos)	12 6	13 0
Phœnix, Roumania	14 0	12 9
Royal Dutch (1,000 fl.)	33 0 0	32 16 3
Shell Transport, Ord.	4 17 0	4 17 0
" " 5% Pref. (£10)	10 0 0	10 0 0
Steaua Romana	12 6	12 0
Trinidad Leaseholds	4 13 6	4 14 0
United British of Trinidad (6s. 8d.)	10 3	10 0
V.O.C. Holding	4 1 0	4 4 0

PRICES OF CHEMICALS. May 8.

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

		£ s. d.
Acetic Acid, 40%	per cwt.	16 6
" 80%	"	1 16 0
" Glacial	per ton	66 0 0
Alum	"	8 10 0
Alumina, Sulphate, 17 to 18%	"	6 15 0
Ammonia, Anhydrous	per lb.	10
" 0·880 solution	per ton	19 0 0
" Carbonate	"	27 10 0
" Nitrate	"	24 0 0
" Phosphate	"	40 0 0
" Sulphate, 20·6% N.	"	10 13 0
Antimony, Tartar Emetic	per lb.	1 10½
" Sulphide, Golden	"	7
Arsenic, White	per ton	16 5 0
Barium Carbonate, 94%	"	5 10 0
" Chlorate	per lb.	4
" Chloride	per ton	10 15 0
" Sulphate, 94%	"	6 0 0
Benzol, standard motor	per gal.	1 11
Bleaching Powder, 35% Cl.	per ton	7 0 0
" Liquor, 7%	"	3 5 0
Borax	"	20 0 0
Boric Acid	"	30 0 0
Calcium Chloride	"	4 12 6
Carbolic Acid, crude 60%	per gal	1 11
" " crystallized, 40°	per lb.	6½
Carbon Disulphide	per ton	24 0 0
Citric Acid	per lb.	2 2
Copper Sulphate	per ton	29 10 0
Cyanide of Sodium, 100% KCN	per lb.	7
Hydrofluoric Acid	"	6
Iodine	per oz.	1 0
Iron, Nitrate	per ton	6 10 0
" Sulphate	"	1 17 6
Lead, Acetate, white	"	41 10 0
" Nitrate	"	34 0 0
" Oxide, Litharge	"	35 0 0
" White	"	41 10 0
Lime, Acetate, brown	"	8 10 0
" " grey, 80%	"	17 0 0
Magnesite, Calcined	"	9 0 0
Magnesium, Chloride	"	6 15 0
" Sulphate	"	3 2 6
Methylated Spirit 64° Industrial	per gal.	1 5
Nitric Acid, 80° Tw.	per ton	21 0 0
Oxalic Acid	per lb.	3
Phosphoric Acid	per ton	29 15 0
Potassium Bichromate	per lb.	4½
" Carbonate	per ton	26 2 6
" Chlorate	per lb.	3
" Chloride 80%	per ton	9 0 0
" Hydrate (Caustic) 90%	"	33 5 0
" Nitrate, refined	"	20 10 0
" Permanganate	per lb.	5
" Prussiate, Yellow	"	6¾
" " Red	"	1 9
" Sulphate, 90%	per ton	11 5 0
Sodium Acetate	per ton	21 0 0
" Arsenate, 45%	"	26 0 0
" Bicarbonate	"	10 10 0
" Bichromate	per lb.	3½
" Carbonate (Soda Ash)	per ton	6 0 0
" " (Crystals)	"	5 5 0
" Chlorate	per lb.	2¾
" Hydrate, 76%	per ton	14 10 0
" Hyposulphite	"	9 0 0
" Nitrate, 96%	"	10 12 0
" Phosphate	"	11 10 0
" Prussiate	per lb.	4½
" Silicate	per ton	9 10 0
" Sulphate (Salt-cake)	"	2 10 0
" " (Glauber's Salt)	"	2 5 0
" Sulphide	"	9 0 0
Sulphur, Roll	"	10 0 0
" Flowers	"	11 10 0
Sulphuric Acid, 168°	"	6 5 0
" " free from Arsenic, 144°	"	4 0 0
Superphosphate of Lime, 35%	"	3 0 0
Tartaric Acid	per lb.	1 4½
Turpentine	per cwt.	2 7 3
Tin Crystals	per lb.	1 6½
Titanous Chloride	"	10
Zinc Chloride	per ton	12 0 0
Zinc Dust	"	35 0 0
Zinc Oxide	"	42 0 0
Zinc Sulphate	"	9 10 0

SHARE QUOTATIONS

Shares are £1 par value except where otherwise noted.

GOLD AND SILVER:	April 8, 1929. £ s. d.	May 8, 1929. £ s. d.
SOUTH AFRICA:		
Brakpan	4 6 0	4 7 6
City Deep	13 0	11 3
Consolidated Main Reef	18 0	16 9
Crown Mines (10s.)	3 2 6	3 3 0
Daggafontein	1 2 6	1 1 0
Durban Roodepoort Deep	9 6	8 6
East Geduld	2 2 6	1 18 9
East Rand Proprietary (10s.)	11 3	10 0
Ferreira Deep	6 3	5 9
Geduld	3 12 0	3 8 0
Geldenhuis Deep	4 6	4 6
Glynn's Lydenburg	5 0	5 0
Government Gold Mining Areas (5s.)	1 19 3	1 19 0
Kleinfontein	2 6	2 6
Langlaagte Estate	1 0 6	1 1 3
Luipaards Vlei (4s.)	4 6	4 3
Meyer & Charlton	9 0	10 0
Modderfontein New (10s.)	5 4 6	5 3 9
Modderfontein B (5s.)	17 0	15 0
Modderfontein Deep (5s.)	1 10 0	1 10 0
Modderfontein East	1 4 6	1 5 9
New State Areas	1 11 6	1 13 0
Nourse	8 3	8 6
Randfontein	6 3	6 0
Robinson Deep A (1s.)	14 0	13 9
" B	11 0	9 6
Rose Deep	6 0	5 3
Simmer & Jack (2s. 6d.)	3 0	3 0
Springs	3 6 0	3 1 3
Sub Nigel (10s.)	1 13 0	1 19 0
Transvaal Gold Mining Estates	9 0	8 3
Van Ryn	9 0	9 0
Van Ryn Deep	1 19 0	1 19 0
Village Deep	4 0	4 0
West Rand Consolidated (10s.)	9 0	8 0
West Springs	18 6	18 6
Witwatersrand (Knight's)	7 0	7 0
Witwatersrand Deep	5 0	4 6
Wolhuter	1 0	1 0
RHODESIA:		
Cam and Motor	1 18 0	1 18 0
Gaika	8 0	7 0
Globe and Phœnix (5s.)	10 9	9 9
Lonely Reef	1 3 0	1 1 3
Rezende	19 0	16 9
Shamva	7 0	7 0
Sherwood Starr	11 6	8 9
GOLD COAST:		
Ashanti (4s.)	1 4 3	1 4 0
Taquah and Abosso (5s.)	2 3	2 9
AUSTRALASIA:		
Associated Gold Mines (4s.), W.A.	1 3	1 0
Blackwater, N.Z.	2 6	2 6
Boulder Perseverance (1s.), W.A.	9	9
Great Boulder Proprietary (2s.), W.A.	2 6	2 6
Lake View and Star (4s.), W.A.	11 0	12 9
Sons of Gwalia, W.A.	3 3	2 9
South Kalgurli (10s.), W.A.	16 9	16 9
Waihi (5s.), N.Z.	13 9	13 6
Waihi Grand Junction, N.Z.	1 0	1 0
Wiluna Gold, W.A.	1 3 0	1 2 0
INDIA:		
Balaghat (10s.)	6 0	5 3
Champion Reef (10s.)	10 3	8 9
Mysore (10s.)	15 6	14 0
Nundydroog (10s.)	18 6	16 0
Ooregum (10s.)	12 0	11 0
AMERICA:		
Camp Bird (2s.), Colorado	2 9	2 6
Chosen (Korea)	18 6	1 0 0
Frontino and Bolivia, Colombia	8 9	8 9
Keeley Silver ($1.00), Ontario	2 0	2 0
Mexican Corporation, Mexico	12 6	14 6
Mexico Mines of El Oro, Mexico	6 6	4 0
Oroville Dredging, Colombia (4s.)	2 9	2 0
Panama Corporation	12 6	15 6
St. John del Rey, Brazil	15 9	19 0
Santa Gertrudis, Mexico	10 0	11 3
Selukwe (2s. 6d.), British Columbia	7 3	5 9
Vipond ($1), Ontario	4 3	4 9
RUSSIA:		
Lena Goldfields	4 3	4 3

DIAMONDS:	April 8, 1929. £ s. d.	May 8, 1929. £ s. d.
Consol. African Selection Trust (5s.)	1 8 9	1 8 9
Consolidated of S.W.A.	1 5 6	1 3 6
De Beers Deferred (£2 10s.)	14 6 0	13 11 0
Jagersfontein	2 11 6	2 10 6
Premier Preferred (5s.)	6 0 0	5 17 6
COPPER:		
Arizona Copper (5s.) Arizona	2 0 6	2 2 6
Bwana M'Kubwa (5s.) Rhodesia	1 0 6	18 3
Esperanza Copper, Spain	19 0	19 0
Messina (5s.), Transvaal	19 0	19 3
Mount Lyell, Tasmania	2 2 9	2 3 0
Namaqua (£2), Cape Province	1 7 0	1 10 0
N'Changa, Rhodesia	4 7 0	3 11 6
Rio Tinto (£5), Spain	60 7 6	57 0 0
Roan Antelope (5s.), Rhodesia	2 10 0	2 7 6
Tanganyika, Congo and Rhodesia	3 7 0	3 1 6
LEAD-ZINC:		
Broken Hill Proprietary N.S.W.	1 7 0	1 7 6
Broken Hill North, N.S.W.	5 12 0	5 11 0
Broken Hill South, N.S.W.	3 6 0	3 8 6
Burma Corporation (10 rupees)	17 3	17 3
Electrolytic Zinc Pref., Tasmania	1 15 0	1 16 6
Mount Isa, Queensland	2 8 0	2 7 0
Rhodesia Broken Hill (5s.)	4 6	3 9
Russo-Asiatic Consd. (2s. 6d.)	4 0	3 9
San Francisco (10s.), Mexico	1 16 0	1 17 6
Sulphide Corporation (15s.), N.S.W.	19 0	19 0
Tetiuhe (5s.), Siberia	5 0	4 0
Zinc Corporation (10s.), N.S.W.	2 10 0	2 11 6
TIN:		
Aramayo Mines (25 fr.), Bolivia	3 8 3	3 0 0
Associated Tin (5s.), Nigeria	11 6	9 9
Bangrin, Siam	1 16 6	1 13 9
Bisichi (10s.), Nigeria	10 0	9 3
Briseis, Tasmania	3 6	3 6
Chenderiang, Malay	11 0	8 6
Dolcoath (10s.), Cornwall	9	9
East Pool (5s.), Cornwall	1 9	1 6
Ex-Lands Nigeria (2s.), Nigeria	3 0	2 6
Fabulosa ($1.00), Bolivia	1 0	9
Geevor (10s.), Cornwall	8 6	7 6
Gopeng, Malaya	2 3 9	2 3 9
Idris (5s.), Malaya	15 9	14 9
Ipoh Dredging (16s.), Malay	1 8 0	1 7 0
Kamunting (5s.), Malay	15 9	15 0
Kinta, Malay	11 6	11 0
Lahat, Malay	14 0	14 0
Malayan Tin Dredging (5s.), Malay	1 6 0	1 6 0
Mongu (10s.), Nigeria	10 3	10 0
Naraguta, Nigeria	1 5 0	1 2 6
Nigerian Base Metals (5s.)	5 6	4 9
N.N. Bauchi, Nigeria (10s.)	1 2 6	1 2 0
Pahang Consolidated (5s.), Malay	10 6	10 0
Pengkalen (5s.), Malay	1 0 0	19 3
Petaling (2s. 4d.)	13 6	12 9
Renong Dredging, Malay	1 8 6	1 8 9
Ropp (4s.), Nigeria	8 6	8 0
Siamese Tin (5s.), Siam	16 3	15 0
South Crofty (5s.), Cornwall	4 9	4 3
Southern Malayan	13 3	13 6
Southern Perak, Malay	2 7 0	2 7 0
Southern Tronoh (5s.)	11 0	11 0
Sungei Besi (5s.), Malay	13 6	13 6
Tavoy (4s.), Burma	15 0	12 3
Tekka, Malay	1 0 0	19 0
Tekka Taiping, Malay	1 1 0	1 0 6
Toyo (10s.), Japan	11 0	11 0
Tronoh (5s.), Malay	1 0 9	1 0 6
FINANCE, ETC.:		
Anglo-American Corporation	2 2 0	2 1 0
Anglo-French Exploration	1 5 0	1 3 6
Anglo-Oriental (5s.)	19 6	19 3
British South Africa (15s.)	1 17 6	1 16 6
Central Mining (£8)	18 10 0	18 12 6
Chemical & Metallurgical Corp. (2s.)	4 0	4 0
Consolidated Gold Fields	2 17 0	2 14 6
Consolidated Mines Selection (10s.)	19 3	16 9
General Mining and Finance	19 0	18 3
Gold Fields Rhodesian (10s.)	10 9	10 6
Johannesburg Consolidated	2 7 6	2 6 6
London Tin Syndicate	3 13 6	3 6 3
Minerals Separation	6 17 6	5 13 6
National Mining (8s.)	4 6	4 0
Rand Mines (5s.)	3 2 0	3 3 0
Rhodesian Congo Border	7 18 6	5 17 6
Southern Rhodesia Base Metals	14 6	11 6
South-West Africa	16 0	16 0
Tin Selection Trust	1 5 3	1 3 9
Union Corporation (12s. 6d.)	4 10 9	4 8 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 pamphlets, lists of patents on mining and metallurgical subjects, and abstracts of the yearly reports of mining companies.

