1885.
NEW ZEALAND.

REPORT

ON

MINING, MACHINERY, ETC., IN VICTORIA AND NEW SOUTH WALES.

BY

H. A. GORDON,
Inspecting Engineer, Mines Department.

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

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(BY MR. H. A. GORDON, INSPECTING ENGINEER.)

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

REPORT ON MINING, CRUSHING, AMALGAMATING, CONCENTRATING MACHINERY AND REDUCTION PLANTS FOR TREATING METALLIFEROUS ORES, &c., IN VICTORIA AND NEW SOUTH WALES.

PART I.

Mr. H. A. Gordon, Inspecting Engineer, to the Under-Secretary, Mines Department, Wellington.

Sir,— Mines Department, Wellington, 18th May, 1885.

In compliance with the instructions of the Government that I should visit the Colonies of New South Wales and Victoria for the purpose of inspecting and reporting on the various systems of mining, underground haulage, ventilation, crushing machinery, and various plants for the reduction of ores, the use and cost of diamond-drills, &c., and collecting all information that was likely to be beneficial to the mining community in this colony, I have the honour to report that I have visited all the principal mining centres in the Colonies of Victoria and New South Wales; but the time allowed me would not admit of my visiting every field, nor was the same necessary, as there is a similarity existing in each class of mining, and in machinery for crushing, concentrating, and reducing each description of minerals. Quartz lodes are differently formed, yet all are stoped out on pretty well the same system, and machinery for extracting the gold has this peculiarity: that everywhere stampers are used for crushing the quartz, but almost each company has some slight difference in either the riffle and blanket-tables, or in the concentrating or amalgamating machinery. In visiting the various fields throughout these colonies I was in a great measure guided by information received from Mr. C. W. Langtree, Acting Secretary for Mines and Water Supply, Victoria; Mr. Harrie Wood, Under-Secretary for Mines, New South Wales; and Mr. C. S. Wilkinson, F.L.S., F.G.S., in charge of geological surveys, New South Wales, as to the fields that would be likely to afford me the most information, both with regard to the different classes of mining for gold, silver, copper, tin, diamonds, and coal; likewise where the principal machinery and plants for smelting, reducing, concentrating, and extracting the various minerals were employed. In reporting on the various systems of mining, and of extracting the different minerals, it may be as well to give a synopsis of the principal mines and plants that I visited in each colony.

VICTORIA.

Gold Mining.

The fields that I visited in this colony were Sandhurst, Castlemaine, Maldon, Clunes, Creswick Creek, Ballarat, Stawell, Malmsbury, Beechworth, and Chiltern.

Sandhurst is the greatest field in the Australian Colonies for quartz-mining, and where improved winding, crushing, concentrating, and amalgamating machinery is employed. Mr. Grainger, the Government Inspector of Mines, accompanied me round this district, which is a complete network of quartz mines, and mining plants of almost every description for extracting the gold from the quartz. He informed me that there were 150 large mines in the vicinity of Sandhurst, besides a large number of smaller ones.

Winding Machinery.

The winding machinery in the Sandhurst district is superior to that employed in any other I have visited. The largest winding plant is that belonging to the New-chum Company, which consists of a pair of steam-engines, having cylinders 22in. in diameter, with winding-drums about 12ft. in diameter, for working winding ropes made of steel wire, which is employed for haulage. The winding-drums are so fixed that they can work in conjunction with each other. One can be taken out of gear while the other is winding, or the winding-shaft can be disconnected entirely from the engine-shaft by sliding plummer-blocks. Each of the winding-drums, as well as the fly-wheel of the engine, is provided with a powerful brake, and the handles of these brakes are connected in such a manner that the engineman has perfect control over the whole of them without leaving the starting-bar of the engine. There is also a circular indicator from 3ft. to 4ft. in diameter, placed some distance in front of the engineman, having feet marked on the outer edge, and on the face of this indicator there is a hand resembling the minute-hand of a clock, which is connected with gearing from the engine-shaft—this makes the hand travel round the face, showing the exact distance that the cage has travelled in the shaft and the different levels that it has passed. This company is at present employed in sinking their shaft, which is 1,250ft. in depth, and they intend, when "opening out," to work with double cages holding two trucks each.

The generality of winding plants in this district have double steam-engines, with cylinders from 18in. to 21in. in diameter; winding-drums, for working with round rope made of steel wire, from 10ft. to 12ft. in diameter; and attached to every winding-engine, there is an indicator to show the exact position of the cage in the shaft, There are some of the winding-engines fitted with a solid round link instead of the ordinary quadrant slot-link for reversing the engines, which is an improvement, as it lessens the number of joints, and consequently reduces the wear and tear, with less liability to rattle.

