1908.

NEW ZEALAND.

FEATURES OF SPECIAL INTEREST AND ELECTRICAL INSTALLATIONS AT MINES IN NEW SOUTH WALES AND VICTORIA

(REPORT ON), BY THE INSPECTING ENGINEER OF MINES, NEW ZEALAND.

Presented to both Houses of the General Assembly by Command of His Excellency.

Mr. FRANK REED, Inspecting Engineer, to the UNDER-SECRETARY FOR MINES.

SIR,— Mines Department, Wellington, 18th August, 1908.

During my recent visit to Australia in connection with the electrical installations there in use, I visited and inspected several mines and observed many features of special interest, including the conditions under which mining operations are conducted in the deepest coal, alluvial, and quartz mines in the British Empire, all of which are situated in Australia. For the information of the Hon. the Minister and yourself I herewith submit a report on the most important mining operations I witnessed, which, in view of the early reopening of deep alluvial mining at Ross, Westland, and deep quartz-mining at Waihi, the Thames, and Karangahake, may be of interest.

BENDIGO GOLDFIELD.

On this goldfield quartz-mining is profitably and safely carried out at the greatest depths yet reached by this branch of mining—viz., 4,492 ft.

The "saddle" reefs of Bendigo are described in most works on mining geology, I will therefore but briefly refer to them.

On the apex of the anticlines of the extensively folded sandstones and slates of Ordovician age these auriferous quartz "saddles" have been deposited by the hydrothermal solutions which have ascended from the underlying granite to the bedding-planes of the folded strata along which, as lines of least resistance, the solutions have been forced at enormous pressure, depositing the mineralised quartz in greatest thickness or width at those points where the resistance was least, and where the strata was fractured—viz., at the apex of the anticline and the trough of the syncline, but in the latter to a very much less extent than the former. From the apex of the anticline or "saddle" the vein-matter or "reef" gradually tapers off to insignificant proportions as the legs of the "saddle" are descended. In some mines several of these "saddles" occur one above the other, under the axis of the same anticlinal fold. In only one instance, and that a doubtful one, have the Ordovician rocks been penetrated by mining operations to the underlying granite, notwithstanding the great depths attained; but it is reasonable to suppose that the auriferous veins will continue to descend, as true fissures in the latter rocks, although it is probable that they will be impoverished of their values. The strike of the lines of reef is identical with that of the folded rocks at the apex of which they occur. The strike of eleven of the most important main lines of reef at Bendigo is north-north-east and south-south-west, and these reefs maintain their course and relative position, parallel to and in proximity with each other, to a remarkable degree. The gold therefrom is of high value, generally exceeding £4 per ounce, and, being free from refractory metals, is easily recovered by battery amalgamation alone, the tailings being regarded as not worth further treatment. The total gold-production from Bendigo exceeds £75,000,000 sterling, being slightly in excess of the total gold-production of this Dominion; but it is to be regretted that, in common with other Australian goldfields, an annual decline in the gold-production is recorded by Victoria.

The Victoria Reef (Mr. Rickard, Manager) and the New Chum Railway Mines, the deepest auriferous quartz-mines in the world, I descended to their greatest depths, and the following description of the mining operations therein may be of interest.

The main three-compartment shaft of the Victoria Reef Mine is constructed only 10 ft. by 7 ft. in the clear, and, in common with nearly all the deep Bendigo shafts, is too small to admit

adequate ventilation for the mine, in addition to the necessary compartments for cages, ladder-ways, and pumping. When the Bendigo shafts were commenced it was never anticipated that such depths would be reached by them, the geologists of the period treating with ridicule the idea that auriferous quartz would contain payable values at such depths as are now attained. This vertical shaft has reached a depth of 4,300 ft., and from the 37th level (4,254 ft.) a winze 328 ft. has been sunk to a "saddle," at a point 4,492 ft. below the surface, being the maximum depth at which auriferous quartz has ever been mined. Upon descending to the 37th (4,254 ft.) level, where "stoping" was being carried out, I found the atmosphere warm and very humid, the temperature of the rocks being officially recorded at 110° to 110·5° Fahr.;* nevertheless the air was tolerably pure, owing to natural ventilation produced only by the increased temperature of the mine with depth, the air being directed by doors and brattice round the working-places. In some Victorian mines Root's blowers are employed to produce ventilation, and they are spoken highly of for mines where exhaust centrifugal fans are inapplicable, owing to absence of return air-ways. On descending further to the deepest point—viz., 4,492 ft.—similiar conditions prevailed, the temperature of the rocks there being 113° and of the air 86° Fahr.* In Bendigo it has been ascertained that the rock-temperature increases at the rate of 1° Fahr. for approximately 75 ft. in depth below the zone of invariable temperature. In Victoria, by the mining statutes the temperature of the metalliferous mines shall not exceed 83° Fahr. by the wet-bulb thermometer. In West Australia the limit is 85° Fahr., except under conditions where it is impracticable. The amount of ventilation required by law in the former State is a minimum of 70 cubic feet per minute per person under ground, and the maximum of 500 cubic feet per minute where noxious gases exist to a dangerous degree; but it has been found that in the deep mines 70 cubic feet per minute per man is not an adequate amount.† At this mine baling is sufficient to keep the mine dry, and throughout the whole field mining operations are favoured by the small quantity of water encountered. With the exception of the levels, little timber is used or required, and, considering the great depth, there is less pressure generally in the mines than might be supposed. This no doubt is due considerably to the arched strata above the saddles supporting the superincumbent rocks. I was much impressed by the excellent precautionary measures taken to prevent shaft accidents—superior, in fact, to anything I have ever seen either on the American, African, or Australian mining-fields.