TEST WORK ON THE ROAN ANTELOPE PILOT PLANT

In *Engineering and Mining Journal*, for March 30, Walter C. Page, Metallurgical Engineer in charge of Pilot Plant and Concentration, Roan Antelope Copper Mines, Ltd., describes the position after operating its 25-ton pilot plant continuously for eleven months, during which time ore from fourteen different working places has been tested thoroughly. He states that the Roan Antelope Copper Mines, Ltd., is assured that the large tonnage of ore thus far developed, which is represented by the quantity tested, is amenable to treatment by the same process, with respect to grinding and reagents, as that worked out in the pilot plant. Results obtained in the latter are, of course, not to be regarded as insusceptible of improvement in the larger plant. The objective of the pilot plant work was not to achieve the ultimate at the outset, but rather to develop a simple scheme which would give good results in the pilot mill and be capable of duplication in a large plant. Refinement of process, higher recoveries, improvement in grade of concentrate, and best economy are rather matters that can better be left for working out in a plant of large capacity. For all that, the recoveries and grade of concentrate obtained in the pilot work were excellent, as accompanying data indicate.

The results of the pilot work indicate that the ore is a partially silicified shale, averaging 3·25 to 3·5% copper, in which the copper occurs principally as chalcocite, with varying amounts of bornite. The copper minerals are finely disseminated throughout the shale—so much so that the appearance of the ore is quite misleading. This is evidenced by the fact that when the first borehole was put down by the company, it passed entirely through the ore formation, and the latter was not detected until core assays were available. The chalcocite and bornite apparently follow the bedding planes. A complete analysis of the ore disclosed in one of the boreholes is as follows :—

	%		%
Cu	3·6	Al_2O_3	28·4
Insol.	72·0	$CaCO_3$	3·91
SiO_2	51·9	$MgCO_3$	2·38
Fe_2O_3	4·6	S	0·9

Some sodium and potassium are also present, probably as alkali silicates. In the foregoing analysis the lime and magnesia have been calculated to carbonates. They are present probably as silicates, however. A striking characteristic of the ore is the almost complete absence of pyrite or other non-copper-bearing sulphides. Very little, if any, of these is present. As a result the concentration of the ore by flotation is rendered extremely simple as regards obtaining a high-grade copper concentrate, and involves no selective action between different sulphide minerals. Owing to the shaly character of the ore, considerable colloidal slime is produced in grinding, which, if not inhibited, does interfere in the subsequent flotation work and demands careful selectivity between gangue and sulphides.

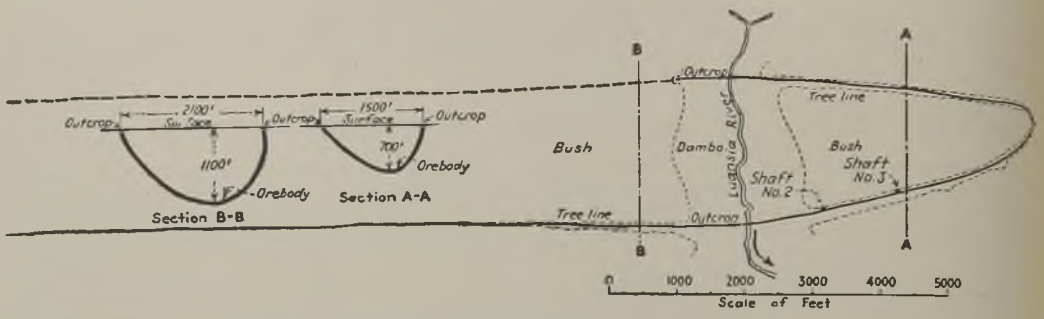
Operation of the pilot plant prior to June 1, 1928, was preliminary in character, serving to determine the basic characteristics of the ore and the reagents to be used. From June 1 on, however, the plant was operated continuously, as if it were in production, running on ore from fourteen different working places in succession, as previously stated. These included every representative working face which was opened in the mine prior to or during the period of pilot plant operation. Ore was taken from different faces in shafts Nos. 1, 2, 3, 5, 9, and 10 (2 and 3 are shown on map on p. 310), these being the shafts, inclined and vertical, from which representative ore was available. Openings Nos. 4, 6, 7, and 8 were shallow pits or shafts. On the ore from each working place, which in most cases was the ore produced from the various cross-cuts, the pilot plant would run for one to two weeks, after which it would continue on ore from a different working, without break in operation and with practically the same reagents as had been determined upon in the period of preliminary operation prior to June 1. Complete and detailed data covering the results obtained on every shift from June 1 to October 20 inclusive afforded the basis for the final report made on the concentration work. The pilot plant flow sheet is shown in the accompanying illustration. Inasmuch as it is self-explanatory, the equipment involved calls for little comment. Approximately 94 to 98% minus 150-mesh was the grinding practice followed during the period of representative operation. This appeared to be the critical point of grinding necessary to liberate the sulphide minerals when using the classifying equipment with which the plant was equipped. This is shown by the fact that the screen analyses of the tailing gave assays of approximately 0·75% copper on plus 150-mesh material, whereas the minus 150-mesh material assayed approximately 0·18% copper. With the use of bowl classifiers and with more efficient and flexible classifier operation in the large plant to be erected, it will probably be possible to practice somewhat coarser grinding with equally good recovery. The fact that the ore has an average and uniform specific gravity of 2·8 should permit very clean classification and liberation of the sulphides with the use of bowl classifiers. This is on account of the wide variation in the specific gravity of the sulphide minerals and the shale gangue minerals.

Classifier overflow was maintained at approximately 25% solids throughout the period of operation, whereas the tailing showed approximately

22% solids, owing to dilution by the return of intermediate middling products.

Temperature of the mill-feed water varied, naturally, from 80 to 90° F. The region in which the Roan Antelope mine is situated is 13° south of the equator and at 4,000 ft. elevation.

the test work. The combination most often used was Aerofloat and pine oil. Consumption of reagents was unique in that it was extremely low, considering the grade of ore, fineness of grinding, and the shaly character of the ore, with the resultant production of colloidal slime.

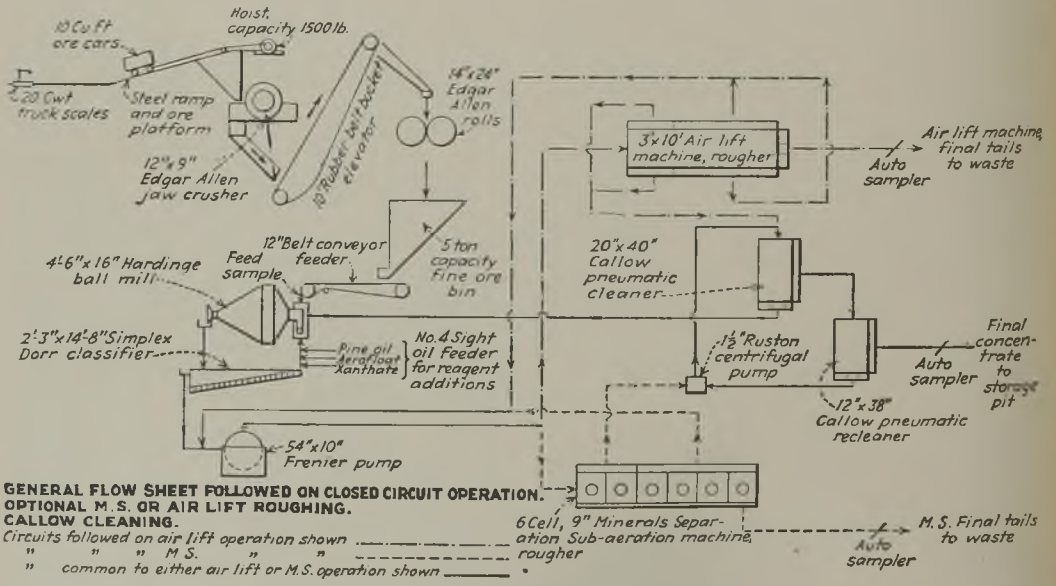


SKETCH SHOWING ROUGHLY POSITION OF SHAFTS 2 AND 3.

The interference experienced from colloidal slime produced in grinding the shaly ore, previously referred to, was overcome more through the adoption of preventive measures against their inherent propensity to form on a large scale in the grinding and classifying circuits, or against their building up in the flotation circuits, rather than through the use of any corrective reagents. The author expresses the opinion that much less trouble will probably be experienced from slime in the future plant, because of the use of more efficient

The consumption of the Aerofloat-pine oil combination was roughly 0·03 lb. Aerofloat per ton of feed and 0·04 lb. pine oil per ton of feed. Approximately 0·02 lb. cresylic acid per ton of feed was used as a diluent for the Aerofloat to permit more uniform and satisfactory feeding of this concentrated reagent.

Addition of such very small amounts of reagents called for the devising of special means. It was accomplished by the use of sight-feed oilers, or drip cups. Reagents were fed ordinarily at a rate



FLOW SHEET OF ROAN ANTELOPE PILOT PLANT.

and more suitable grinding and classifying equipment.

The reagents used in the flotation department were in general Aerofloat, potassium xanthate, and steam-distilled pine oil and cresylic acid. These were used in varying combination throughout

of 4 to 20 drops per minute. This was the range made possible by the use of sight-feed oilers. This method of feeding proved entirely satisfactory, although calling for close inspection. The problem of discovering how to feed such small amounts of reagents required in a plant of such limited capacity

gave some difficulty at first. However, the author had previously used drip cups for this purpose in the test plant of the International Smelting Company at Tooele, Utah, on lead-zinc work. The cost of reagents delivered at the present time at the Roan Antelope property is roughly 50% more than in the Western states.

Use of lime was found neither beneficial nor detrimental within reasonable amounts; that is, the presence of lime had little, if any, effect on grade of concentrate or recovery. Addition of lime was not found necessary, because of the basic characteristic of the ore and because both the mine water that was used in the pilot plant operation, as well as the water from the local rivers, was slightly alkaline. In the large plant it is expected to use lime to facilitate settlement of the tailing for recovering water. It is obvious that any lime returning to the mill in reclaimed water will do no harm in the flotation circuit.

Owing to the lack of other than copper-bearing sulphides in the ore, an excellent grade of concentrate and a remarkably high recovery were obtained. This will be seen in the following representative tables of pilot plant operation on four different lots of ore from as many working places. Results obtained from a continuous run of 14 shifts on crosscut ore from No. 3 shaft, at 420 ft. vertical depth, were as follows :—

	%
Feed, Cu	3·52
Tailing, Cu	0·22
Concentrate, Cu	50·05
Concentrate, Fe	3·49
Concentrate, insoluble	27·9
Concentrate, S	13·45
Calculated recovery	94·10

A run of 23 shifts on ore from a different crosscut in No. 3 shaft gave the following results :—

	%
Feed, Cu	3·41
Tailing, Cu	0·207
Concentrate, Cu	55·26
Concentrate, Fe	3·49
Concentrate, insoluble	20·4
Concentrate, S	15·17
Calculated recovery	94·26

A run of 20 shifts on ore from No. 10 shaft gave comparable results :—

	%
Feed, Cu	3·39
Tailing, Cu	0·255
Concentrate, Cu	51·08
Concentrate, Fe	3·69
Concentrate, insoluble	25·03
Concentrate, S	14·89
Calculated recovery	92·94

A run of 47 shifts on ore from No. 2 shaft gave the following results :—

	%
Feed, Cu	3·71
Tailing, Cu	0·207
Concentrate, Cu	49·01
Concentrate, Fe	4·63
Concentrate, insoluble	27·46
Concentrate, S	15·13
Calculated recovery	94·32

The average results of twelve shifts taken from ten days' operation on ore from No. 9 shaft is as follows: Concentrate, 64% Cu, 4% Fe, 10% insoluble, 18% S. Tailing, 0·15% Cu. These data are given merely to show what it is possible to do on this ore when the conditions more nearly approach the ideal, as they did in this operation. This particular ore apparently was more highly silicified, a condition which resulted in a correspondingly smaller production of slime. Screen analysis of the flotation concentrate showed it to be 96 to 98% minus 200 mesh. The concentrate settled very quickly and was easily filtered. It was almost impossible to maintain steady and satisfactory cleaning and re-cleaning operations in a plant of such small capacity and on such a high ratio of concentration giving such a relatively small quantity of concentrate to re-treat. This condition naturally will not exist in the future economic operation, and concentrate averaging from 55 to 65% copper may not unreasonably be anticipated, with eventual recoveries that will be at least equal to those obtained. In conclusion, it may be said that equally good results were obtained from the use of Minerals Separation and air-lift type machines shown in the flow sheet when operating consecutively on ore from the same respective working places.

SEISMIC METHODS IN GEOPHYSICS

In our issue of February last abstracts were given from a paper by W. H. Fordham on this subject, which gave some particulars of the instruments employed and we append here abstracts from A. O. Rankine's paper at the March meeting of the Institution of Mining and Metallurgy, which it will be seen deals with the general principles of this important and increasingly interesting method.

The author asked the question: "How does a seismograph, by recording the times of arrival of the disturbances transmitted to it through the earth from an explosion, enable us to estimate the depths and shape of the interfaces between strata of different materials?" What are the particular materials is not for the moment important. The interface, for example, may be that between a salt-dome and the overlying sands and clays, or a limestone anticline such as occurs in the Persian oilfields. What is necessary for the successful application of the seismic method is that certain physical properties of the strata should change abruptly across the interface, and that the extent of the interface should be large compared with its depth below the surface.