The cages that are used for winding are, in every instance, fitted with safety appliances—*i.e.*, there is a safety-hook for coupling the rope to the cage, which prevents any accident from over-winding; a safety appliance is fitted on the cage, which is controlled by steel springs attached to the bar that lifts the cages, so that when the tension on the lifting-bar caused by winding is taken off—as for instance, the rope breaking, those springs force the clips to spring out and catch on the guides, or sides of the shaft; thus preventing the cage from falling. The safety-hook is made in the form of an inverted V, having the narrow end upwards, which, should overwinding take place, draws the hook through a short cast-iron tube that is fixed on the top of the poppet-heads. This hook is constructed with a joint, and likewise held together with a copper rivet, so that when force is exerted in drawing the hook through the tube, it cuts the copper rivet, which releases the winding rope and allows the bottom of the hook to widen out, thereby leaving the hook attached to the cage resting on the top of the iron tube and thus preventing the cage from getting down. In addition to these safety appliances, there is an auxiliary or safety-brace constructed about 10ft. above the main brace, where all the trucks are taken out of the cage to be emptied. This safety-brace has folding doors made of iron bars set on edge, the upper edge inclining a little in towards the shaft, so that the cage in passing through this brace, the folding-bars are pressed back, and again return into their former position, thereby preventing the cage from getting below this; or at least if it happened to break through the doors, the fall would be broken to such an extent that the folding-doors at the main brace would hold it from getting down the shaft, in the event of the hook not acting, or the rope breaking, and the spring safety appliance failing to hold the cage at the place where the breakage took place. These safety-cages have been the means of saving several lives; but even the managers, who have been working them for years, question whether they are always to be depended on when an accident takes place, even when constant attention is bestowed on them to see that the springs are always in good order. The Government Inspector of Mines tests them from time to time by severing the rope when the cage, with a loaded truck, is being wound up. The Inspector informed me that, on the whole, the tests were very satisfactory.

Drawing No. 1 shows a cage fitted with Webb's patent safety appliance, which catches on each side of the guides as soon as the tension on the bar for lifting the cage is taken off.

Drawing No. 2 shows a cage fitted with Seymour's patent appliance, known as "Seymour's patent safety-cage." The difference between these patents is that Webb's grips on each side of the guides, and Seymour's on the face of the guides. The latter cage is at the present time considered the best that has yet been tried; but there is this objection to it: the grippers on the face of the guides are likely to make the partitions in the shaft spring to such an extent that the cage might be thrown out of the guides, and if so, there is nothing then to prevent it from falling down. However the two drawings show the two best principles of safety-cages that are used in this district. It may be well to mention that the Inspection of Mines Act makes it compulsory on the owners of mines to use approved safety-cages.

Crushing Machinery.

The crushing machinery, as far as stamping-batteries are concerned, has little or no improvements on those in use at the Thames. They are all revolving stamps in this district, from 7cwt. to 9cwt. each, having a fall of from 8in. to 10in., and making about 70 blows per minute. The general impression here is that the stamp shank screwed to hold the disc is not only more expensive, but does not answer nearly so well as a couple of keys in the disc, inasmuch as the screw-thread weakens the shank, and causes it in some instances to break where screwed. The riffle and blanket tables are somewhat similar to those used in New Zealand; but almost every crushing-battery has concentrators for collecting the pyrites, none of which are in use here, although, according to Professor Black's assay of pyrites from the Invincible Mine, at the head of Lake Wakatipu (which gave over 11oz. of gold per ton), these pyrites are allowed to run to waste—at least they were running to waste at the end of December last, when I visited the works. The manipulation of pyrites will be referred to further on when describing the United Pyrites Company's works.

Quartz Workings.

Sandhurst.

The quartz lodes in this district, as well as in other places in Victoria, are differently formed to those in New Zealand. There are three classes of reefs or gold-bearing quartz lodes—that is, the saddle, the vertical or slightly inclined, and the flat lodes. The two former are the class of lodes that are found here. On the Garden Gully line of reefs they are known as saddle reefs—that is, the crown of the reef forms a saddle, and has two legs, one going in an easterly and another in a westerly direction. The Garden Gully Company's workings are about 750ft. below the level of the surface, and at the cap of the reef, before the legs commence to go down, the lode is in many places 40ft. in thickness; but where it splits and forms into two lodes, they are each from 16ft. to 20ft. in width, and run down about 100ft. until they wedge out. Afterwards another saddle is formed, although not directly under the upper one, but a little to one side. A succession of these saddle reefs have been gone through, and the impression is that they will continue to do so as they go down. There is always a certain distance between one reef and another. The cap of the second reef or quartz lode, is generally found a little to the eastward or westward of the cap of the one above it, in proportion to the dip or inclination of the strata where the reefs exist. The quartz from this company's workings average from 15dwts. to 20dwts. per ton, thus enabling them to pay last year in dividends £37,000.