The New Chum Railway Mine, the total depth of which is 4,289 ft., was visited and descended. At a depth of 4,164 ft. a "saddle" was being stoped, and there I saw free gold associated with mispickel on the footwall at the apex, the reef being at that point about 15 ft. wide, the most recent crushing from which averaged 17 dwt. of gold per ton milled. The temperature of the rocks here was 110° Fahr. and of the water 114°.

Equipment.—Horizontal direct-acting non-condensing winding-engines of local manufacture, fitted with Corliss valve-gear, and coupled drums with post brakes, are mostly employed on these goldfields; but no provision is made to counterbalance the great weight of winding-rope in use, consequently the engines are subjected to very irregular loads. For this purpose, in the great British collieries, conical drums are always installed. Two cages are employed, of one-truck capacity each. Dial winding-indicators are geared to each section of the drum independently, so that in the event of one section being uncoupled its indicator remains stationary.‡ Safety cages and detaching hooks are required by law, and, in addition, safety catches or "keps" are fixed in the head gear at a depth of about 15 ft. 6 in. below the bell or ring; these catches consist of pieces of timber 9 in. wide by 3 in. thick, and the full length of the winding compartment, at each end of which they are attached by strong hinges, permitting the catches or "keps" to open upwards in the event of an overwind being operated by the ascending cage; but they are immediately closed again by strong springs pressing against them, and in this position they will arrest the falling cage in the event of the safety hook failing to hold in the bell or ring. When so closed they form a bearing of 3 in. wide on each side of the cage. The catches are fixed to a platform upon which the occupants of an overwound cage may descend to the ground by a ladder-way. This arrangement I consider well worthy of general adoption in this Dominion.§ The speed of winding is regulated by statute to a limit of 500 ft. per minute when men are being hoisted, or when nearing the surface 200 ft. per minute.

Winding ropes and chains, together with safety cages, hooks, and all other equipment, are frequently examined and tested, and such tests recorded in a book at the mine, so that every precaution which appears possible is taken in Victoria to prevent shaft accidents, and notwithstanding the immunity from shaft accidents in this Dominion I believe that some of the aforesaid precautionary measures may with advantage be copied.

Treatment of the Ore.—Owing to the free-milling character of the ore, together with the conservatism of some of the mining companies, the treatment of ore has not generally kept pace with modern practice, and in this branch of mining New Zealand is considerably in advance of Victoria.

The largest mill in Victoria is Lansell's Bendigo Battery of 110 heads, and this mill, which crushes for the public, was visited and inspected by me. I will describe what I saw at this typical Victorian mill. The ore for treatment is brought in tip-drays and deposited by them on the ore-floor, which is at the same level as the dies of the mill; it is then shovelled into the mortars in lumps in size up to that of a man's head, one person thus feeding fifteen stamps. Punched iron screens, with 175 apertures per square inch, are employed, but the height of the discharge is not regulated by chock blocks as the dies become worn, and no attention is given to this important matter. The pulp, after passing over the amalgamated plates, travels over a concentrator and a