The earth, if shaken in any way, for example by a natural earthquake or an explosion deliberately arranged, has the power of transmitting the disturbance at definite speeds through its crust to distant points. It does not transmit well; the vibrations are rapidly damped out as they progress and consequently violent shocks are required to make themselves felt at considerable distances. The earth being a solid, the disturbance in general consists of two parts (*a*) a longitudinal disturbance in which the vibration coincides with the propagation direction, and (*b*) a transverse disturbance with a vibration direction at right-angles to the former. Of the two the longitudinal disturbance travels much more rapidly, and as the method we are describing depends on the times of

arrival at the seismograph of those disturbances first reaching it, we may leave out of consideration the slower transverse disturbances, and thus avoid for present purposes the complications of the complete theory.

The fundamental requirement as regards the physical properties of the media above and below the interface which it is desired to locate by the seismic method is that the velocity of longitudinal disturbances must be less above the interface than below it. This condition is fulfilled, for example, by Texas salt-domes, the velocity in salt being rather more than 5,000 m. per sec., and in the overlying sands and clays about 2,000 m. per sec. In general, if V_1 is the velocity in the upper medium and V_2 that in the lower medium, V_2/V_1 must be

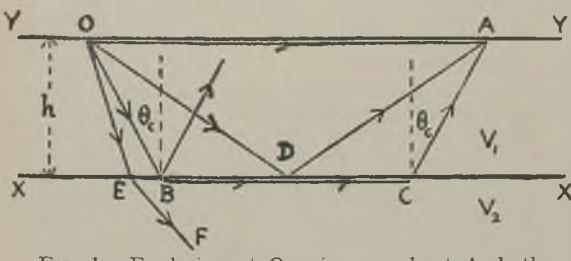


FIG. 1.—Explosion at O, seismograph at A, both as earth's surface YY. Velocity above interface XX is V_1, below V_2, with $V_2 > V_1$.

greater than unity, and the greater the value of this ratio the more favourable will the conditions be for applying the seismic method.

Let us consider first the simplest possible case, namely, a horizontal interface XX (Fig. 1) below the earth's surface YY (also horizontal) at a depth h. Suppose, too, that the earth's surface receives a sufficient shock at O, and that a seismograph is situated at A, capable of recording (*a*) the instant of occurrence of the shock, and (*b*) the times of the subsequent arrival of the various disturbances. (In practice the shock is produced by an explosion, and the instant of occurrence is transmitted by a wireless signal actuated by the explosion. The seismograph, also, can be designed to record, if required, both vertical and horizontal movements of the earth's surface at A.) If we treat the problem according to the ordinary laws of reflection and refraction, two disturbances of a longitudinal character may be expected to reach the seismograph at different times. First, the direct disturbance travelling close to the surface from O to A with a velocity V_1, and therefore arriving at a time $t_1 = \frac{OA}{V_1}$ reckoning from the instant at which the explosion occurred. Secondly, there will be a disturbance reflected at D, and travelling by the path ODA, so that OD and DA make equal angles with the interface. The time occupied for this path, which is wholly in the upper medium, is

$$t_2 = \frac{OD + DA}{V_1}$$

and this makes t_2 necessarily greater than t_1, for $OD + DA$ is greater than OA, the third side of the triangle ODA. This is unfortunate, for it generally rules out the possibility of measuring t_2. For the reflected disturbance is often small compared with that arriving direct by the path OA, and the latter usually causes the seismograph to be disturbed for a time much greater than the difference between t_1 and t_2. Consequently, the reflected effect becomes obscured by the larger and still persisting direct effect, and it is only in exceptional cases that it can be identified.

If we consider refracted rays, i.e. those passing into the lower medium, it is clear that all of them will be directed downwards, as OEF, and will not again reach the surface. With one extreme exception. The ray OB, which makes an angle θ_c—the critical angle—with the normal, has its counterpart in the ray BC which grazes along below the interface, and corresponds also to any ray such as CA emerging again into the upper medium also at the critical angle, and reaching the seismograph. (The value of θ_c is, of course, given by the relation $\sin \theta_c = V_1/V_2$). Apart from the question of how much energy follows this path (this will be considered later), it is obvious that the time of transmission may become *less* than that for the direct path OA. For, when OA is great, the advantage accruing from the high velocity V_2 over the part BC of the path more than compensates for the delay due to penetration down to the interface and back to the surface again. Thus, even a small disturbance, travelling by the equivalent path $OBCA$, would, at great enough distances, reach the seismograph *earlier* than the relatively great direct disturbance. Unlike the reflected effect, its initiation would be recognizable on the seismogram because it would not be inextricably mixed up with the larger movements which follow it. This would be a very great advantage, for, as will be seen later, it would provide means of determining the depth of the interface, in terms of the measured times of arrival of the *initial* impulses at the seismograph in various positions with respect to the explosion.

Before going further, however, we must consider the question of whether in actual fact any energy at all travels by the path under investigation. According to the ordinary laws of refraction there

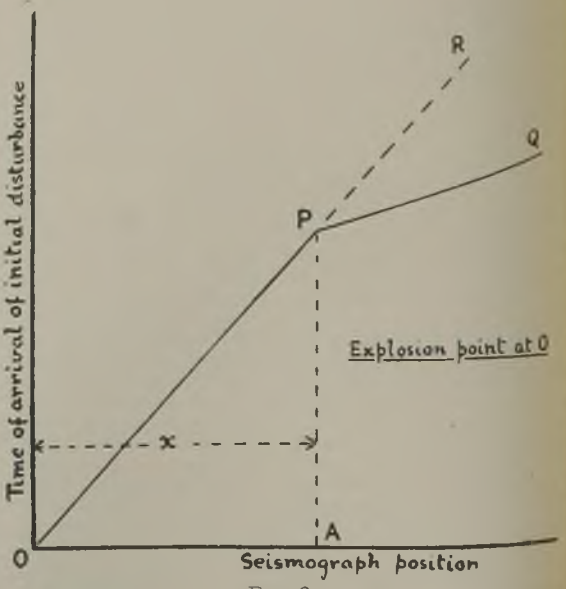


FIG. 2.

is none, for the disturbance at B would from this point of view suffer total reflection, and no energy would enter the lower medium. On this basis no practical application of the phenomenon could be made. Yet the fact remains that the effects of natural earthquakes, at distances so small that the curvature of the earth plays no important part, do indicate on seismographs preliminary disturbances of appreciable magnitude, which appear to have travelled by paths similar to that indicated above; at any rate, the times of arrival are consistent with the assumption of such paths. This apparent contradiction has been to some extent satisfactorily explained by Dr. H. Jeffreys,[1] who has given reasons for regarding the problem, in relation to short distances, as one of diffraction rather than refraction. The theory he develops leads to the curious, and, from our present point of view, satisfactory conclusion that an appreciable amount of energy may be expected to arrive at A at a time calculable by making the erroneous but simple assumption that the ordinary laws of refraction do apply, with $OBCA$ as the path.

On this basis we may expect similar effects in the smaller-scale problem of relatively shallow subsurface structures, using artificial explosions instead of natural earthquakes. This is, indeed, the essence of the seismic method; that it is possible to identify on the record produced by a seismograph sufficiently remote from the explosion, the time of arrival of a small but definite preliminary disturbance, which corresponds to, but does not actually follow, the limiting grazing path of the kind described.

The procedure in practice is to obtain seismographic records at a sufficient number of distances in a straight line from the explosion point. Each seismogram shows the instant of explosion (transmitted wirelessly) and the interval elapsing between this and the first arrival of the earth-borne disturbance. There follows, if the record extends over a long enough period, the disturbance due to the much slower air-borne wave, used at one time to derive the instant of explosion, but in modern practice this is no longer of importance. The onset of the earth-borne disturbance changes type as the distance increases. For short distances that travelling by the direct path OA (Fig. 1) arrives first, and if a graph is plotted, as in Fig. 2, with time of arrival (reckoned from the instant of explosion) as ordinate, and distance from explosion point as abscissa, a straight line OP is obtained, the slope of which is a measure of $\frac{1}{V_1}$. At a certain distance, denoted by x, the indirect disturbance corresponding to the path $OBCA$ (Fig. 1) arrives simultaneously with the direct disturbance. Thereafter, at greater distances, the small indirect disturbance arrives first, and corresponds to the branch PQ of the time-graph, the slope of which measures $\frac{1}{V_2}$. Owing to its relatively great magnitude the time of arrival of the direct disturbance is usually recognizable even when it reaches the seismograph *after* the indirect one; this is shown in the dotted line PR, which is a continuation of OP. In practice, however, this branch of the curve is not of importance, for we are concerned primarily with *first* arrivals throughout.

If the slopes of OP and PQ differ considerably, i.e., if the ratio $\frac{V_2}{V_1}$ is large, the point P at which the break in the curve occurs can be found accurately, and consequently the distance x at which the transmission times of the direct and indirect disturbances are equal. A relation exists between x and the depth h of the interface, which is conveniently expressed by the equation :—

$$\frac{h}{x} = \frac{1 - \sin \theta_c}{2 \cos \theta_c} \quad \text{(a)}$$

Moreover, the value of the critical angle θ_c is given by the ratio of the slopes, of the lines OP and PQ. For

$$\frac{\text{slope of } PQ}{\text{slope of } OP} = \frac{1}{V_2} \Big/ \frac{1}{V_1} = \frac{V_1}{V_2} = \sin \theta_c.$$

Thus the graph in Fig. 2 obtained from the seismograms provides the data for calculating the depth h of the interface, and incidentally gives the velocities in the upper and lower media. For example, if $V_2 = 2V_1$, $\sin \theta_c = \frac{1}{2}$ or $\theta_c = 30°$. Inserting the values in equation (a) we obtain $\frac{h}{x} = \frac{1}{2\sqrt{3}} = 0{\cdot}288$, which gives h as about 29% of x.

The structure chosen for this argument is the simplest possible one, but it emphasizes the fundamental principle upon which the seismic method is based, namely the elucidation of underground structure by examination and interpretation of the time-graphs of *initial* disturbances received by seismographs, and more particularly the discontinuities shown by these curves. Many more complicated cases arise in practice. The interface may be sloping instead of horizontal; it may not be plane, or it may have abrupt changes of direction, as in faults. Moreover, there may be more than two superposed strata. All such complications introduce new unknown variables besides the depth, whose effects can be worked out theoretically. To deal with these additional features in practice it is necessary to multiply the observation points, and to change both the position of the explosion point and the direction of the observation line. In all cases the method of attack has to be indirect, that is, a probable form of structure must be assumed, and the corresponding expected results calculated; these are then compared with the field observations, and the general assumptions modified, if necessary, until satisfactory agreement is secured. Accumulated experience is, of course, also of great value, since it facilitates the recognition of particular forms of the time-distance-graphs associated with particular types of underground structure.

A number of examples were then given of typical time-graphs and their interpretation, including some of the more complicated cases and the author concluded his paper as follows :—No real difficulty, except that of the labour computation, presents itself in dealing theoretically with still more complicated structures. The calculations are tedious, and sometimes it is necessary to resort to graphical methods. But provided there are sufficient surface data none of the problems is really insoluble. There are, of course, cases where the practical limitations of the method, as at present used, prevent enough data being obtained. If, for example, the structure sought is very deep, or if there are only small differences in the velocity in

[1] H. Jeffreys: "On Compressional Waves in Two Superposed Layers." *Proc. Camb. Phil. Soc.*, vol. xxiii, p. 472 (1926).

the media, the ranges of observation may be beyond the sensitivity of the instruments available, even when the greatest practicable explosion is used. The line of attack here is obviously that of improvement in the seismographs and in the efficiency with which the earth is shaken by the initial explosive disturbance. Improvement of instruments may also lead to another method of dealing with the problem. A three-component seismograph, i.e. one giving the vertical and two horizontal components of the earth's movement, if it could be made to record these movements precisely, would enable the angles of emergence of the disturbances reaching the earth's surface to be determined. This would add to our knowledge of underground structure by providing a check on the calculations in the previously described method.

This whole question is, however, bound up with that of celerity of survey. The chief advantage of the seismic method over the gravity method is the relative rapidity with which results can be obtained, both as regards the field observations themselves and the calculations that have to be made therefrom. We must, I think, be careful to preserve this feature even at the expense of some accuracy. The seismograph should be regarded as the pioneer, to be followed, if desirable and possible, by the torsion balance to secure more exact information. Where the earth's surface is rough, however, the gravity method becomes inapplicable; in such circumstances it seems that we shall have to rely on the seismic method as the chief weapon of attack upon deeply-buried structures. Consequently, it may ultimately be necessary to develop the method on more precise lines, so as to take into account factors hitherto neglected. The most important of these seems to be the probable curvature of the disturbance paths, arising from gradual increase of velocity with depth in the various strata, in addition to the abrupt changes at the interfaces upon which the approximate theory solely depends.

THE FROOD ORE DEPOSIT: A SUGGESTION AS TO ITS ORIGIN

At the Annual General Meeting of the Canadian Institute of Mining and Metallurgy C. V. Corless read a paper on the Frood ore deposit which is published in the March *Bulletin*. We quote below therefrom *verbatim*.

The origin of various types and groups of ore deposits was some years ago a subject of much controversy. To this statement the copper-nickel deposits near Sudbury afforded no exception. Not since the Report of the Ontario Nickel Commission, in 1917, has there been any serious discussion of the origin of this very important group. This may be because, from the opening-up of Murray mine by the British America Nickel Corporation until the recent work at Frood mine, no new orebody of importance has been developed in the district.