In working this description of reef, especially near the cap where the lode is a great width, great care is taken in stoping to have the ground, as each stope is taken out, filled in with material sent down from the surface, or from cross-drives in the slate formation; and in many instances walls are built with stone to keep up the roof. The passes where the quartz is sent down are all logged lengthwise into the stopes, as the ordinary method of logging will not stand the pressure. The Garden Gully Company uses the National rock-drill for stoping out with; but the manager informed me that the saving over hand labour was not great in working the drill in the stopes; but in sinking shafts, winzes, uprises and driving levels, its use cheapened the cost considerably. The great advantage that he claimed for the rock-drill in stoping was, that it allowed them to take out the quartz at a more rapid rate, and likewise tended to give better ventilation in the mine. The crushing plant belonging to this company consists of 30 head of stamps of the ordinary pattern, having riffle and blanket tables, but they use no concentrating appliance, the amount of pyrites in the quartz being very small. They have not yet deemed it necessary to erect concentrators.

Lansell's Mine.—Adjoining this company's ground, on the New Chum line of reef, is Mr. Lansell's (180) mine, which has the deepest shaft in the Sandhurst District, it being 2,040 feet. Some years ago Mr. Lansell offered £2,000 to any company that would sink a shaft on any of the reefs in the district to a depth of 2,000ft., but he could find no one to accept his offer, till finally, having worked out the upper reefs, which went down to a depth of 750ft., he commenced sinking his own shaft, going down through barren ground for 750ft.; and kept on sinking until 2,040ft. was reached. A quartz lode was found at the 1,500ft. level of the same character and description as those found on the upper levels, having two legs, the same as those on Garden Gully line of reef, with foot and hanging walls running very regular, and extremely well defined. The lodes run in a northerly and southerly direction in almost a straight line—so straight that a candle can be seen along the lode on the upper levels, after they have been stoped out, for over 300yds. The only guide they had in going down was a vein of lava from 6in. to 12in. thick, and this vein still continues. Below the 1,500ft. level there are three other levels constructed; the reef opened out in each of them, and stoping commenced; but at the 1,875ft. level, which is the deepest one, the legs of the lode are tailing out, or getting so thin that it will not pay to work them deeper. The manager, Mr. Northcote, was extremely obliging, doing everything in his power to afford me all information with respect to the method of working, and the manner in which the lodes run. He contemplates that he has now five years' work in this lode, which he has proved to be payable in all the levels, and before the lode is worked out, the shaft will be again sunk and prospected to try and find another reef. The sinking of the shaft is carried on simultaneously with the stoping out of the lode, by having a small winding-engine on the surface, with a winding-rope down the ladder-shaft for haulage. A pentstock or house is built under the landing for the cages at the lower level, and the sinking continued, the stuff being hauled up in ordinary iron-bound buckets, which are landed in the lower chamber and afterwards emptied. This material is filled into trucks, and either sent up in the cages to the surface or to some of the upper levels as filling in stuff. I was extremely anxious to see the workings of this mine, as it is the deepest on Sandhurst, being over 1,000ft. under sea level; but I was told by every one that no strangers were allowed down the shaft. However, on informing the manager of my mission, he not only gave me permission, but accompanied me through the workings. The air in the lower level is very warm, notwithstanding that there is good ventilation. Having no thermometer with me, I could not tell the temperature; but, judging from the heat, it would be about 110° Fahr. There is slate rock on both sides of the lode very compact and tolerably hard, and the ground stands in many places without timber until it is filled in.

St. Mungo and South St. Mungo Companies, Eaglehawk.—These companies' mines are situated in the Eaglehawk District, about four miles from Sandhurst. The quartz lodes in these mines have a totally different formation to those on the Garden Gully, and New Chum line of reefs. In this instance the reef has a slight inclination from vertical, and is mixed up to a considerable extent with slate. The lode is from 20ft. to 40ft. in thickness, but a great percentage of this is slate, which is mixed among the quartz in large blocks; but in stoping out the reef the slate is picked out from among the quartz, and used for building walls to keep up the ground. The main levels are timbered with very heavy timber, being from 14in. to 18in. in diameter; and in many instances it is double-banked. In stoping out, very little timber is used; the stopes are kept filled in as the ground is taken out, and walls are built at short distances apart up to the roof. Instead of using timber, the slate that is mixed up with the lode, is used to build pillars or walls with; and sometimes these pillars have to be built up to very near the face of the workings. In almost every instance each stope is closely filled in before commencing another. All the passes are logged lengthwise into the stopes, and separate passes are kept specially for the workmen to get up and down to and from their work. The deepest part of their workings is about 750ft. Each of these companies has dividend-paying mines. I was informed by the manager of the South St. Mungo Company that £40,000 had been divided among the shareholders within two years. The quartz in this reef contains a great deal of pyrites, which is saved by percussion-tables, and sent to the pyrites works for treatment; and it averages from 6oz. to 7oz. of gold per ton. The St. Mungo Company, as well as several others, use the electric light in their battery-house and in the main levels; they consider it a great saving as compared with candles, and gives a much better light. Both these companies have very complete crushing-plants; they are considered the best there are in the Sandhurst District. The former company has a battery of thirty heads and the latter a forty-head battery. As these plants are considered to be the best that there are in Victoria, a full description and plans of the St. Mungo Company's plant will be given further on; and, as they resemble each other, it will be unnecessary to give a separate description of each.