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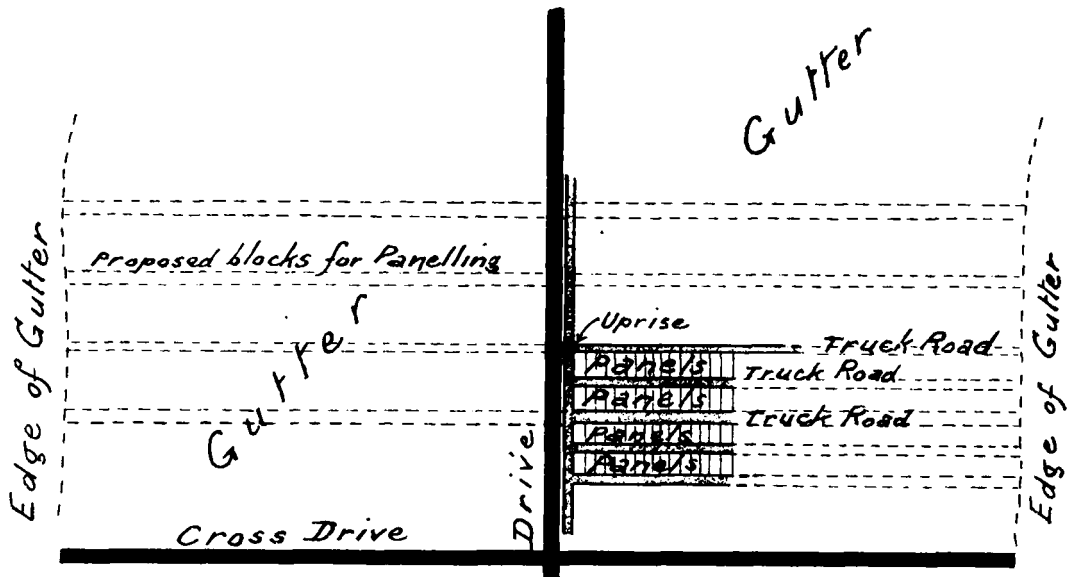
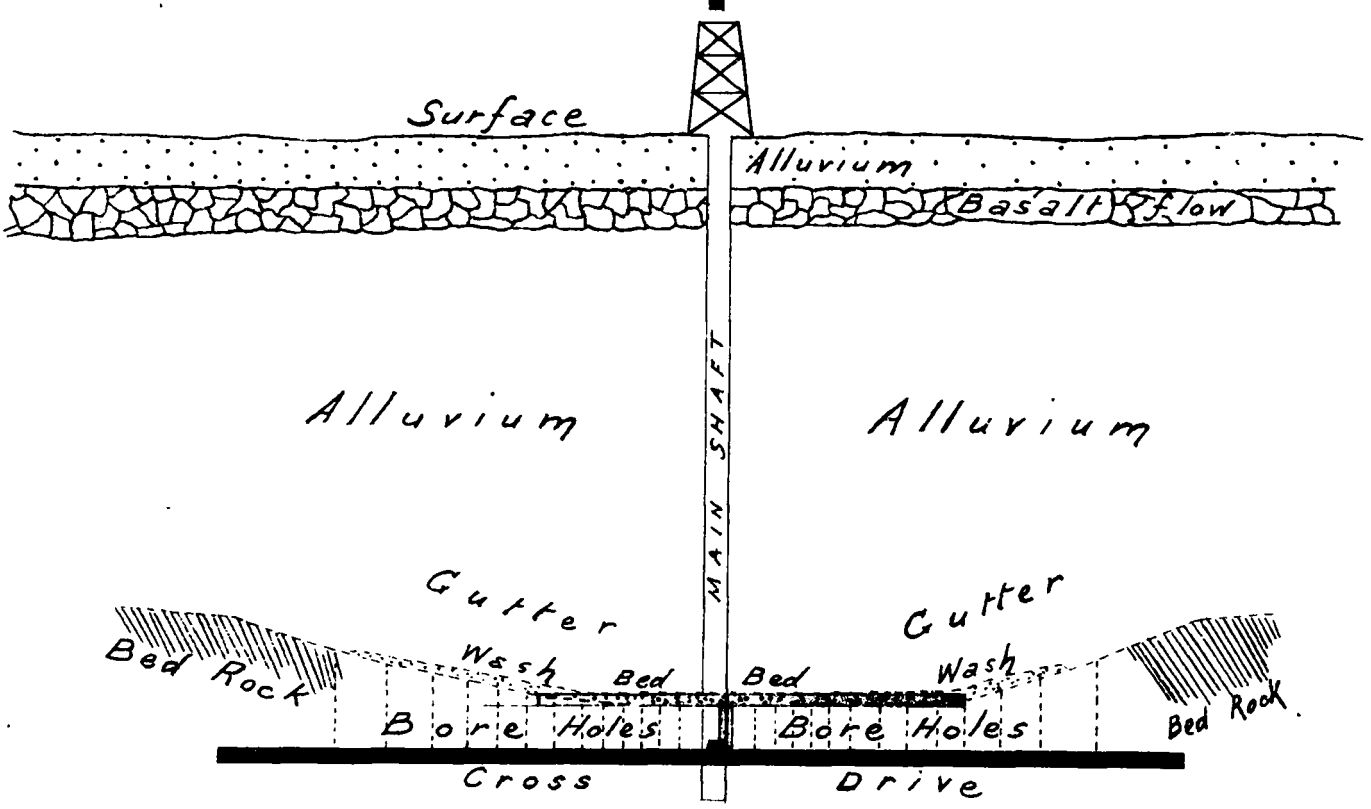
* Annual Report for 1907 of Chief Mining Inspector, Victoria. † In this Dominion the minimum quantity of air necessary for each person employed underground in a metalliferous mine is 100 cubic feet per minute. ‡ This is a very important safety precaution, and human life has already been saved thereby; at the new Blackwater Gold-mine, in this Dominion, I recently observed a similar arrangement. § A somewhat similar safety "kep" is in use at one of the Reefton mines, New Zealand.