The controversy fifteen or twenty years ago between those who favoured the theory of magmatic segregation, among whom Dr. A. P. Coleman was the leading exponent, and those who considered that most, if not all, of the Sudbury deposits could more satisfactorily be accounted for by the theory of replacement, will be remembered by many members of the Institute. Perhaps, as too often happens in controversial discussion, each side tended to over-emphasize the importance of those geological phenomena which seemed to be most easily accounted for by the theory it favoured. A more balanced view would perhaps admit that replacement was probably predominant in the formation of most of the offset deposits, and magmatic segregation in that of most of the marginal deposits. But there is danger in generalization. Each body of ore should be studied by itself, and no general conclusion of this kind should be allowed to warp the judgment in making such a study.

It is the purpose of the present paper to summarize briefly a few interesting facts that have been revealed by diamond drilling, and by the development completed at the time of writing, in what appears at present to be the largest body of copper-nickel ore in the Sudbury area, and to offer a tentative hypothesis suggested by these facts, in the hope that investigation and discussion regarding the origin of this very important group of ore deposits may be renewed.

Allusion has already been made to the grouping of the orebodies, by Dr. Coleman, into two classes: 'marginal deposits' and 'offset deposits.' The latter, it may be remembered, he further subdivided into 'columnar offsets' and 'parallel offsets.' The Frood orebody he classified as a parallel offset. As will be seen by inspection of his well-known and most useful geological map, the surface of the offset in which the Frood orebody occurs is roughly two miles in length, and is at an average distance of about one mile from the southern margin of the norite laccolith.

If we were to speculate as to the origin of such offsets, we might naturally surmise that the profound disturbance which must have accompanied the movement into a new position in the earth's crust, of several hundreds of cubic miles of fluid magma comprising the Sudbury laccolith, from some, probably near-lying but more deeply seated, reservoir, may have caused local cracks, or zones of shattering and weakness, into which sheets, or dykes, or 'offsets' of magma from the same general source were forced. Such conception of this detail of the geological event need not imply that any such crack was ever actually wide open. But however we may imagine the Frood offset to have originated, the fact remains that the greatest known copper-nickel orebody in the Sudbury area is a large part of it.

The Frood orebody has a north-east to south-west strike, and, on the Mond Nickel Company's property, a north-westerly dip of about sixty degrees. The ore is of the type usual in the Sudbury nickel-copper mines, consisting of a mixture of sulphides of iron, copper, and nickel, with small amounts of gold, silver, and platinoids, and varying amounts of rock matter. The sulphides are chiefly pyrrhotite (with a small percentage of pyrite), chalcopyrite, and pentlandite. The pentlandite is generally more intimately distributed throughout the pyrrhotite than is the chalcopyrite; but a considerable amount of the pentlandite is easily distinguished by its characteristic colour and cleavage.

The sulphides in the upper 800 ft. of the orebody, or thereabouts, are largely thickly spotted through rock. There is, in fact, so large a percentage of rock matter in this part of the orebody that, unless the

ore is used as a flux for cleaner ore, it will undoubtedly be milled before smelting.

The ore improves with depth until, at about 800 ft. from surface, well over 50% of the whole is low enough in rock content to be suitable for direct smelting. The smelter grade of the block of ore between 800 and 1,100 ft. depth (on the Mond Nickel Company's property) averages 2·1% copper and 2·4% nickel. In the next 300 ft. block, from 1,100 to 1,400 ft. depth, the rock content has further diminished, copper remains nearly constant, and nickel increases to 2·7%. In the 300 ft. block from 1,400 to 1,700 ft. depth, rock matter further decreases and nickel again slightly increases. From 1,700 to 2,000 ft. depth, both copper and nickel increase and rock matter still further diminishes. The average assay of nickel and copper combined is over 5% in this block, the ratio of copper to nickel being approximately three to four.

As implied in the above, the Mond Nickel Company sank a 2,000 ft. shaft and opened-up the ore in 300 ft. blocks from 800 to 2,000 ft. depth. The steady improvement in the grade of the ore thus opened-up, and to a slightly greater depth as indicated by a few holes drilled from surface to a little over 2,000 ft. depth, proved to be of so much interest that the Company decided to drift into the hanging-wall, in order to continue the exploration by drilling to a depth of about 3,500 ft. (from surface).

The results of this underground drilling were so important that the 2,000 ft. shaft was deepened with all possible speed to 3,350 ft., and the ore was quickly opened-up on the 2,800 ft. and 3,100 ft. levels. At time of writing, the average analysis of the large ore section developed on the 2,800 ft. level is approximately 12·5% insoluble, 7% copper, 3% nickel; and of that on the 3,100 ft. level is 3·1% insoluble, 21% copper, 1·7% nickel. On the latter level, as will be observed, the enrichment in copper has become so great that the chalcopyrite and rock matter together total about 70% of the whole, leaving only about 30% for the pyrrhotite and pentlandite. Of this remainder (30%), the nickel is between 5 and 6%. And, indeed, if a similar calculation is made for any other level, the nickel will be found to be a remarkably constant percentage of the pyrrhotite and pentlandite taken together. The pentlandite is generally about one-sixth of the two minerals taken together, or about 20% of the pyrrhotite with which it is associated. This approximate constancy of ratio between the pentlandite and the pyrrhotite in the different blocks of ore may be due to the practical identity of their specific gravities. Or, it may be partly due to considerable similarity in the chemical properties of iron and nickel, and to the comparatively slight difference (about 5%) in their atomic weights.

Before entering into a discussion as to what light, if any, these facts may cast on the origin of the Frood deposit, it may be well, by a brief summary, to focus attention on them a little more sharply :—

(1) Viewed broadly, the Frood ore, as far as developed, shows a steady diminution in rock matter and increase in sulphide content, with depth, passing from ' spotted norite ' or ' spotted diorite ' in the upper levels, to practically clean sulphides at about 3,000 ft. depth.

(2) Though there are local variations, the nickel-bearing mineral, pentlandite, bears a remarkably constant ratio to the pyrrhotite, if the rock matter and chalcopyrite are allowed for in the average analyses of the large blocks of ore developed down to 3,100 ft. depth.

(3) Though the chalcopyrite is more variable than the pentlandite, as is true in all Sudbury copper-nickel ore deposits, yet the copper percentage of the total sulphides, as shown by average analyses of the blocks of ore down to 2,000 ft. depth, is fairly uniform. A clearly noticeable increase in copper percentage begins a little below 2,000 ft.; this increase becomes marked at about 2,500 ft.; it is so marked from 2,800 ft. to 3,100 ft. that, at the latter depth, the chalcopyrite constitutes about 65% of the total ore. Incidentally, it may be added that the gold, silver, and platinoids increase somewhat beyond the proportionate increase in base metals.

Now, these appear to the writer to be phenomena which we might infer would probably result from a relatively sudden injection of a large body of highly fluid magma, very rich in sulphides of iron, nickel, and copper, forced into the earth's crust along some local, not too far from vertical, plane of weakness. As already suggested, suitable conditions for such a geological occurrence may have been afforded during the upheaval, before local conditions had recovered balance and become stable, either after, or closely accompanying, the major intrusion of the hundreds of cubic miles of magma, the uneroded remnant of which is now known as the Sudbury norite laccolith.

If this fundamental conception of a sudden intrusion of a richly mineralized body of magma, the uneroded part of which now constitutes the Frood offset, be granted, the rest is easy to imagine. Such a large body of magma, heavily loaded with sulphides, encased between walls of rather low heat-conductivity, would probably remain fluid for sufficient time to effect the differentiation with depth which is being revealed by the recent exploration and development. With its heavily concentrated load of sulphides, such differentiation would be very rapid, as is illustrated by the rapid separation of sulphides and slag in a furnace settler or forehearth. Possibly the conductivity for heat, of the north wall of the offset (the present hanging-wall), may have been slightly lessened by the nearness of the large laccolith, which may not yet have solidified. At any rate, during the period of regrouping of the elements and incipient crystallization of the minerals, while the magma of the offset was still highly fluid, a large percentage of the lighter rock-forming minerals would tend to float, and the sulphides would tend to sink, forming with increasing depth an increasingly rich concentration of ore in the lower part of the magma, the uneroded part of which in the course of millions of years was to be known as the Frood ore deposit. The analogy of this differentiation with the separation, by gravity, of slag and matte in a furnace settler, may be useful, but should not be pushed too far. The volume and depth of the molten materials in a settler do not permit of any perceptible differentiation beyond separation into slag and matte. Nor should a magma be considered as a mere melt of the materials we now find to have crystallized out from it. In trying to account in this way for the enrichment in copper on the deeper levels of the mine, we have to consider these facts: The atomic weight of copper is about 8% greater than that of nickel and about 14%

greater than that of iron. But chalcopyrite is about 9% lower in specific gravity than either pentlandite or pyrrhotite. Possibly under the physical and chemical conditions existing at the time, some heavier mineral than chalcopyrite may have first formed. Or, again, the relative specific gravities of chalcopyrite, pentlandite, and pyrrhotite, before and after crystallization, may be quite different. If anyone has reliable data on these points, it is hoped they will be brought out in discussion. Otherwise, if the hypothesis suggested withstands criticism, these points should be investigated.

As already indicated, the writer is aware of the controversial nature of any hypothesis regarding the origin of any Sudbury ore deposit. The above suggestion, of an original segregation of sulphides by gravity in the parent magma, before intrusion of the laccolith, and of a further differentiation after the intrusion of the Frood offset, is put forward, however, in the hope that geologists, who are better fitted by their training and have more time to consider such questions than mining engineers, who must give first attention to extraction and reduction of the ore, will renew research and discussion on the origin of the Sudbury copper-nickel deposits. It is perhaps not possible that complete agreement should be reached on so debatable a subject. Probably the ore in the various deposits, and even in different parts of individual deposits, reached its present position in more than one way. It is suggested that, if the above hypothesis casts light on the origin of the Frood deposit, the Levack orebody (or rather orebodies), as well as some others, should be reconsidered. The district has become so important that it merits much more thorough and detailed geological study than it has yet received. It is further suggested that the hypothesis of segregation of at least a large part of the sulphides before the intrusion of the Sudbury laccolith, and of the origin of the Frood offset chiefly from this concentrated part of the parent magma, may afford a natural explanation of the occurrence of so large a part of the known ore in the district (perhaps as much as 50% of the total) in so small an offset.

There are some very real difficulties in connection with the origin of the marginal deposits which have never been adequately explained by the theory of magmatic segregation of the sulphides after the intrusion of the norite laccolith. Though the scope of the present paper does not permit of a discussion of these, it is suggested that the Frood orebody may furnish the hypothetical key to the solution of some of these difficulties.

After all, segregation of the sulphides before intrusion of the laccolith is not a great step from segregation after intrusion. Even should the latter, which has probably been the most generally accepted theory, come to be replaced by some modification, or by a wholly different theory, we must grant that it served a most useful purpose in directing the minds of mining men so clearly to the great importance of the lower contact of the laccolith, and to its offsets.

It is not, however, contended that because the suggested sequence of events at Frood is conceivable, it is necessarily true, or even necessarily probable. This mode of origin does appear to be at least capable of accounting for the rather unusual group of phenomena revealed so far at this mine. The origin of any group or type of ore deposits, because of the remoteness of the events, the obscurity of many of the essential conditions, and the inimitable greatness of scale of the phenomena, must always remain a matter of inference. Under such circumstances, no intolerance of opinion, or of reasonable suggestion, should exist; discussion should be broad-minded and frank; and any tentative conclusion should be regarded merely as a stepping-stone, the truth being perhaps approachable, but beyond human power to prove conclusively.

STRENGTH OF CONCRETE OR SAND-FILLED MEMBERS AS MINE SUPPORTS

W. J. Walker and S. F. Gimkey, in papers before the Chemical, Metallurgical, and Mining Society of South Africa and the South African Institution of Engineers, presented details of some tests on which they have been engaged for some months past. We quote here from the former, published in the *Journal* for February last.

These experiments were originally planned to determine the distribution of pressure along axially loaded sand-filled steel pipes of different diameters, with the object of determining their suitability as mine props. Experimental work of any kind, as it goes on, gives results and yields information which generally leads to another method of attack from that originally intended, and that was what happened in the case of the experiments undertaken.

Below is emphasized and indicated briefly the essential results obtained in these tests.

As indicating the importance of the subject with regard to its application to mining fields other than those of the Rand, it is of interest to note that as most of the Ruhr coal mines are owned by steel companies it is proposed to substitute steel for timber in about 75% of the mines during the next five years. At present 9% of the coal mines are using steel supports exclusively, as compared with 5% last year, 3% in 1926, and 1% in 1925. By the end of this year it is expected the percentage will have risen to 14. Estimates show that the saving in costs by the use of steel supports is considerable. When wood was used exclusively the cost was 91 pfennig (about 11d.); where steel is used the cost is 45 pfennig (5½d.). If 75% of the Ruhr Mines turn over to steel arches and pit props, the monthly saving will be about £130,000.

Fig. 1 is merely a diagrammatic indication of the theoretical problem involved in the pressure distribution through a sand column which is loaded vertically. This indicates a pipe filled with sand, two plungers, one at the top and one at the bottom, with an intensity of pressure on the ends—P_0; at a distance x from the top, the vertical pressure is p while q is the horizontal.

The horizontal pressure q is the important one,

as far as the stability and strength of the column is concerned. The relation between p and x and q and x is shown in the graphs (Fig. 2).