The United Pyrites Company.—This company has the most interesting works in connection with the extraction of gold from the matrix, that I have seen in Victoria. They consist of reverberatory furnaces for roasting or calcining the pyrites, grinding-pans (something in principle to the Spanish arastras) for grinding the roasted material, to which is connected separating pans, so that when the material is ground up to a pulp, it is flushed off into the separator, and the fine globules of quicksilver collected. One of these separators is connected to every three grinding-pans; and in addition to this, there are three large vats for extracting the gold from the roasted material by chlorination. The cost of treatment by the grinding process is £3 per ton, and by the chlorination process £3 10s. per ton.

The roasting or calcining process is done as follows: There is a reverberatory furnace, built on an inclination from the fireplace towards the chimney of about 2½in. in every foot. The furnace is 46ft. in length and 7ft. 6in. in width, inside measurement; the height of the walls from the floor of the furnace to the springing of the arch is 14in., and the height from the floor to the centre of the crown of arch would be about 20in. At the lower end of this furnace is a fire-box 22in. wide, fitted with fire-bars for burning wood; and there is a low bridge between the fire-box and the furnace. Along the side of the wall of the furnace, and on a level with the floor of same, there are small holes or ports left about 6in. in height, and 10in. long, every 4ft. apart, fitted with iron doors. These ports are made so that the pyrites can be stirred as it comes down the inclined floor of the furnace; the great object in roasting is to desulphurize the pyrites as much as possible, so as to make amalgamation with quicksilver complete. At the upper end of the incline furnace there is a large receiving-hopper placed over the top, capable of holding about from three to four tons of raw pyrites, which dries there, and is fed through a small hopper into the furnace as required. The material to be operated upon is stirred up in the furnace with rakes and slides, so as to allow the fumes from the sulphurets to get away as quickly as possible; and as the stuff gets down the inclined floor of the furnace towards the fire-box it is heated, when at the lower end, to a bright-red colour, and when it is considered to be properly desulphurized a trap-door in the bottom of the furnace is opened and the roasted material drawn out and allowed to cool. When the pyrites is sufficiently roasted or calcined, there is an absence of any fumes, and the material has a different character. When worked with the rake, it turns far more freely, and has not that heavy and clogged nature that it had, when it was emitting the fumes. At the upper end of the furnace there is a short flue leading into a large brick chimney; but there does not appear to be any appliance or apparatus for condensing the fumes and making them a marketable product: they are simply allowed to go up the chimney. A furnace of this dimension is capable of roasting about four tons of ore per day. When the ore is very refractory, a small quantity of salt is mixed with the pyrites, which has the effect of freeing the gold from its oxides, and rendering it easier for chlorination, by removing lead, antimony, or other sulphates obnoxious to the final process.

The roasted or calcined ore is allowed to cool, and thence removed by small trucks to either the grinding-pans or the chlorination vats. The grinding-plant consists of twelve arastras, and four separators. These arastras are about 5ft. 8in. in diameter on the outer edge of pan, and 3ft. in diameter in the inner edge, thus leaving a space of 16in. wide for drags to work and grind up the roasted material to a pulp. There is a cast-iron false bottom in each arastra, loosely fitted in and filled around with Portland cement, and the depth of the sides of the pan, which are vertical, is 15in. A small quantity of the roasted material is now put in with about 40lb. of quicksilver, and a little water. Afterwards the pans are set in motion, having two drags one opposite each other, of about 3cwt. each, and made to revolve at a speed of about twenty revolutions per minute. The first object in grinding is to break up and mix the mercury as much as possible with the material under treatment; and, after that has been done, more water is added, the ore ground to a fine pulp, afterwards flushed into a separator, and the same process repeated. This separator is about 4ft. in diameter, 16in. in depth, and has a carrying arm which comes close to the bottom without touching, driven at a speed of about fifteen revolutions per minute; the object of the separator being to collect the minute globules of mercury together, that has diffused through the material operated on, by the grinding process, and escaped among the tailings and water. When this operation is considered to be sufficiently performed, the sludge is flushed off by water, and the process repeated.

Chlorination Process.