Deep Alluvial Gold Mining in Victoria.
The Panel System of Mining after drainage of the Wash by bore holes from the Main Drives.



Plan showing Main Drives in bedrock (in blue) also Panelling in Wash (in red).



Section showing Main Shaft and Drives (in blue). also Bore Holes and workings in Wash (in red).

Scale 100 Feet to an Inch.

length of blanket-tables, and from thence it is elevated to the tailing heap, where it is left, not being considered worthy of further attention. Stamps of 900 lb. are employed, and the average daily duty per stamp is about 3·2 tons. The engine which operates the 110 stamps is stationed at the extreme end of the cam-shaft, and the steam is generated by externally fired boilers of German pattern. I was informed that the public are charged at the rate of 2s. 3d. per hour per each 5 heads of stamps, which amounts to about 4s. 3d. per ton for treatment only. The bulk of the gold is saved inside the mortars. I inspected one mill of modern construction—viz., the 20-head mill at the Comet Mine; and I believe one or two others exist where the treatment of quartz is carried out on more modern lines than at Lansell's Bendigo battery.

The Ballarat School of Mines was also visited by me, and I was most courteously received by the professional staff, and shown over the establishment, which is the most extensive and complete school of mines I have ever seen. Every department of metalliferous mining and engineering appears to be catered for, and to enumerate what I saw would take a volume. The mining community of Victoria are fortunate to possess so fine an institution. Over three hundred students attend the lectures, and those I saw appeared to be an intelligent, keen body of young men of the same type as our New Zealand students. The equipment of the treatment plant is not so complete as that now being installed at the Thames School of Mines, the finer treatment by tube mills, air agitating-tanks, and the vacuum-filter process being absent at Ballarat. I did not observe that coal-mining received any great attention; but geology, electricity, chemistry, and mechanical engineering were taught in splendidly equipped buildings.

Deep Lead Alluvial Mining.

The deep alluvial gold deposits of Victoria are the result of enormous denudation of the Ordovician rocks containing the auriferous quartz reefs as extensively worked in the Ballarat, Bendigo, and other districts, and it is estimated that such denudation has lowered the surface thousands of feet, resulting in the degradation of enormous quantities of rock and their contained auriferous matrices, setting free the gold-particles now found in the gravels. The rivers of that period were infinitely more potent than the streams of to-day; and there was probably glacial action in the mountains, glacial conglomerate in places forming the bed upon which rest the more recently formed auriferous gravels. With the lowering in force and volume of the ancient rivers, deposits of finer material were spread over the rich gravels in their channels, and then came a period of volcanic activity wherein, from numerous points of eruption, issued lava-streams which completely filled in and covered the old channels, forming level plains, along the edges of which the existing rivers have since eroded their courses. The old channels now constitute the gutters or leads which are extensively worked for their auriferous contents.

For the purpose of developing the deep leads rectangular shafts are sunk through the alluvium and basalt into the bedrock for a minimum distance of 20 ft. from the bottom of the former, from which level main drives necessary for haulage and drainage are driven in the bedrock under the leads and along their course; a series of boreholes are then put up by hand, so as to tap and thoroughly drain the accumulated water in the drifts and gravels, to admit of safe and profitable extraction of the auriferous wash resting upon the bed-rock or bottom. Uprises are then put up to the level of the wash, and cross-drives are driven along the lead, which, if the wash is reasonably solid and dry and does not exceed 4 ft. 6 in. in depth, is worked on the panelling system, by being divided by parallel truck-roads spaced 36 ft. apart (centre to centre) into blocks of indefinite length. The truck-roads may be 5 ft. high, with a bottom width 6 ft., and 3 ft. 6 in. top width inside the post-and-cap sets of timber employed. The system of panelling consists of splitting the blocks (by another truck-road) longitudinally, and from this road extracting the block in panels or strips 4 ft. 6 in. wide and 16 ft. deep, for the entire width of the strip; but if the ground is heavy, 8 ft. deep only is worked from the truck-road on either side. In the event of the wash being in thickness less than 3 ft., to enable mining to be conducted, the necessary height is obtained by removal of the bottom underlaying the wash.