Taking the usual theory developed by Rankine and applying it to this particular problem—to a 6 ft. pipe, 6 in. diameter, and taking the angle of repose of the sand as being 30°, the pressure distribution over a sand-filled column, with plungers on top and bottom, is given by the p curve in Fig. 2. The pressure is high at the ends, and

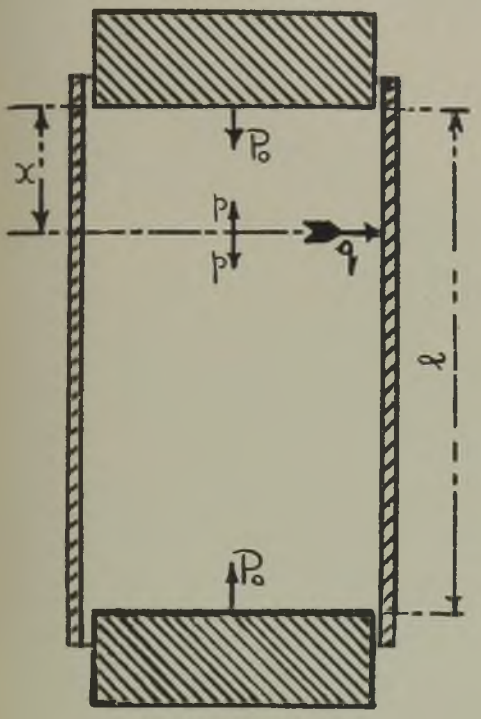


Fig. 1.

the curve represents the load pressure as it diminishes towards the centre. That, of course, is due to the pressure being taken up laterally on the pipe walls. The q curve is below the p curve and is of the same form but flatter, while the load is a mere fraction—in this case a third of the vertical pressure.

Table I.—Mild Steel Pipes.

Pipe Dimensions.	Maximum Load. (long tons).	Compression (inches).	Remarks.
5 in. by $\frac{1}{4}$ in. by 3 ft.	55	$3\frac{9}{16}$	Buckled.
Ditto, with 54—$\frac{3}{8}$ in. holes	55	$9\frac{1}{4}$	Buckled.
Ditto, 1 ft. long, with 60—$\frac{3}{8}$ in. holes	65	$4\frac{1}{2}$	Burst.
6 in. by $\frac{3}{16}$ in. by 3 ft.	80	4·3	Buckled.
10 in. by $\frac{3}{16}$ in. by 3 ft.	240	4·9	Burst and buckled.
12 in. by $\frac{1}{4}$ in. by 3 ft.	360	5·4	Partial failure.

It will be observed from the results of tests on sand-filled pipes given in Table I that the second pipe is a similar pipe to the first, but with 54 $\frac{3}{8}$ in. holes drilled in the walls. The third one is a pipe of the same diameter, but a foot high only with 60 $\frac{3}{8}$ in. holes in it, and the load was 55 tons in both the first and second cases, in spite of the weakening of the second pipe by the drilling of these holes; and in the second pipe, which was a foot high, the load was 65 tons. Another interesting point about the first two tests was this: the compression in inches, that is, the compression of the sand column, in the first case, was $3\frac{9}{16}$, while in the second pipe, which was similar in all respects, excepting that it had 54 $\frac{3}{8}$ in. holes drilled in it, the compression of the sand was $9\frac{1}{4}$ in.

Table II.

Pipe diameter.	Ratio of lateral to longitudinal pressure.
5	0·485
6	0·440
10	0·266
12	0·213
16	0·167
30	0·09

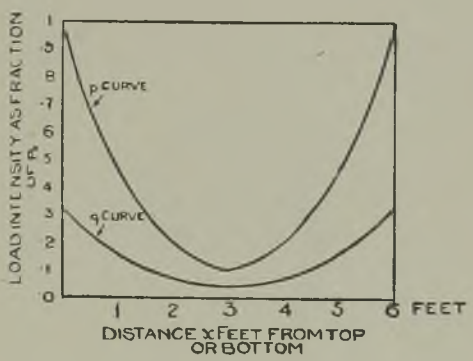


Fig. 2.

Table II indicates a set of the most important results obtained. This gave the cue for further experiments. By calculation, applying the ordinary thin cylinder formula to the pipes tested, the value of the ratio of the lateral pressure—that is q—to the longitudinal pressure p in a 5 in. pipe, was 0·485, the 6 in. 0·440, down to the 12 in. which is 0·213. The last two figures relating to the 16 in. pipe and the 30 in. pipe are extrapolated from the results obtained with those other four pipes; that is, in the 16 in. pipe, the ratio of the lateral pressure to the longitudinal would be 0·167, in the case of the 30 in. pipe it would be 0·09.

The next set of tests were carried out with the object of determining the strength of some of the "pancake" columns used on the Reef in some of the mines. All the "pancake" columns tested were from 18 in. to 20 in. in diameter. The Amsler testing machine used would not take anything over 24 in., and the only sizes of which we could avail ourselves were 18 to 20 in. diameter. The loads which these columns take—and quite a number were tested—were from 35 to 115 tons.

Based on the usual 6 in. cube tests, on which reliance is placed for determining the strength of these columns, the loads carried by columns of that nature should be somewhere in the neighbourhood of 250 to 300 tons. The value of the load taken is anything from a third to a quarter of the value as indicated by cube tests; in other words, the greater the area of the discs the less becomes the intensity of the load which they will take. That is because, when these discs are placed on top of one another, they have not anything like good surface contact; there is point contact all over, and consequently the thrusting of stones through the "pancakes," shearing all the cement binding the stones; and, in addition to that, the higher the column—that is the greater the number of "pancakes"—the quicker the column will shear, because the probability of shearing is increased by the number of "pancakes" in a column. The net result is that a sand-filled pipe column will take the bigger load—or, putting it in a more practical manner, a 30 in. pancake will take a load based on these results, somewhere in the neighbourhood of 150 tons only, whereas a 30 in. sand-filled pipe—say $\frac{1}{8}$ in. thick—will take a load somewhere in the neighbourhood of a thousand tons.

The next stage of the work was suggested by certain tests which were carried out at the University on behalf of the Crown Mines. These consisted of tests on telescopic steel tube columns made up of tubes (rivetted sheet steel) of two diameters and $\frac{1}{4}$ in. thick.

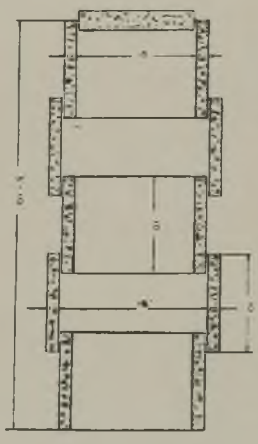


Fig. 3.

Fig. 3 indicates the nature of the telescopic arrangement applied to these tests. The column is on the left. Taking the bottom tube first, the diameter was somewhere in the neighbourhood of 17 in. in that case. The next one was somewhere in the neighbourhood of 16 in., and so on; 17 in., 16 in., 17 in., to the top. Various arrangements were tried; some with four telescopic tubes; some with five; and in some cases the smaller ones were at the bottom and sometimes the larger ones. The load taken in this Crown Mines test was somewhere in the neighbourhood of 290 tons. In conjunction with these tests similar tests were carried out on non-pressure Hume pipes arranged in the same way as the steel ones, of internal diameters of 18 in. and 16 in., the thickness of the tubes' walls being $1\frac{1}{2}$ in. These were tested with the idea, presumably, of determining the possibility of the use of a cheaper type of pipe than the steel pipe. The normal load taken by these non-pressure concrete Hume pipes was somewhere in the neighbourhood of 10 tons only, which, of course, meant they were not suitable for the purpose intended. Table III shows the results of tests on telescopic tubes of Hume pipes, which were carried out on the same lines as those just described. But the tests on the steel pipes and the concrete pipes already tested indicated that the failure of the Hume pipes at that time was due to the flat ends of the smaller cylinders.

Table III.—Five Section Telescopic Column of Hume Pipes with Sharp Edges.

Type of Piping.	Max. load (long tons).	Max. Com. (inches).
Non-pressure	40	$5\frac{3}{4}$
50 lb. piping	130	$8\frac{3}{4}$
100 lb. Piping	230	11
150 lb. Piping	285	9
200 lb. Piping	330	8

In these later tests, the small collars were tapered; i.e., the walls were tapered to give them easy penetration into the sand. The idea was conceived that prevention of penetration threw undue stresses on the larger collars, which always burst first. They were always the primary cause of failure.

"Pancake" plants exist to such an extent on the Reef that it was considered that some sort of structure corresponding to a "Pancake" might be built up, and, therefore, be in line with previous methods of support. This particular idea was a development from the Hume pipe tests. The idea was conceived, instead of having columns such as Hume pipe columns, to have small rings 4 in. thick, as used for "pancakes," and have the hole through the rings of fairly large diameter, build them up on top of one another with a layer of sand between them, and sand inside the whole length of the collar. The first tests were carried out on cast iron rings, and the inside edges. The inside edges of these rings are not flat but they are sharpened; in the cast iron rings they were sharpened to a 45° angle—that is the internal diameter of the ring was represented by the edge of the angle—and in carrying out tests with these cast iron rings the load taken was 284 tons for an internal diameter of 6 in., and calculating out the ratio of the lateral to the longitudinal pressure from those tests, the value was determined to be somewhere in the neighbourhood of 3·67; whereas, in the case of the 6 in. plain pipe column the value was somewhere in the neighbourhood of 2·27. This indicated that sharpening the inside edges (as was the original conception, of course) diminished the lateral pressure by breaking the surface of the interior of the sand column.

From the information thus obtained it was decided to try reinforcing concrete rings. These rings were 24 in. in diameter, with an internal diameter of 12 in., and were reinforced near the outer periphery by a $\frac{3}{4}$ in. diameter steel bar welded in a complete ring. Table IV represents the complete tests carried out on a column of these rings about 4 ft. high, and the final compression was 12 in., that is, the column was about 3 ft. high at the end of the test, and the final load taken was 366 tons.

TABLE IV.—Reinforced Concrete Rings.

Compression. (inches).	Load (long tons).	Remarks.
0	7	—
4	90	Concrete cracked in No. 2 and No. 5.
4·7	140	Concrete cracked in No. 6.
8	220	All discs cracked.
9	270	Reinforcement broken in No. 5. Load drops to 265 tons.
12·3	366	Reinforcement in No. 6 broken.

In Fig. 4 the collars have a 45° angle; that represents the angle of the cast iron collars. In the reinforced concrete collars the angle was made sharp; instead of being 45°, the angle was 30° to the horizontal. That was one of the reasons why

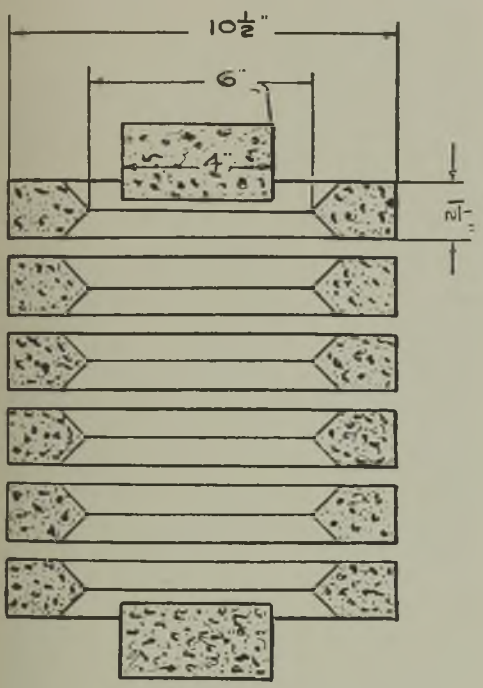


FIG. 4.

the 366 tons load on that collar was obtained, the ratio of lateral to the longitudinal pressure in that case being calculated to be somewhere in the neighbourhood of 7 to 1, the highest value got in any of the tests.

Considering some of the possible objections to sand-filled columns, the first point to discuss is that of reinforced concrete telescopic pipes versus "pancakes". There is no question about it that, taking it material for material, the telescopic pipes can be made cheaper than the "pancake." The main difficulty which is always introduced in argument is the handling of the sand in the use of these columns. As far as can be seen, that difficulty can be overcome by the provision of suitable carriers, the collars being packed with sand with a load, say, of 10 to 20 tons, on the surface, placed in these suitable carriers and taken underground in that way.

Steel pipes, of course, from the cost point of view cannot compete with the reinforced concrete pipe. One can only compare, from the point of view of strength, the telescopic pipe column of 30 in. diameter, with a 30 in. diameter "pancake." The possible load that a non-pressure Hume pipe telescopic column of 30 in. diameter will take (that is, with the sharpened edges), based on the information of tests, is 211 tons. Without the sharp edges the possible load would be in the neighbourhood of 70 to 80 tons. A "pancake" column of that diameter will only take a load of 150 tons. In addition, the telescopic column has the possibility of giving as the hanging-wall comes down on top; and, further, the danger of sudden collapse in the case of a telescopic column is very small indeed. In the case of a "pancake" column, these tests indicate that the final collapse—the maximum load taken—is the point of complete collapse, and, probably very sudden collapse.

Taking the case of the ring column versus "pancakes," the problem is much more difficult than it is in the case of the collars—the rings are undoubtedly the stronger and cheaper job.

Another point is that from all the tests it is very evident that it is the wire reinforcement which is the main factor in giving strength to the whole structure, whether telescopic column or ring column, and the conclusion come to is that the concrete mixture need only be one of minimum strength consistent with holding this reinforcement together and strong enough to withstand the usual treatment received when being transported. "Pancakes" could be reinforced in the same way as the rings, and it is obvious that if they were they would withstand a very much greater load than they do with their present reinforcement, which is usually just a piece a wire rope, which is not a homogeneous ring, but it is simply lapped over at the ends. In comparing, therefore, "pancakes" with rings or pipes, the cost of a pancake column would obviously be greater, since, in the "pancake," there is concrete throughout the whole structure. There is more material in the "pancake" with the reinforcement than in the ring. In addition, the "pancake" column has no "give." With the homogeneous reinforcement, of course, it would not have the sudden collapse which it has now under the present method of manufacture.