If the roasted material has to go through the chlorine process, it is taken after being damped to the chlorine vats. These vats are 10ft. in diameter, 2ft. 10in. high on the sides, and are made of soft wood 2½in. thickness, having the inside of them coated with an admixture of Stockholm tar and pitch put on hot, or else coated with asphaltum cement. Each vat has a false bottom, which stands about 1in. above the main bottom, made of timber and perforated with holes, and on the top of this false bottom is placed a thin layer of broken quartz, coarse gravel, and on the top of all, quartz tailings or sand, which forms a filter bed about 5in. in thickness, the false perforated bottom being laid on strips of wood along the bottom. The material to be operated on, is then filled in on the top of the filter-bed, to within a few inches of the top of the vat, and the generator set to work. The generator consists of a large earthenware jar, capable of holding about twenty-five gallons of liquid, and into which is placed an admixture of sulphuric acid, manganese, salt, and water. The proportion is given further on. In order to thoroughly understand the process it will be necessary to consult the annexed plan, Drawing No. 3, which is a plan and section of the United Pyrites Company's works at Sandhurst. The whole process of chlorination was described to me by the manager, Mr. Edwards, who is likewise part proprietor. The plans are as follows: Drawing No. 3 comprises a vat 10ft. in diameter, 2ft. 10in. high on the sides, made of wood 2½in. in thickness (kauri pine preferred). The inside must be coated with Stockholm tar and pitch, and put on while hot, or it may be coated with asphaltum cement. A false bottom, made of wood and perforated with holes, is laid on strips 1in. thick, which forms a chamber or recess between the main and false bottom. The holes B and C come between the main and false bottom, and the hole C is fitted with a lead cock to draw off the water. The hole at B receives the lead pipe E leading from the wash-bottle F, which is a Winchester quart bottle with the bottom cut out, and this bottle also covers the end of the lead pipe H leading to the earthenware generator I. The end of the pipe E, as shown on plan, is about 4in. out of the water that is contained in an earthenware dish, in which the Winchester quart bottle is placed, and the end of the pipe H is 2in. under the water, so that the gas passing from the generator through the pipe H passes through the water, and is washed and freed from hydrochloric acid before passing through pipe E leading into the vat. The gas coming out of the pipe into the chamber or recess, between the false, and main bottom, is distributed all over the bottom of the vat, and rises through the filter-beds K and the roasted ore. The filter-bed is formed of first a layer of broken quartz about the size of walnuts, next a layer of smaller size, then a layer of small gravel, and on the top a covering of quartz-sand, making altogether a thickness of about 5in. On the top of this filter-bed the roasted ore is sifted after being damped, but care must be taken not to make it too wet, only in such a state as a handful may squeeze into a ball that will stand gentle handling, and the vat is then filled to within 5in. or 6in. of the top. The vat having been filled with ore, which is about from 5 to 6 tons, the generator is next set to work. This is done by putting 35lb. of manganese, 50lb. of common salt, 85lb. of sulphuric acid, and 50lb. or 5 gallons of water into the generator, which is a large earthenware jar having a capacity capable of holding from 20 to 25 gallons. After a short time four bottles of acid are added. The gas should come up pretty briskly, which will be indicated by the wash bottle F, and if this does not take place the contents of the generator should be stirred and more acid added, and heat applied to the generator, either by having it placed on a hot sand-bath with fire under it, or by having the generator placed in a tub of water heated by a jet of steam from the boiler that supplies steam for the engine which drives the other machinery. When the gas rises to the top of the ore in the vat, the cover is then put down and made air tight, which is done with a linseed meal joint. There is a hole in the top of the cover that is left open until the gas smells strong through it, after which it is corked up, and the generator kept at work for fifteen to sixteen hours. At the end of that time, if circumstances have been favourable, the cork in the cover is removed, and a little ammonia on a cork held over the hole, which will indicate whether the ore has been chlorinated successfully or not by the ammonia giving off white fumes. If there is sufficient gas it may remain eight hours longer, then remove the cover and run water on the top of the chlorinated ore until the vat is filled; this process is done by an inverted T gas-pipe having a joint at the end of the vertical and centre of the horizontal pipe. The horizontal pipe is almost the same length as the diameter of the vat, having small holes on the sides. The holes on either side of the centre being opposite to each other, this gives the horizontal pipe a revolving motion like a turbine water-wheel when the water is turned on, and it distributes the water in a regular shower equally all over the surface of the vat. When the gas or air bubbles cease to rise on the surface of the water, the cock C is opened, and the chloride of gold solution is then drawn off into twenty earthenware jugs or pans holding thirty gallons each, or into a vat of equal capacity, into which is added, to precipitate the gold, a little hydrochloride acid, and half a gallon of strong sulphate of iron in each jug or pan; but more sulphate of iron must be added if the jug or pan, on being filled, should lose its dark colour. The water should be tested as it is drawn off by taking a glass tumbler, and adding to the water or solution a few drops of hydrochloric acid, and afterwards some sulphate of iron; if there is gold in the solution it will turn dark, and thus be tested until no colour can be obtained. The solution should stand in the pots or pans ten or twelve hours, and when the gold has been precipitated, the clear water is then drawn off by a lead syphon, after which, the bottoms of the pots or pans should be washed out into another pot, and left to settle until the water is clear, after which the water is then syphoned off, and the gold powder collected and put into filter-papers. After the water is filtered off the powder is dried, the papers are burnt, and the powder put into a clay crucible with a little nitre and borax, and smelted.

Roasting or Calcining the Ore.