The above system of working is shown on the accompanying plan and section, but the system is often varied and modified to suit local conditions. The panels are protected by light timber post-and-cap sets closely spaced, and no attempt is made to remove or draw these sets when the block is extracted. The superincumbent gravels shortly fall, burying the exhausted panels and disused truck-roads, and sometimes the cross-drives also.

If the conditions are unfavourable to panelling, owing to the heaviness of the wash, the ground is worked on the blocking-out system, which consists in driving parallel places in close proximity and the employment of heavier timber, and this will no doubt be adopted at Ross goldfields, Westland, where, in the early days, the blocking-out system was employed.

In Victoria the practice regarding the measurement of wash and the working-costs of its production are rather ambiguous, and need explanation. The quantity mined and treated is stated at per fathom, which consists of a superficial square fathom—viz., 36 square feet—by whatever depth of wash or bottom is removed, which may vary between 3 ft. and 7 ft., consequently a fathom of the former depth contains 4 cubic yards, and of the latter 9·3 cubic yards. The working-costs are stated in pennyweights of gold per fathom, the gold being estimated at £4 per ounce. The working-cost in Victoria range between 8 dwt. and 14 dwt. per fathom, which may be regarded as extreme cases.

In the Maryborough district I visited and descended two important deep alluvial mines—viz., the Charlotte Plains and the Duke and Main Lead Consuls.

The Charlotte Plains (Mr. G. F. Bryant, manager), employs the most extensive electrical installation on any mine in Australasia, and was the first mine in Victoria to use electrical power. The electrical equipment is particularly interesting, inasmuch as it includes extensive up-to-date machinery for generation, transmission, and utilisation of electric power. Briefly, the plant includes

a generating station for developing alternating three-phase current, together with transmission-lines and substations equipped with motors. The alternators, which are directly coupled to three engines of the horizontal cross compound condensing side-crank type, are of 750-horse power each, and include three 400-kilowatt machines and 30-kilowatt exciters. The large generators are of the revolving-field type, having 48 poles, and are run at a speed of 150 revolutions per minute, and generate a three-phase 60-cycle current at a potential of 6,600 volts. The high-pressure voltage is transformed down to 440 volts at the substation for motor use at the hoists, pumps, puddling-pans, Root's blowers, &c., and to 220 volts for locomotives of the Ganz type*, two of which are employed. The pumping plant for this mine consists of a three-throw plunger pump capable of raising 2,000 gallons per minute to a height of 360 ft.; formerly a Mather and Platt two-stage centrifugal pump of similar capacity was employed; but I was informed by the manager, Mr. G. F. Bryant, that his company found that the plunger pumps were cheaper to work and more efficient, consequently the centrifugal pump was replaced by them. The electric winding plant consists of a 75-horse-power induction-motor connected by spur gearing to the coupled drums, which are controlled by a friction brake, the motor being started, reversed, or stopped by a starting-switch as used on electric cars. A great defect in this hoist has been the spur gearing (of 2½ to 1), the teeth and other parts of the wheels constantly breaking, and it is considered by the electrical and mechanical staff that a chain gearing would be preferable. With this exception the plant works satisfactorily. Ventilation is produced by a Root's blower† of the largest size (No. 9), and conveyed through pipes 16 in. in diameter for a distance of about one mile for the use of the fifty-four men employed in the mine. The underground haulage in the main drives is operated by Ganz electric locomotives, which, it is stated, are capable of developing a draw-bar pull of 650 lb. at a speed of five miles per hour. The trollies are connected to the motors by flexible cables; the wires are carried by insulators held by safety brackets in a top corner of the haulage-road. The weight of the locomotive is 1½ tons, and the gauge of the road 16 in.

The auriferous lead at this mine averages about 1,200 ft. wide, and is worked from a main shaft 344 ft. deep. The average depth of the wash from the surfaces is 247 ft., the lead having an inclination of about 1 in 100. I was informed by the manager that the working-costs absorb 11 dwt. of gold per fathom, and that miners' wages vary between 7s. 6d. and 9s. 2d. per shift.