The question of penetration of the column into the hanging wall does not depend mainly, or even primarily, on the load capacity of the support. There is a definite weight supported by a column. If the column penetrates the hanging wall, such penetration has nothing whatever to do with the structure of the column. It is mainly a question of what "give" the column has. If it is a slab column, of course, it has no "give" and the hanging wall will be penetrated; if penetration does not proceed such columns must have a tendency to collapse suddenly.

In the case of the ring or collar structures there is "give," and penetration cannot take place until the whole structure has jammed so tightly that further "give" is impossible. That, of course, will only take place after movement of the wall has taken place, say, 12 in. for a 5ft. stope; and the time taken for that movement, of course, will depend on the circumstances in the mine concerned.

Nickel and Copper Deposits in the Norite Complex, Transvaal.—In the *Journal* of the Chemical, Metallurgical and Mining Society of South Africa for January, 1929, is a paper by E. R. Schoch dealing with these deposits, which are situated a few miles west of the Pilansberg, about 38 miles north-west of the town of Rustenburg, the nearest railway station being Boshoek, some 17 miles in a direct line. The country is taken up by a branch of the immense norite lopolith, which forms part of what is known as the Bushveld Igneous Complex. Topographically, this area has a low relief, and may be described as undulating. Here and there kopjes and low ridges indicate the outcrops of the underlying rocks, but the country is, for the most part, covered with black turf, so characteristic a feature of the basic and ultra-basic rocks of the Bushveld Complex. In addition, there are what may be described as "floating islands" of quartzites and shales, representing dismembered fragments of the Magaliesberg range. The norite lopolith in this area has undergone severe differentiation, that is to say, the original magma, instead of solidifying uniformly, has—probably as the result of varying temperatures and pressure—crystallized out in a variety of minerals or aggregates of minerals, which form irregular bodies, lenses, or sheets in the parent magma. The different phases of cooling are well exemplified underground where the rock shows varying texture; in places it is coarsely crystalline, and in others, again, fine-grained and very compact, whilst the difference in hardness is very pronounced. Geological Survey Memoir No. 21 gives the following summary of the rock formation. The predominating rocks in the three upper sections of the differentiated zone are Bronzitite, Hartzburgite, Serpentine, and Anorthosite. The lowest or Basal Section is composed of basic or pyroxenitic olivine norite. The so-called Middle Section of the differentiated series contains the magmatic nickel deposits, and is apparently the most highly differentiated portion of the norite lopolith. A rather curious phenomenon is that whereas on surface the norite formation, especially on the higher neighbouring hills shows distinct pseudo-stratification, with a shallow dip towards the Pilansberg, this characteristic is entirely absent underground, and the formation in depth presents a jumbled up mass of rock typically of igneous origin. That the formation has been subjected to severe dislocation and disturbance is evident from numerous fault planes, slicken-sides, and crush zones.

The nickel and copper deposits themselves occur in a comparatively narrow zone, and follow approximately the basal contour of the Pilansberg Complex. Individually the orebodies have no direct connection with one another, so far as developed, and are scattered at random within the zone of differentiation. The area over which they have been followed is considerable, covering a distance along the strike of approximately 16 miles. With regard to the shape of the nickel-copper deposits, they are best described as sausage or pipe-like bodies, roughly circular in cross section, and generally with no sharply defined walls, the ore in most cases becoming less massive towards the outer periphery. The pipes are more or less vertical, with occasional fingerlike off-shoots into the country rock. As may be expected in a disturbed area, the ore in places is cut off by faults, but generally speaking the vertical continuity of the orebodies is remarkable, and invites discussion as to their actual mode of origin. Incidentally, the orebodies are also traversed by diabase dykes; the latter are of more recent age than the deposits themselves, and have scarcely influenced their appearance and texture at the points of contact. The mineral composition of the ore is somewhat complex; it contains in the main pyrrhotite, pyrite, pentlandite, chalcopyrite, and marcasite. All the foregoing minerals, with the exception of marcasite, are classified as primary minerals, whereas marcasite which is unstable and readily decomposes when exposed to the atmosphere, is classed as a secondary mineral. The mineral pentlandite contains the nickel, and chalcopyrite the copper, both occurring as sulphides. In addition to the above-named minerals, there are a number of accessory minerals present, the principal of which are chromite, magnetite, gold, silver, and platinum metals, which come under the primary class, whilst sulphates of iron, nickel, and copper, together with oxide of iron, are of secondary origin. The country rock of these deposits is chiefly bronzitite, which includes a large variety of gangue minerals, the most interesting of these being graphite, epsomite, and opal. Associated with the deposits on surface are what are known as gossans. They are generally reddish, or yellowish-brown, and form a rather striking geological feature on account of their vivid colouring in the midst of the otherwise monotonous black turf. The gossans represent the remnants of sulphide bodies, from which the ore has been leached out. In places these surface accumulations gradually pass downwards into sulphide ore, whereas in others nothing of the sulphides remains, and the gossan forms, as it were, the residual skeleton of the original orebodies. The chemical composition of the gossans is mainly ferruginous iron, with a goodly percentage of opaline matter. Copper is often present in small quantities in the form of malachite and chrysocolla, whilst a hydrous sulphate or nickel called morenosite also occurs. Generally speaking, however, it may be said that the leaching process on surface has been very thorough and complete. A remarkable feature is the comparatively uniform distribution of the nickel contents in the orebodies (the same does not always apply to the copper contents, which fluctuate within wider limits). It is true that there are sections here and there where the nickel values vary considerably, but, generally speaking, they are consistent within reasonable limits, and this augurs well for development in greater depth.

The average grade of the ore so far developed is roughly 3·5% nickel and 1·0% copper. In this connection it is noteworthy to state that unlike the Sudbury ores, where the ratio of nickel to copper is approximately as 2·5 is to 1 the ratio in the Vlakfontein ore is much higher and is approximately as 3·5 is to 1.

The regularity of values is further remarkable when one considers the leaching action which has taken place, as revealed in the gossanized residues, and which continues even at the present day in the sulphides above the underground water-level. Although evidence of secondary enrichment by reprecipitation of the minerals might be expected to show up below the oxidized zone, actual assay results do not confirm the process

of secondary enrichment within narrow limits, and whereas no physical evidence of this process has been observed, it seems probable that re-deposition of the heavy metals is very gradual downwards, without perceptible boundary, being largely dependent on the underground water-level, which seems to have fluctuated considerably from time to time. At present the water table stands at about 50 feet, but varies according to the surface contour of the ground.

The size of the orebodies varies on different horizons, their diameter ranging from 10 feet to 50 feet. The specific gravity of the average ore is comparatively high, namely: 3·6, so that a short ton of ore in the solid measures about 8·5 cubic feet, which means that it takes proportionately less footage to develop one ton of this ore, than it would if the ore were quartz, such as Rand Banket, for example. The ore when pure is very hard, but being brittle breaks well when drilled over. The country rock, on the other hand, when hard is very tough and breaks badly.

Generally speaking, three classes of ore may be distinguished, namely:—

(1) Massive ore, which consists of almost pure sulphides.

(2) Coarsely disseminated or mottled ore, in which large crystals, mainly of dialage, alternate with crystals or masses of pyrrhotite, marcasite, pentlandite, and chalcopyrite.

(3) Finely disseminated or spotted ore, in which blobs and small patches of sulphides are distributed in a finely-grained matrix of bronzitite and other silicates.

No hard-and-fast rule can be laid down as to what part of the orebody these different types of ore occupy, but it has been observed that the bulk of the finely disseminated ore is generally found towards the outer periphery of the pipe, whilst large masses of pure sulphides will be found nearer the centre. The inference to be drawn from this phenomenon is: that the concentration of heavy minerals has been more intensive in the middle of the vent than it has been on the outer periphery, and this arrangement—taken in conjunction with the sausage-like shape of the deposits—raises the question whether the result is consistent with magmatic segregation alone.

Dr. Wagner contends that the disseminated sulphide specks were, in their original form, droplets of non-consolute iron-nickel copper matte, and that the rocks containing them owe their origin to the accumulation, under influence of gravity, of early formed crystals separating from the parent norite magma, and he goes on to say that "there is thus the strongest presumptive evidence in favour of regarding the orebodies as local aggregations of such matte droplets." This process is called the theory of magmatic differentiation, and is a widely accepted theory for the formation of eruptive ore deposits. Dr. Wagner, however, holds the view that the veins and vein-like bodies of solid sulphide ore, when fully exposed, always exhibit abrupt downward termination, proving that the ore came from above. This, the author is unable to reconcile with what he has seen of the solid ore in depth at different points, where as a rule no abrupt termination is visible, and he is disposed to think that more recent disclosures rather tend to refute the theory of the ore coming from above, and having its origin, therefore, at shallow depth. Moreover, in his opinion, it is difficult to find an explanation for the question why these globules of matte should have concentrated into a number of vertical pipe-like chimneys at widely separated points, instead of forming more or less continuous horizontal sheets or lenses of ore, as might reasonably be expected from heavy bodies following the laws of gravity. Judging from the structure of the pipes, the dissemination of the mineral contents, and their relationship to the country rock, the author suggests that these deposits have their origin in deep-seated regions. Their shape and perpendicular position suggests, to his mind, that the deep-seated concentrated matte, under stress of great pressure and heat, aided by the eruptions of the Pilansberg, would seek an outlet or outlets, and would cause mineral solutions and metallic vapours to rise up through cracks or vents in the norite matrix, and deposit their minerals along these channels, in the process of which a certain amount of replacement of the wall rock was inevitable. In the circumstances, this latter process, which is known as that of Pneumatolysis, may therefore be equally responsible for the formation of these deposits.

An important fact which emerges from the description of these deposits is that development down to a depth of 350 feet vertically (and at which depth no visible alteration in behaviour is noticeable) has proved them to be no mere surface deposits, but that they appear to have a deep-seated origin, and it is also reasonable to suppose, judging from the consistent nickel values obtained right down to the lowest point, that the metal contents will show similar results in depth. Developments to date have also proved that, whereas the deposits are not very large individually, they are of sufficient size and quantity to constitute a sound mining proposition, and that there is here the nucleus for a local nickel industry, which may eventually produce enough of that metal to satisfy the requirements of this country, and leave a handsome margin for export purposes.

Mineral Production of Tanganyika Territory during 1927.—The Report of the Mines Department Tanganyika Territory for 1927 arrived in London recently and the following is extracted therefrom:

During the year 20 companies and 248 individuals held land under title and were engaged in prospecting and mining operations. 935 Prospecting Licences were issued and 355 renewed. The following titles were held at the end of the year: 28 Mining Leases, having an area of 1,038 acres; 866 Claims, having an area of 124,604 acres; 62 E.P.L., having an area of 362 square miles.

In addition 32 ex-enemy "minefields" and 39 claims, which had been purchased from the Custodian of Enemy Property, were in existence. The area of land covered by these titles is 7,577 acres, making a total of 133,219 acres held under leases or claims. The table given on p. 322 shows the minerals prospected for or mined, and the number of titles in connection therewith.

The mineral production during the year was valued at approximately £197,493, an increase of 68% on 1926. The revenue derived from royalties, rents, and other mining fees was approximately £18,930. The output of diamonds amounted to 18,766¼ metric carats valued at £101,480. The number of diamonds won was 20,194, of which 102 each weighed 10 carats or over. The largest

	Ex-enemy.	Leases.	Claims.	E.P. Ls.
Mica	25	7	182	1
Gold	44	nil	296	12
Precious Stones	nil	14	305	5
Tin	nil	2	1	42
Salt	1	3	12	nil
Copper	nil	nil	30	2
Coal	nil	nil	36	nil
Red Ochre	nil	2	1	nil
Silver	nil	nil	2	nil
Garnets	1	nil	1	nil
	71	28	866	62

stone weighed 52½ carats, and the average weight was ·93 carats. The number of loads washed was 229,238, the yield being 8·2 carats per hundred loads. The average value per carat was £5 8s.

The output of bullion of alluvial and lode origin contained 8,179·629 oz. of fine gold valued at £34,530 and 918·43 oz. of fine silver valued at £100' a total of £34,630. Of this the alluvial deposits of the Lupa and Sira Rivers in the Mbeya District of Iringa Province, produced 7,441·829 oz. of fine gold valued at £31,386 and 817·170 oz. of fine silver valued at £90, a total of £31,476, and reef mining in the Musoma District of Mwanza Province produced 737·800 oz. of fine gold valued at £3,144 and 99·26 oz. of fine silver valued at £10, a total of £3,154. There was an increase in production of 1,500 oz. as compared with that of 1926. This increase was to a great extent due to a new " strike " made in March on the Itewe Hills, at the headwaters of the Kasanga River, a tributary of the Lupa. The extent and importance of the discovery is not yet known ; for the locality forms a water-shed which at cessation of the rains soon becomes entirely lacking in water, there not being sufficient even for domestic purposes. The gold recovered was remarkably coarse, nuggets up to 120 oz. being won. The alluvial deposit appears to be shallow, and therefore early exhaustion is indicated. It is by no means unlikely that similar discoveries will be made, for colours of gold are found over a very wide area of country. The new discovery caused a minor " rush ", but owing to scarcity of water mentioned above, the diggers were forced to suspend operations until the end of the year, when approximately 112 claims were pegged in the locality. Gold continued to be recovered from the gravels of the Lupa and Sira Rivers ; but the quantity yielded to the digger must become increasingly small. An E.P.L. was granted to a company on the Sira, covering a basin which, if its gold content proves to be sufficiently high, is ideally suited for hydraulic mining. Arrangements have been made to test the deposit by drilling. Another company has decided to test the possibility of winning gold by dredging the Sira above its junction with the Lupa.

Forty-five tons of tin-ore at £10,555 were exported during the year. As the result of further prospecting, the limits of the Bukoba Tinfield have been extended to the south of Lake Lufunza up to the shores of Lake Ruanyana. The Kagera river forms the north and west boundary. The area covered by E.P.Ls. granted and under application is approximately 400 square miles. Five applications were also received covering 24 square miles adjacent to the Ruvuvu River, on the Belgian border, almost due west of Biharamulo.