Drawing No. 3, Fig. 1, shows the plan, Fig. 2 the elevation, and Fig. 3 the cross-sections of a reverberatory furnace, as used by the United Pyrites Company at Sandhurst. The length from the bridge A to the entrance of the flue B is 46ft., and the width, inside measurement, is 7ft. 6in., with 18in. brickwork, as shown on Fig. 1. The height inside the furnace is 14in. from the hearth to the rise of the arch, and there are ten working openings, each about 6in. high by 10in. long, on each side of the furnace, 4ft. apart from centre to centre. The furnace is built on an incline from close to the bridge adjoining the fireplace to the flue, leading into the chimney at the opposite end, of 2½in. to the foot, which Mr. Edwards informed me was suitable to the class of pyrites he had to deal with; but, if the pyrites were pulverized very fine, and well concentrated, 1½in. to the foot would be sufficient. At the lower end of the incline there is a fire-box, D, the same length as the inside width of the furnace, 22in. in width, supported by a strong masonry wall at the lower end of furnace or side of the fireplace, as shown on drawing. The fire-box is filled with cast-iron grate-bars, suitable for burning wood, and the sides of the furnace are bound with wrought-iron straps, as shown, having bolts passing through the furnace top and bottom. On the top end of the furnace there is a place, marked E, which is built up to hold from three to four tons of raw pyrites, with the object of drying it, after which it is fed through the hopper E into the furnace, as required. The ore in the furnace is worked and turned over with rakes, and slides through the openings in the sides, which are fitted with an iron slide-door, to open when required; and as the ore travels down the incline it gets subjected to a greater heat, until it is almost a bright-red colour when it reaches the lower end. When the ore is sufficiently desulphurized it emits no fumes on being stirred up, and is of a loose, fine character when turned by the slides or shovel. Adjoining the bridge there is a flat portion on the hearth, which has a trap-door opening into a pit below, where the roasted ore is hauled out and allowed to cool, before being taken to either the grinding or chlorination process.

Grinding Process.

The roasted ore, when cool, is taken away in trucks to the machine-house, and stacked on the floor alongside the grinding-pans, which are similar to the Spanish arastras. The arastras are cast-iron pans, as shown on plan, drawing No. 3, Fig. H, which also shows the elevation as well as section of pan with cast-iron false bottom, which are made of hematite iron put in loosely and filled around with Portland cement. A vertical shaft passes through the centre of the pan, which carries two hard-wood arms, 4in. by 3in., to which is attached by chains two cast-iron drags, of 3cwt. each, and driven at a speed of twenty revolutions per minute. Fig. B shows a separator, partly section, with the arms and stocks attached, which revolve at a speed of fifteen revolutions per minute. These stocks are not for grinding; their use is mainly to keep the tailings alive by their motion when the arastras are being flushed off, so that any mercury that may escape from the arastras among the tailings, is separated and collected at the bottom of this pan. When this process is considered to be complete, the outlet holes K are opened and the whole of the water can be run off. One of these separators is used to take the tailings, and water from three arastras.

It may be of interest to give a brief description of the mode of working the arastras, as described to me by Mr. Edwards. First turn on sufficient water from an $1\frac{1}{4}$-in. cock (placed at each pan) to cover the bottom 1in. deep, then add 30lb. to 40lb. of quicksilver; next put in a bucketful of roasted ore, after which set the drags in motion; then add one or two more bucketsful of ore, and a little more water if there is not sufficient, but not so much as to cover the whole of the quicksilver; then let the drags run for about half an hour, after which turn on more water, as that allows the drags to have greater grinding power on the ore, and likewise allows the small globules of mercury that had previously formed to collect in a body at the bottom of the pan. Let it run in this condition for half an hour longer, then pull out the top plug, which is about 6in. from the bottom, and open the water-cock, keeping the drags still going, when, in about ten minutes, the tailings will be flushed off through the iron shoots into the separator, which is kept going, having the two top holes always open. After the water has been running into the arastra for ten or fifteen minutes, stop the drags and drain off the water through the plug-hole, which is half an inch from the bottom. When the water is all drained off, put in a bucketful of ore, start the drags, and repeat the process as before.

This description will enable any one to get an idea of how the pyrites is treated in the Sandhurst District; but before closing my remarks on the different processes used in Victoria, I will again refer to this subject.

At Mr. Koch's battery at Long Gulley there is a new machine, which is patented by Messrs. Huntingdon and Koch, for amalgamating roasted ore on the same principle as that known as the "Jourdan process." The ore is ground dry, in a bath machine to a fine powder, and passed through a screen having about two thousand holes to the square inch. This dust is then forced up through a column of mercury in the following manner: There is a hollow tube, which forms a vertical shaft having two short hollow arms near the lower end, which revolves in a column of quicksilver about 18in. in depth at the speed of from 250 to 280 revolutions per minute. The arms at the lower end of the hollow shaft have openings on the sides on the same principle as a primitive turbine wheel of the very old type. The great velocity at which the shaft and arms revolve draws in the dust, which is fed through the hollow vertical shaft, and the quicksilver, having the greatest density, forces the lighter particles to the top and retains the gold. I was not greatly impressed with this system, as it is almost impossible to force the refuse through the quicksilver without carrying some of the mercury in fine globules almost in flour, and when this takes place, it carries a certain percentage of gold along with it. However, this was only a small model which was at work, and no trial beyond this has yet been made.