The Duke and Main Lead Consols Mine (Captain Glover, manager), which was also inspected, is worked under somewhat similar conditions to the Charlotte Plains and other deep-lead mines in the Maryborough district. At this mine electricity is not so extensively employed; at the present time the puddling plant, plunger, and other pumps, and Root's blower are the only equipment at which this power is used, but it is proposed to introduce electric traction by Ganz locomotives, as previously described. The mine is drained by Cornish pumps in the shaft, and by two horizontal plunger pumps in an underground chamber. Originally three-throw centrifugal pumps of Worthington type were employed, and I was informed that they successfully dealt with two-thirds of the quantity of water which they were estimated to lift—viz., 700 gallons per minute against a head of 284 ft.; but the plunger pumps were found to be more efficient, and are now in use. Boring upwards to drain the gravels prior to working has been extensively carried out at this mine, the average cost per foot being about 2s. 6d. for labour alone. A hand plant operated by rocking-lever is used, the holes being of sufficient dimensions to admit of 3 in. casing being introduced; the greatest height thus bored upwards is 72 ft. In the event of the borehole coming in contact with a large hard boulder, the hole is "bulled" with gelignite, or else abandoned.

At the Victorian Deep Leads alluvial mine a successful instance exists of electrically driven double-action Cornish pumps producing, I was informed by the Consulting Engineer, an output of 1,910 gallons per minute against a head of 360 ft. Three-phase alternating current is employed, the induction-motor having 400 R.P.M., while the pump works with 8·3 strokes of 8 ft. per minute, the motor being connected to the pump by rope-driven pulleys and reduction gear. The diameter of the pumps is 20 in., and of the columns 22 in. I was informed that the efficiency of this pump was exceedingly high. Mr. Wilkinson, M.E., the representative of Messrs. Bewick, Moreing, and Co., in Victoria, who control the mine, also informed me that these pumps had been employed constantly for four years, and gave every satisfaction. The evidence is most important in view of the misapprehensive statements that Cornish pumps cannot be successfully driven by electricity, and it will be satisfactory information to the many mining engineers who prefer the Cornish pump to all others for reliability.

Newcastle Coalfield.

The coalfields of New South Wales of Palæozoic age probably constitute the most valuable mineral asset in Australasia. The total contents of these coalfields in exploitable seams not less than 2½ ft. in thickness have been estimated to be 78,000,000,000 tons by the late Mr. C. S. Wilkinson, Government Geologist, and by Mr. E. F. Pittman, A.R.S.M., F.G.S., the present occupant of that position, to be 115,000,000,000 tons. In the former estimate a deduction of one-fifth was made for waste in getting, and in the latter a deduction of one-third. The area of the Newcastle Coalfield, the most important coalfield in the State, has been estimated by Professor T. W. E. David, B.A., F.G.S., of Sydney University, to cover an area exceeding 212 square miles.

The principal seam worked at Wallarah, about sixty miles north of Sydney, is supposed to be identical with that at Bulli, nearly the same distance south of Sydney.

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* These electric locomotives are employed at the Great Southern Consols, Berry Consols Extended, Charlotte Plains, and New Havilah alluvial mines. They give satisfaction on long-haulage roads of flat gradient if carefully handled and kept clean. They cost only £252 each. † This blower, owing to leakage of the pipes, has not been a great success, the quantity of air admitted being 4,620 cubic feet per minute, at a water gauge of 28·5 in., of which only 1,136 ft. was delivered (*vide* Chief Inspector Merrin's annual report, 1907).

The deepest coal-measures are supposed to be in the neighbourhood of Sydney, where the shaft of the Sydney Harbour Colliery has been sunk to a depth of 3,000 ft. to a 6 ft. seam of superior coal. This shaft is situated within one mile of Sydney, and the mining operations will be carried out under the harbour. Owing to the favourable situation of this mine the mine-trucks will practically be tipped direct into the ship's hold. This colliery is only exceeded in depth by three others in the world, all of which are situated in Belgium.

The output from the New South Wales collieries during 1907 amounted to 8,657,924 tons, being third in magnitude of production of the British dependencies overseas.

Mining operations on the bord-and-pillar system are conducted according to the most modern practice, and the equipment of the more recently established collieries is of a high order.

Among the collieries visited by me the two most important as regards equipment and output were the Hebburn and South Bulli, and as these mines contain respectively large electrical installations of D.C. low and A.C. high pressure, I will endeavour to describe the most important features I observed at them.