Coal is found in rocks of the Karoo formation. The most promising seams so far exposed are in the Ufipa District, and in the Songwe-Kivira area, near Lake Nyasa. Coal has also been discovered in the Kidodi and Rufiji districts, but the seams are not of economic importance, the area still remains to be thoroughly examined. The Ufipa deposit was under investigation during the year. A sample was delivered to the Railway Administration in order that a practical test of its quality might be conducted. It can be said that the result of this test was, on the whole, favourable, more particularly when it is remembered that the sample was obtained from but little below the outcrop. The economic development of this deposit is rendered difficult by its distance from any existing railway. The possibility of transporting the coal to a port on Lake Tanganyika is under consideration.

The monthly returns rendered by title-holders shows that 3,100 natives were employed on leases, E.P.Ls. and claims. These figures are the monthly average, but the numbers employed vary greatly from month to month, depending partly on the seasonal departure of labourers to work on their farms, and partly on climatic conditions. Thus, in locality of the Lupa and Sira Rivers there was a very considerable increase during the rainy season, during which period only was it possible to work the alluvial deposits in the arid region of the Itewe Hills. A number were also employed as porters, etc., on general prospecting. With one exception it is reported from every district that the supply does not meet the demand. In some cases the shortage is seasonal only. In other districts there is a constant shortage at all seasons of the year. Reviewing the position in each mining field ; in Bukoba the local native, as a general rule, will not work for wages. There offers, however, an ample supply from Ruanda and Urundi. Any company or individual engaged in mining or prospecting is ensured a sufficiency of labour, if arrangements are made to provide an adequate food ration. But the food markets are poor, the local native subsisting almost wholly on bananas. In Mwanza Province, there has been a great improvement in the labour position during the year. Here again the numbers of natives seeking work on a particular mine depends on the quality and quantity of the food ration issued, a more important factor than the cash wage paid. In the mica mining area east of Kigoma it is reported that the supply of labour was generally sufficient to meet the demand. In Ufipa District there was a serious shortage of labour during the last three months of the year. The labour offering for transport has become steadily less, and is totally inadequate for the requirements of the numbers of prospectors, some of whom have been compelled to wait at Mbeya and Mbalazi for weeks before obtaining porters. Labour for alluvial work on the boxes was very scarce, in spite of a considerable rise in the rate of pay offered. By comparison, panners are more easily obtained. But for work on reefs, trenching and general prospecting work it is reported that labour was practically unobtainable. If the position does not improve in the near future, the development of mining in this so promising district will be very seriously hindered. It may be necessary to import labour from Portuguese East Africa for drilling and work underground. In the mica mines of Morogoro District a constant shortage of labour is reported, the position being aggravated during the farming season.

SHORT NOTICES

Aerial Exploration.—In the *Canadian Mining and Metallurgical Bulletin* for March, John E. Hammell describes the organization and work of an aerial minerals exploration company in the north of Canada.

The Mining Districts of Nevada.—In *Economic Geology*, March-April, 1929, H. G. Ferguson describes the geology of the mining districts of Nevada, and from the available data discusses the future prospects of the region.

Zoning in Michigan Copper Deposits.—In *Economic Geology*, March-April, 1929, T. M. Broderick describes the zoning in the Michigan copper deposits and discusses its significance.

Operation of the Pneumatic Table.—In *Technical Publication* No. 196 of the American Institute of Mining and Metallurgical Engineers, A. F. Taggart and R. L. Lechmere-Oertel describe the results of a series of experiments in the laboratory of the School of Mines, Columbia University, during the winter of 1927–28.

Oil and Gas in the Canadian Prairies.—In *Bulletin* of the Canadian Institute of Mining and Metallurgy, April, 1929, T. G. Madgwick describes the oil and gas situation in the Prairie Provinces of Canada.

Flotation Reagents.—In *Technical Publication* No. 204 of the American Institute of Mining and Metallurgical Engineers, A. F. Taggart, T. C. Taylor and C. R. Ince describe experiments with flotation reagents.

Ore Finding and the Petrographic Microscope.—In *Engineering and Mining Journal*, March 2 and 23, N. Smith describes the application of the petrographic microscope to research in ore-finding geology.

Treatment of Lead-carbonate Ores.—In *Technical Paper* 413 of the United States Bureau of Mines, V. Miller and R. E. Head describe the roasting of lead-carbonate ores preliminary to gravity concentration.

Sulphur as a Wood Preservative.—In the *Journal* of the South African Institution of Engineers for March, E. F. English describes the use of sulphur as a wood preservative.

Geology of part of N.W. Rhodesia.—In a paper read before the Geological Society of London on April 24, R. Murray-Hughes described the geology of that part of north-western Rhodesia which lies approximately between lat. 14° and 17° and long. 24° and 30°.

Surveys in N.W. Alaska.—In *Bulletin* 797-D, of the U.S. Geological Survey, P. S. Smith describes the results of surveys made in north-western Alaska in 1926.

Platinum and Black Sand in Washington.—In *Bulletin* 805-A of the U.S. Geological Survey, J. T. Pardee describes the investigation of the platinum and black sand deposits of Washington.

Differential Flotation.—In *Technical Publication* No. 195 of the American Institute of Mining and Metallurgical Engineers, C. R. Ince discusses the separation of two or more minerals of the same class by flotation.

Subsidence from Mining.—In *Mining and Metallurgy* for March, H. Louis writes a further contribution to the discussion on the paper on subsidence.

RECENT PATENTS PUBLISHED

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

13,041 of 1927 (290,628). Hüttenwerke Trotha A.-G., Halle-Trotha, Germany, and W. Wetter, Halle (Saele), Germany. A process for the separation of tin from oxidic stanniferous and plumbiferous materials.

22,433 of 1927 (288,193). W. H. Smith, Detroit, U.S.A. A process for reducing iron ore and at the same time "cracking" hydrocarbons, which are the reducing agents.

29,881 of 1927 (307,439). National Processes, Ltd., London, and S. Robson, Avonmouth. Improvements in the roasting of pyritic ores, consisting of diluting the unroasted ore with a porous or granular and substantially sulphur-free material, such for example as already sintered ore, to produce a material containing not more than sufficient sulphur to give the required temperature for roasting and obtaining incipient fusion of the particles on a sintering machine.

3,870 of 1928 (307,595). H. J. Stehli, Cedar Grove, New Jersey. Improvements in, or relating to, sintering zinc ores.

4,213 of 1928 (307,188). S. I. Levy and G. W. Gray, London. Improvements in and relating to the treatment of pyrites, especially from the point of view of the recovery therefrom of elemental sulphur, and of copper, lead, zinc and iron.

4,302 of 1928 (307,190). S. I. Levy and G. W. Gray, London. Relates to the treatment of pyrites with chlorine gas and the subsequent separation and recovery of all the elements contained in it without loss of chlorine.

10,264 of 1928 (307,233). W. Morrell, Shipley, Yorkshire. Relates to a powder for case hardening iron and steel, and other metals.

15,720 of 1928 (308,516). Titanium, Ltd., Montreal. The production of alkaline-earth titanates.

NEW BOOKS, PAMPHLETS, Etc.

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

Catalogue of Plans of Abandoned Mines. Volumes I and II. Octavo, paper covers. Price 15s. each. London: H.M. Stationery Office. These two volumes cover the counties of Cheshire, Cumberland, Durham, Lancashire, Northumberland, Westmorland, and the Isle of Man in Volume I, and Cornwall, Devon, Dorset, Gloucester, Kent, Somerset, Stafford, and Worcester in Volume II. Particulars are not only included of the large collection of plans of abandoned mines at the Department of Mines, but also of many plans in private ownership, information regarding which has been included by the courtesy of the owners.

The Coal Industry of the Eighteenth Century. By T. S. Ashton and Joseph Sykes. Cloth, octavo, 268 pages. Price 14s. Manchester University Press.

Geological Map of Southern Rhodesia. Provisional geological map of Southern Rhodesia, on the scale $\frac{1}{1,000,000}$; revised edition; compiled in the Geological Survey Office, Salisbury, S.R., 1928.

Price 3s. 6d. London: Office of the High Commissioner for Southern Rhodesia.

South Australia, Mining Review for half-year ended June 30, 1928. Paper covers, 70 pages, illustrated. Adelaide: Mines Department.

U.S. Geological Survey, Annual Report, 1928. Paper covers, 76 pages. Washington: Government Printing Office.

Subsidence and Ground Movement in the Copper and Iron Mines of Upper Michigan. U.S. BUREAU OF MINES, BULLETIN 295. Paper covers, 66 pages, illustrated. Price 40 cents. Washington: Government Printing Office.

Californian Mineral Production for 1927. DEPARTMENT OF MINES AND MINING, CALIFORNIA BULLETIN No. 101. Paper covers, 311 pages. San Francisco: Department of Mines and Mining.

An English-Russian Mining and Metallurgical Glossary. By N. I. TRUSCHKOFF. Cloth, octavo, 141 pages. Leningrad: The Kubuck. It should be noted that this is only an English-Russian and not also a Russian-English Glossary. It appears to be fairly comprehensive, and occasional mis-spellings are easily understandable. The price of the book is not stated.

Mining Subsidence. By H. BRIGGS. Cloth, octavo, 215 pages, illustrated. Price 14s. London: Edward Arnold and Co. Reviewed elsewhere in this issue.

Petroleum and Coal, The Keys to the Future. By W. T. THOM. Cloth, octavo, 223 pages, illustrated. Price 11s. 6d. Princeton University Press, New Jersey, U.S.A. London: Humphrey Milford, Oxford University Press.

Proceedings of the Lake Superior Mining Institute, Twenty-Sixth Annual Meeting (Menominee Range). Paper covers, 324 pages, illustrated. Ishpeming, Mich.

Industrial Carbon. By C. L. MANTELL. Cloth, octavo, 410 pages, illustrated. Price 21s. New York: D. van Nostrand Company, Inc. London: Chapman and Hall.

South African Mining and Engineering Year Book and Directory (1929 Edition). Board covers, 9½ by 13¾ in., 628 pages, illustrated. Price 22s. 6d. London: Argus South African Newspapers, Ltd., 72-78 Fleet Street, E.C. 4.

COMPANY REPORTS

City Deep.—Although the tonnage crushed for 1928 was higher at 1,027,000 tons, the yield and working revenue decreased by 0·698 dwt. and 3s. per ton respectively, whilst working costs were up 1s. 10d. per ton milled. The year's operations, therefore, resulted in a working loss of £122,940, which compares with a working profit of £120,157 for 1927. The present unsatisfactory position is due to the decline in the value of the ore and in the percentage of payability. From the ore treated last year 306,034 oz. of gold was obtained, the total revenue being £1,302,786, or 25s. 4d. per ton milled, whilst total costs at the mine were £1,412,800 or 27s. 6d. per ton milled. The reserves at the end of 1928 were 1,445,100 tons, value 6·1 dwt. In concluding his report, which is dated March 1, 1929, the consulting engineer states that, whilst the prospects of the mine depend mainly upon the results of future development, the general improvement of underground methods is also an important factor. The work already accomplished should, he adds, lead to a steady reduction of operating losses, but regular profits cannot be anticipated, whatever the results of new development, before the early part of next year.

Durban Roodepoort Deep.—The report for 1928 states that 468,100 tons was treated for 159,485 oz., value £676,710, receipts from silver and osmiridium bringing the total revenue to £678,783, or 29s. per ton milled. Working costs were £658,945 or 28s. 2d. per ton milled, and working profit £19,838, or 10d. per ton milled. No dividend was paid, the net profit of £10,681 being appropriated on account of expenditure on equipment, etc. Improved results were obtained during the last quarter of the year, the tonnage milled and working profits both showing an increase. The ore reserve, including pillars, was at the end of the year 1,896,100 tons, value 7·26 dwt. over a stoping width of 43·3 in., an increase of 434,500 tons, and of 2·3 in. in the stoping width, but a decrease in value of 0·14 dwt. The native labour supply showed a slight falling off and is still considerably below requirements.

New Kleinfontein.—The report for 1928 states that 612,900 tons was milled for 139,144 oz. of gold. The working costs were 19s. 2d. per ton milled, an increase of 3·04d., due to the reduction in the tonnage of ore obtained from reclamation and to work done in the Apex section. On the other hand, working revenue showed an increase of 4·95d., owing to the improvement in the grade of ore milled, attributable to some extent to additional sorting. The working profit for the year was £5,217. The estimated reserves at December 31 last were 531,222 tons, value 4·90 dwt. over a stoping width of 53·84 in. Reference is made in the superintending engineer's report to the difficulty experienced in maintaining a sufficiently high grade of ore to cover expenses.

Robinson Deep.—Owing to a falling off in the value of the ore treated, the report for 1928 showed a decreased profit for the year of £15,255, although the 918,400 tons milled was 68,700 tons in excess of 1927. The working cost was down 5·2d. per ton milled, but this was more than counter-balanced by a falling off of 0·26 dwt. per ton milled. The gold output was 254,033 oz., value £1,078,963, or 23s. 6d. per ton milled, the working expenditure being £905,009, or 19s. 8½d. per ton milled, and the working profit £173,954, or 3s. 9½d. per ton milled. The ore reserves at the end of 1928 at 1,407,000 tons, value 6·1 dwt., showed a falling off of 621,000 tons in quantity and 0·5 dwt. in value, as compared with the previous year. Dividends totalling 3s. per share on the "A" shares absorbed £75,000.