Since writing the above description, Mr. Langtree, in his report on Victorian mines, states that this machine has been publicly tested, and upwards of 100 tons of ore put through, in competition with ordinary appliances, at Sandhurst. The results were, according to the nature of the ores, from 11·32 to 18·2 per cent. more gold than from batteries, tables, riffles, blankets, &c. Sketch of this machine is attached (Drawing No. 4).

There is also another pyrites works in Sandhurst, belonging to Messrs. Roberts and Co., which is a very complete roasting and grinding plant, similar to that of the United Pyrites Company, with the exception that they do not use the chlorination process. Both of these works are spoken highly of by the miners as being very successful in their treatment of pyrites.

Castlemaine.

The thing most worthy of note in this district is the Coliban Water Supply. The machinery employed is of the ordinary type, and no new appliances are used. The water supply in this, as well as in the District of Sandhurst, is brought from the Coliban River, near Malmsbury, where a large reservoir is constructed. The water is brought in conduits and tunnels to Sandhurst, and into supply-reservoirs at Forest Creek and Harcourt, which are used for distributing the water in these districts. The works connected with this water supply are constructed similar to those in connection with the water-races, dams, and reservoirs on the west coast of the Middle Island, only with this exception, that works in connection with the Victorian water supply are constructed on a far more elaborate scale. The total cost of these works has been about £1,000,055.

The following are the rates charged for water:—

(1.) On every house or tenement of £20 annual value and under, £1 per annum.

(2.) On every house or tenement above the annual value of £20, a rate of £5 per centum on the amount of the valuation up to £300 inclusive; £3 per centum on the amount of the valuation in excess of £300 up to £700; and £2 5s. per centum on the amount of the valuation in excess of £700.

(3.) On every shop, not used as a domicile, above the annual value of £20, a rate of £4 per centum on the amount of the valuation up to £300 inclusive; £2 per centum on the amount of the valuation in excess of £300 up to £700; and £1 5s. per centum on the amount of the valuation in excess of £700.

(4.) The rates to be charged for water supplied from standpipes shall be 1s. per 100 gallons.

(5.) The rate to be charged for water supplied by the Board from the mains by measure shall be 1s. per 1,000 gallons, except in the case hereinafter specially mentioned.

(6.) For water supplied from the mains for sluicing purposes, the rate shall be 2d. per 1,000 gallons.

(7.) For water supplied from the mains for mining purposes other than sluicing, the rate shall be 4d. per 1,000 gallons.

(8.) For water supplied from the channels to crushing-mills, pyrites-works, &c., the rate shall be 3d. per 1,000 gallons.

(9.) For water supplied to gardens and nurseries, cultivated for trade purposes, and to cricket-grounds, the rate shall be 6d. per 1,000 gallons.

(10.) For water supplied to any cemetery, the rate shall be 4d. per 1,000 gallons.

(11.) For water supplied to any public parks or gardens, the rates shall be 6d.per 1,000 gallons.

(12.) *a.* The rate to be charged for water supplied from the main aqueducts and from any of the branch aqueducts which diverge therefrom shall be ½d. per 1,000 gallons, in quantities of not less than 1,000,000 gallons per month. *b.* The rate to be charged for water supplied in fixed quantities of less than 1,000,000 gallons from any portion of the main aqueduct, or from any of the branch aqueducts, shall be—for quantities under 250,000 gallons, 2d. per 1,000 gallons; above 250,000 but under 500,000 gallons—the first 250,000 gallons 2d. per 1,000 gallons, for the excess 1d. per 1,000 gallons; above 500,000 gallons but under 1,000,000—the first 500,000 gallons 1½d. per 1,000 gallons, for the excess ½d. per 1,000 gallons. Delivery of the water shall be taken within one month from the time of purchase, failing which the purchaser shall forfeit all his right thereto. The minimum quantity of water to be charged for in each case where water is supplied by measure shall be: (1) If for domestic and other than domestic purposes, the quantity of which—the charge at 1s. per 1,000 gallons—would be equal to the amount of the assessed rate which would be payable for the premises so supplied, if supplied otherwise than by measure; and (2) if for other than domestic purposes only, 25,000 gallons per quarter.

To compare the prices charged for water supplied to the miners with the prices charged in New Zealand, they are as follows: A sluice-head, according to "The Mines Act, 1877," is a stream of water capable of discharging 60 cubic feet per minute, which is equal to 1,080,000 gallons per week, or, in other words, a sluice-head is a stream of water capable of discharging 1,080,000 gallons per week if flowing eight hours per day. This, at 2d per 1,000 gallons, which is the price charged for taking water from the mains for sluicing purposes, equals £9 per head per week, and if the water is supplied from the main or branch aqueducts, the price charged for same purpose is ½d. per 1,000 gallons, which is equal to £2 5s. per head per week. This water supply is managed by the Department of Mines.

Maldon.