The Hebburn Colliery (Mr. R. A. Harle, manager), the property of the Australian Agricultural Company (Limited), situated thirty-one miles by rail from Newcastle, is a recently opened mine, having a daily output of about 2,000 tons, and will operate over a total area of 3,131 acres, 1,329 acres of which is freehold. Two seams of 7½ ft. and 6 ft. in thickness, inclined at 1 in 19·5 are worked. These seams are separated by 17 ft. The coal is hauled up dip haulage-roads to the surface, no winding being required. The surface arrangements are laid out on the most modern labour-saving principles, and electric power at low pressure and by direct current is extensively employed. The generating plant consists of a Roby compound engine of 370 brake horse-power, which drives two 6-pole Scott and Mountain generators providing 365 amperes each, also a similar machine supplying 360 amperes, all generators being connected by flexible couplings on one shaft. The power thus produced is used principally for coal-cutting by the Jeffrey's chain breast machines, driven by enclosed flame-proof motors of about 21-horse power, the mine in places being gaseous, in which places the New South Wales Electrical Special Rules require many important conditions to be observed to prevent the ignition of gas by sparking or flashing, among which precautions are the aforesaid flame-proof motors; also switches which are submerged in oil, and the electrical pressure employed shall not exceed 650 volts. Each coal-cutting machine employs two men; and 4½ bords, each 18 ft. wide, are holed or undercut to a depth of 5 ft. or 6 ft. by one machine per shift, thereby producing about 100 tons of coal, at a cutting-price of 4⅝d. per ton, in safety-lamp sections, the price where open lights are used being 1d. less. Each machine requires a current of from 35 to 45 amperes at a pressure of 230 volts. At the Northern Extended Colliery, which I also visited, the cost of cutting by a Sullivan chain breast machine was about 3d. per ton; the above figures were supplied to me by the managers of the mines referred to. At Hebburn the trailing cables which conduct the current from the junctions are protected by plaited green hide to effectively protect the insulation from abrasions, other forms of covering having been found unsatisfactory. The trailing cables are securely clamped to the motors. The cutting-machines, owing to the gradients, are "flitted" or transported by their own electric power. These machines are extensively employed throughout the State where the conditions are favourable—viz., upon hard seams not too highly inclined; but they would not be so successful or economical in the free-working and often highly-inclined bituminous coalfields on the west coast of this Dominion. The mine is unwatered by a four-stage centrifugal pump lifting 200 gallons per minute against a head of about 200 ft., requiring a current of about 65 amperes at a pressure of 240 volts. The ventilation of the Hebburn Colliery is effected by a 9 ft. 6 in. by 12 ft. Cappell double-inlet fan, which at present is run at 42 R.P.M., and produces 200,000 cubic feet of air per minute at a water gauge of 1·6 in. The maximum output of this fan is estimated to be half a million cubic feet per minute. This machine is also driven by a Robey compound engine.

The South Bulli Colliery (Mr. A. E. O. Sellars, manager), was also inspected, and being the only colliery in Australasia employing alternating-current electricity at high pressure, the following details may be of interest. The power-station contains one G.E. Company's generator of 146-horse power, also one Siemen's generator of 467-horse power, the former machine being preferred by the management. These generators supply a voltage of 2,300, which, being transformed down to 220 volts at the motors, is utilised for all the power required in the mine—viz., one motor of 100-horse power for driving an air-compressor for "Little Hardy" coal-cutters used in gaseous places; one of 75-horse power for driving-rope haulage (120 amperes); three of from 5- to 30-horse power for pumps (25 to 55 amperes); one of 70-horse power for conversion to direct current for working "Goodman" chain breast coal-cutters. The output of this mine, which is worked from an adit in the hillside, is about 2,000 tons per day, and when the mine is fully opened up the underground haulage will extend seven miles in one continuous main haulage-road in coal. The ventilation is produced by a fan of the Walker type, 26 ft. in diameter and 8 ft. wide, now producing 230,000 cubic feet per minute, at a water gauge of 3 in., but when running at 140 R.P.M. it is estimated that 450,000 cubic feet per minute will be produced at a water gauge of 4·5 in. I was informed by the manager that a centrifugal pump was installed at this colliery, but proved a failure owing to the gritty water. This pump was guaranteed to lift 250 gallons per minute against a head of 400 ft., but it was only tested against a head of 250 ft., and after working for three months for eight hours per day the efficiency declined from 65 per cent. to 40 per cent. The gritty water wearing away the impellers, causing them to bend at the tips, the suction failed, and the pump ran hot. The makers removed the pump without payment for the same, the guarantee having failed.