Rose Deep.—The report for 1928 states that the ore milled was 663,400 tons, a decrease as compared with 1927 of 4,900 tons, the gold output being 137,969 oz., value £585,256, receipts from silver and osmiridium increasing the revenue to £587,811. The working costs were £558,904, or 16s. 10d. per ton milled, and the working profit £28,907, or 11d. per ton milled. A dividend of 2½%, taking £16,575, was paid. The ore reserve, including pillars, was at the end of the year 922,700 tons, value 4·9 dwt. over 65 in., an increase of 26,180 tons as compared with the end of 1927, the value being slightly higher. Good progress has been made with the opening up of the Southern Section, 48,800 tons from which is included in the ore reserves.

Geldenhuis Deep.—The report for 1928 states that as compared with 1927 the ore crushed

at 774,500 tons was up 22,400 tons, but, owing to a decline in the yield, the working revenue was down 5d. per ton milled. The gold output was 168,887 oz., value £716,142, the total revenue being increased to £719,097 by receipts from silver and osmiridium. The total working costs were £707,801, or 18s. 3d. per ton milled, and the working profit £11,296, or 4d. per ton milled. A dividend of 2½% taking £14,167 was paid. The ore reserve, including pillars, at the end of the year was 760,300 tons, value 5·66 dwt. over a width of 56·6 in., an increase of 32,800 tons in the available reserve being mainly due to the tonnage opened up in the ex-Jupiter claims.

Village Deep.—The report for 1928 states that 659,500 tons was treated for 181,370 oz., value £768,933, receipts from silver and osmiridium bringing the total revenue to £770,976, or £1 3s. 5d. per ton milled. Total working costs were £733,100 of 22s. 3d. per ton milled, leaving a working profit of £37,876, or 1s. 2d. per ton milled, due to a decrease of 8d. per ton milled in working costs, notwithstanding a reduction of 5 in. in the stoping width. A dividend of 2½% absorbed £25,003. The ore reserve at the end of the year, including pillars, was 1,525,400 tons, value 5·7 dwt. over a stoping width of 54·4 in., an increase of 120,500 tons and of 0·1 dwt., with a reduction of 4·8 in. in the stoping width. Development on the Main Reef Leader gave more encouraging results, particularly in the Eastern Section.

Simmer and Jack Mines.—Although for 1928 there was an increase of 36,000 tons in the ore milled, the report states that it would have been greater had there been an adequate native labour supply. The ore milled was 898,200 tons and the gold output 216,773 oz. The revenue from gold was £921,209, or 20s. 6d. per ton milled. The working costs totalled £854,674, or 19s. per ton milled, an increase of 10·1d per ton milled as compared with the previous year, mainly due to the extra cost of development. The working profit was £66,535, or 1s. 6d. per ton milled, a decrease of £38,474. No dividend was paid, the unappropriated balance at the end of the year being £66,712, as compared with £42,043 at the commencement of 1928. The ore reserves at December 31 last were estimated at 1,814,000 tons, value 5·9 dwt. over a stoping width of 48 in., an increase of 199,000 tons, the value being 0·2 dwt. higher and the stoping width 1 in. more.

Meyer and Charlton Gold Mining.—Last year 202,700 tons of ore was crushed for 53,414 oz. of gold, value £226,705, or 22s. 5d. per ton, working costs being £209,826, or 20s. 9d. per ton, and working profit £16,880, or 1s. 8d. per ton, sundry revenue bringing the total profit to £24,386. No dividends were declared, it being considered, in view of the comparatively small profits now being earned, better to conserve the funds for a final distribution on liquidation. The ore reserves at the end of the year were estimated at 43,301 tons, value 5·1 dwt. over a stoping width of 42 inches. Two additional small areas were acquired during the year on a royalty basis from the City Deep and Village Deep.

West Rand Consolidated Mines.—The report for 1928 states that 643,000 tons was milled for 163,540 oz., value £691,777 or 21s. 6d. per ton of ore milled. Working costs were £621,890, or 19s. 4d. per ton, and the working profit £69,887 or 2s. 2d. per ton. During the year the tonnage milled progressively increased, reaching in December 81,200 tons, which gave a profit of over £16,000, whilst working costs, which averaged 19s. 4d., have since the full plant came into operation fallen to below 18s. per ton milled. The ore reserves at the end of the year were estimated at 3,502,000 tons, value 5·6 dwt. over 49 in., an increase of 401,647 tons, the value and stoping width being unchanged.

East Rand Proprietary Mines.—Owing to an adequate supply of native labour and to additional hoisting facilities, the ore crushed for 1928 at 1,685,700 tons showed an increase of 99,200 tons as compared with 1927. The gold output was 440,848 oz., value £1,870,397, the total revenue being increased to £1,877,832 by receipts from silver and osmiridium. The total working costs were £1,871,488, or 21s. 1d. per ton milled, 5d. less than for 1927, whilst the working profit was £96,344, or 1s. 2d. per ton milled. The ore reserves at the end of the year, including shaft pillars, etc., were 3,624,600 tons, value 6·4 dwt. over 55 in., an increase of 494,600 tons, the value being unaltered. No dividend was paid, but over £89,000 was applied to debenture redemption. In his report the manager states that the amount of development during the year was the largest since 1910.

Witwatersrand Deep.—For 1928 the ore crushed was 525,300 tons for 122,950 oz. of gold, value, including £1,414 from silver, £520,613, or 19s. 10d. per ton. Total costs were £515,691, or 19s. 7d. per ton, the net profit being £4,922, or 3d. per ton of ore milled. The balance unappropriated at the end of the year was £68,523, as compared with £94,544 at the end of 1927. The ore reserves at December 31 last were 647,300 tons, value 6·2 dwt. over 47 in., an increase of 30,222 tons as compared with 1927.

Globe and Phoenix Gold Mining.—The report for 1928 states that satisfactory development results were obtained on the 11th and 12th levels and that on the 15th a stretch of good ore has been opened up. The profit for the year, including the credit balance of £25,998, was £134,011 and dividends totalling 3s. per share, free of tax, were paid. The ore reserves at December 31 last were estimated at 86,700 tons, value £469,140, as compared with 101,000 tons, value £554,400, at the end of 1927.

Rezende Mines.—For 1928 76,400 tons was milled for 35,632 oz. of gold. The total revenue was £162,734, and the total expenditure, including £17,000 for depreciation, £124,298, leaving a profit of £38,436. Dividends totalling 5s. per share were paid, absorbing £37,500. The ore reserves at December 31 last were estimated at 165,000 tons, value 9·6 dwt., as compared with 212,000 tons of the same value at the end of 1927. In their report the consulting engineers state that further extensive exploratory work below the No. 10 level has disclosed nothing of a payable value, in consequence of which all work below that level has been discontinued.

Nundydroog Mines.—The report for 1928 states that 126,638 tons of ore was milled, the total gold output being 75,427 oz. Receipts, after allowing for royalty and a small adjustment of the 1927 gold sales account, were £307,031 and costs aggregated £213,864, leaving a profit for the year of £93,167, or £12,416 in excess of 1927. Excluding development, working costs were £1 1s. 3d., as compared with 19s. 2d. for 1927, the increase being mainly due to extra expenditure on ventilation. Dividends for 1927 amounted to 2s. per share, against 1s. 9d. for the preceding year. Ore reserves at December 31 last were

estimated at 246,464 tons, against 221,161 tons at the end of 1927, an increase of 25,303 tons. With reference to development operations during 1928, the report states that the year's work has considerably improved the position at the mine and the outlook continues satisfactory.

Balaghat Gold Mines.—In their report for 1928 the directors state that the ore crushed was 47,950 tons for 29,978 oz. of gold. Costs amounted to £98,447 and receipts, after allowing for royalty and a small adjustment of the 1927 gold sales account, were £122,601, leaving a profit of £24,154. Working costs showed a further decrease of 1s. 9d. per ton. Dividends for 1928 amounted to 1s. 6d. on the preference and 6d. on the ordinary shares, the same as for the preceding year. At December 31 last the ore reserves were estimated at 74,131 tons, an increase of 3,737 tons as compared with the total at the end of 1927. A considerable quantity of quartz of excellent grade is stated to have been revealed in the ore body in the southern section of the property.

East Pool and Agar.—Lower development values affected the production of black tin during 1928, this amounting to 940 tons, an average of 23·84 lb. per ton of ore treated, the output of refined arsenic being 610 tons. For the year a loss of £4,385 was shown, the credit balance carried forward being £258, against £11,330 brought in. The company's operations were affected by the lower price ruling for its product, the tin sold averaging £126·24 per ton, as compared with £151·73 in 1927. The directors state, however, that the current year has commenced under more favourable conditions.

Lagares Tin Mines.—The report for the fourteen months to September 30, 1928, states that above the 40 metre level the proved ore reserves approximate 130,000 tons, and that there is approximately 10,000 tons of ore on surface. A plant to treat 100 tons a day has been constructed.

Toyo Tin.—The report for the fourteen months to November 30, 1928, states that the proved ore reserves amounted to 186,450 tons, assaying 2%. Plant is in course of erection to deal with a monthly throughput of 6,000 tons, and is expected to be in operation by June next.

Oroville Dredging.—The report for the year to September 30, 1928, states that during that period the dredges of the Pato Mines treated 3,052,802 cubic yards for gold value $688,671. A dividend of 1s. 3d. was paid to Oroville shareholders, the balance carried forward being £25,851.

DIVIDENDS DECLARED

Amalgamated Mining Trust.—3s., less tax, payable May 16.
Anglo-Oriental.—Pref., 3d., less tax.
Ditto.—Ord., 9d., less tax.
Aramayo Mines.—5%, payable May 1.
Broken Hill Proprietary.—1s., less tax, payable May 15.
Central Mining and Investment.—12s., free of tax.
Changkat Tin.—1s., payable April 30.
Globe and Phoenix.—1s., free of tax, payable June 13.
Gold Fields Rhodesian Development.—6d., less tax, payable May 30.
Kaduna Prospectors.—6d., less tax.
Kaduna Syndicate.—6d., less tax, payable May 14.
Kent Tin.—5%, less tax, payable May 27.
Marmajito Mines—Pref. 3s., less tax.
Ditto.—Ord., 6d., less tax.
Mazapil Copper.—1s. 6d., less tax.
Northern Nigeria (Bauchi) Tin.—Pref. and Ord., 1s. 6d., less tax, payable May 10.
Pahang.—Pref., 9d., less tax, payable May 1.
Ditto.—Ord., 3d., less tax, payable June 1.
Patino Mines.—4s., payable April 30.
Petaling Tin.—15%, payable April 30.
Rambutan.—6d., less tax, payable May 7.
Rantau Tin.—Pref., 9%, less tax, payable May 14.
Ditto.—Ord., 6%, less tax, payable May 14.
Tekka Taiping.—6d., less tax, payable April 30.
Waihi Gold.—1s., free of tax, payable May 10.
Weardale Lead.—6d., less tax, payable April 18.
Zinc Corporation—Pref., 4s. 6d. (final, 1928, 2s. 6d.; 1929, 2s.), less tax, payable June 12.
Ditto.—Ord., 2s. 6d., less tax, payable June 12.

NEW COMPANIES REGISTERED

Anglo-Peruvian Alluvials, Ltd.—Registered April 9. Capital: £10,000 in £1 shares. Objects: To acquire mines, mineral and other properties, etc., in the Republic of Peru or elsewhere. Office: 411-419, Salisbury House, London Wall, E.C. 2.

Bartica, Ltd.—Registered April 22. Capital: £100,000 in 2s. shares. Objects: To acquire the undertaking of United Diamond Fields of British Guiana, etc. Directors: V. Coen, F. Behr, Sir John W. Courtis, M. G. Liverman, and V. A. Pires. Office: 32–34, Holborn Viaduct, E.C. 1.

Chemical Reactions, Ltd.—Registered April 25. Capital: £50,000 in 49,000 "A" shares of £1 and 20,000 "B" shares of 1s. Objects: To carry out research work on the by-products obtained from the distillation of coal, lignite, fossil organic matter, natural petroleum oils, or any other material. Directors: Sir David Milne Watson, Sir James C. Calder, Sir Alexander Walker, H. Spence, and W. R. Ormandy.

Coal Carbonization, Ltd.—Registered April 11. Capital: £100 in £1 shares. Objects: To acquire benefit of or a license in respect of certain existing inventions relating to low temperature carbonization of coal and other fuels and to adopt an agreement with the Leeds Fireclay Company. Office: 15, St. Helen's Place, E.C.

Keza (Tanganyika) Tinfields, Ltd.—Registered April 10. Capital: £100,000 in 5s. shares. Objects: To adopt agreement with Eastern Securities, Ltd., etc. Office: 23, Abchurch Lane, E.C. 3.

Near East Development Syndicate, Ltd.—Registered April 16. Capital: £2,500 in £1 shares. Objects: The acquisition of the rights and benefits of claims upon which mining licences have already been granted on asbestos areas by the Ministry of Mines of Bulgaria in accordance with an agreement dated December 4, 1928. Office: Salisbury Square House, Salisbury Square, Fleet Street, E.C. 4.

Trinidad and General Holdings, Ltd.—Registered April 8. Capital: £80,000 in 540,000 Priority and 1,060,000 Ordinary shares of 1s. each. Objects: To acquire the undertaking of Trinidad and British Maikop Oil, Ltd. (incorporated in 1923), etc. Directors: E. W. Hillyard, A. W. Cornforth, H. St. J. Hodges. Office: 20, Copthall Avenue, E.C. 2.

Ulu Klang Tin.—Incorporated in Federated Malay States February 20, 1928. Capital: 1,200,000s. dollars in 1s. dollar shares. Objects: To acquire certain mining rights over land in the Mukim of Ulu Klang, State of Selangor, to adopt an agreement with Munjo Park, etc. Office: 2, Billiter Avenue, E.C. 3, where H. B. Ward is authorised to