During my visits of inspection to the Australian goldfields and coalfields I made close investigation into the results obtained from centrifugal pumps, and the consensus of opinion of the mine-managers and engineers using them was that with bronze impellers and under favourable conditions

regarding clear water they are fairly satisfactory at low heads, but not so efficiently as the plunger, or as reliable as the Cornish types. When, however, the water is gritty, they were universally condemned. When steam-power is used the opinion was unanimously in favour of the old Cornish lift-and-plunger pump, which bears out the New Zealand practice at Waihi and the Thames. I could not discover one instance of the centrifugal pump having been used for sinking purposes; the bare suggestion was received with condemnation. Judging from the report of H.M. Inspector of Mines for Cornwall, the results obtained in that county were not much better than they have been in Victoria.* The number of disused centrifugal pumps I saw in Victoria was startling evidence of their inefficiency in alluvial gold-mines.

In the State of New South Wales electric-generating plants have been installed at thirty-three collieries, the total capacity in electrical output amounting to 2,176 KW, equivalent to 2,917-horse power; the motor-driven machinery is divided as follows:—

16	collieries have	...	...	...	62 coal-cutters.
6	"	...	...	...	8 haulage equipments.
19	"	...	...	...	33 pumps
6	"	...	...	...	10 ventilating-fans.
5	"	...	...	...	7 motors applied to other uses.

There are, in addition, 1,482 electric lamps on the surface and 777 below ground.

The plants of twenty-five mines come under the category of low pressure (*i.e.*, 250 volts and under); seven are classed as medium pressure (*i.e.*, 250 to 650 volts); and only one—viz., South Bulli Colliery—ranks as high pressure (*i.e.*, 650 to 3,000 volts).† All are direct current except the last, by which a three-phase alternate current is used; and of the collieries I visited the South Bulli installation appeared to be the most modern and extensive, and, notwithstanding the high voltage, was under complete and safe control, no accidents having been experienced therefrom.

There are, admittedly, risks connected with the use of electricity. Recent authoritative statistics show that during the last two years the deaths from electric shock in the mines of Great Britain totalled thirty-seven, of which number fourteen persons were on the electrical staff, as against twenty-two employees in the mines, who inadvertently came in contact with "live" wires or fittings or structural work that had become "alive" accidentally. In New South Wales one life has been lost by shock owing to contact with a bare wire in the Central Mine at Broken Hill; and in Victoria a man was killed at Rutherglen by coming in contact with a bare wire used for electric traction below ground at the low voltage of 240.

In this Dominion no lives have hitherto been lost at the only two mines at Allandale and Waihi using electric motive power, but several lives have been lost owing to electric shocks received from tramway and other wires not connected with mines.

For the protection of human life special rules were recently adopted as the result of a Committee of Inquiry appointed by the Secretary for Mines of New South Wales; these regulations are based upon those established for some years in Great Britain; and in view of the further and increasing application of electrical power in the mines of this Dominion the adoption of similar regulations appears to be very desirable, for in the event of installations being erected before such regulations appear the mine-owners may feel reluctant to alter the same, as the result of subsequently established ordinances.

In conclusion, I beg to acknowledge the great assistance rendered to me in New South Wales by the Chief Inspector of Collieries, Mr. A. A. Atkinson, who accompanied me on some of my inspections, and was ever ready to render my visit a successful one. I am also greatly indebted to the following gentlemen for their assistance and advice: Mr. J. B. Jacquet, A.R. S.M., Chief Inspector, Metalliferous Mines, New South Wales; Inspector W. Humble, F.G.S., Newcastle, New South Wales; Mr. A. H. Merrin, M.C.E., Chief Inspector of Mines, Victoria; Captain Abraham, Inspector of Mines, Victoria; also to the Under-Secretaries of Mines of Victoria and New South Wales.

I have, &c.,

FRANK REED,

The Under-Secretary for Mines, Wellington. Inspecting Engineer of Mines.

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* Extract from the report of Mr. J. S. Martin, H.M. Inspector of Mines in Cornwall, &c., for the year 1907.—"The experience generally in Cornwall up to the present with electricity, more especially in its application to centrifugal pumps, has not been successful, due to a muddle, as I understand, between electrical and mechanical engines. At Tywarwhaile, the results attained to a depth of about forty fathoms below adit with both the gas-producer, electrical plant, and centrifugal pump, have been quite up to anticipation, but at Great Dowgas, Hingston Downs, Wheal Bury, and Wheal Vor, centrifugal pumping has so far not been satisfactory, and the failure has been attributed to different causes, insufficient power among others." † Extract from the Report of the New South Wales Committee of Inquiry into the use of Electricity in Coal-mines, 1908.

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