The general custom here is to burn the quartz before crushing in order to extract the sulphur from the pyrites, so as to allow the gold contained therein, to be absorbed by the mercury in the riffle boxes, and tables. At the Grand Junction Company's works, which I visited with Mr. H. B. Nicholas, the Senior Inspector of Mines in Victoria, there are four kilns erected for burning the quartz as it comes from the mine. These kilns adjoin each other, and are built up with strong dry stone walls in the following manner: A cutting or bench is made into the face of a hill, and the wall is built at the front side and ends, high enough to admit of the whole depth of the kiln being built between the front wall and the side of the cutting already made, having openings on the front wall opposite the places where the kilns are built, to haul out the quartz, to take it to the battery. Circular kilns are built in the shape of an inverted cone, as close to each other as the walls will admit. These are capable of holding and burning 50 tons of quartz each. The bottom of the kilns is sufficiently high above the tramway, which runs along the front, to allow the burnt quartz to be hauled out into the trucks. Before commencing to put the quartz into the kilns, there is a good layer of firewood placed in the bottom; then a layer of quartz, next a layer of firewood, afterwards quartz again, and so on, until the kiln is filled; but in filling the kiln, firewood is set on and all around the sides, and the quartz heaped up on the top as much as possible, after which, the fire is kindled at the bottom, and the kiln kept burning from seven to eight days. By the end of this time the quartz is tolerably well calcined, especially near the bottom of the kiln, where it is run together like slag. The manager of the Grand Junction Company informed me that the cost of this process amounted to about 4d. per ton, and he contended that, irrespective of the cost of liberating the sulphur and arsenic, it paid the company to roast the quartz in this manner, as the amount of work done by the crushing-battery was greatly increased owing to the quartz being more friable. The crushing-battery is of the ordinary type, having revolving stamps and keyed discs, but no quicksilver or copper plates are used on the riffle-tables, they being simply covered with blankets. At the end of the blanket-tables the tailings run into Chilian mills and are ground up with quicksilver, after which they run over rocking-tables 12ft. long and 4ft. wide, which are likewise covered with blankets. This tends to concentrate the material more than by simply allowing it to run over a plain stationary surface. Whether the roasting process and rocking-tables have the superior advantages that is claimed for them, may be a question, but they are not adopted in any other district. The machinery on every field has different peculiarities, and each one seems to imitate the other in the several districts where they are situated. This may, in a great measure, be due to a number of the shareholders and directors being local men, and when once any custom, or mode of working is adopted and established on a field, it becomes a hard matter for any one, unless at his own expense, to introduce any new appliance which would tend to upset the established custom, as it would, until well tried and found to be successful, be considered an innovation.

Diamond- and Rock-Drills.—In making inquiries of various mining managers of this field with regard to the use of rock- and diamond-drills, their unanimous opinion is, that the compressed-air rock-drills are a great saving in every respect, both with regard to the cost of working, and the greater rapidity with which the quartz can be taken out; but they do not consider the diamond-drills so well suited for prospecting unless under exceptional circumstances—such as testing reefs under the water-level; and even in this case they do not always give satisfactory tests, as they may go through the lode obliquely, and thereby lead one to suppose that the lode is of much greater width than it actually is.

Clunes.

The Port Phillip Company at the Clunes is the oldest quartz-mining company there is in the Australian Colonies, having been steadily in work for the last twenty-seven years, and their crushing-battery, although of a very old type, is as large as any yet employed in Victoria. Their crushing-battery consists of 80 heads of stampers of from 6cwt. to 8cwt. each, and makes about eighty blows per minute, with a drop of about 8in., and two of Appleton's stone-breakers. The stamps have the old-fashioned square shanks and heads, with discs keyed on, and are lifted by steel-faced tappets, wedged in, and projecting from a cast-iron drum of about 20in. in diameter. The stamp-boxes are made to discharge the tailings at back and front, having gratings made of copper plate about 14 B W gauge in thickness, with 84 holes to the square inch, which appears at first sight remarkably coarse; but the manager informed me, that, in order to crush the quartz fine, he kept the lower side of the gratings some distance above the bottom of the stamp-box, and by this means got the tailings as fine as with gratings having double the quantity of holes, and the gratings last much longer. These gratings are manufactured in England, and cost 2s. 4d. per lb. The company uses ordinary riffle-tables and quicksilver wells, at the end of which, are blanket-tables. After this the tailings and water go into a shoot and are carried into concentrating buddles 24ft. in diameter; one of these buddles being used to every five heads of stamps. These buddles have an inclination upwards of 1 in 12 towards the outer edge, and the tailings and water coming from the blanket-tables, flow into a hollow tube fitted on the vertical shaft that drives the arms, which has eight pipes leading out of it, that carries the tailings and water to the outer edge of the buddle, and at the same time they are made to act as stays for supporting the arms (which are of equal number). To each arm is attached three scrapers, or vertical plates of iron about 14in. in length and 3in. wide, standing at a slightly obtuse angle to the arms. As the tailings flow down the incline they are discharged in the centre, and, by means of the motion of the scrapers (which make about eight revolutions per minute), the stuff is always kept loose, which allows the sand to wash away, and leaves the pyrites and heavier particles on the inclined plane. At intervals of about eight hours, the pyrites is taken out of the buddle and stacked ready to undergo a similar process in another buddle, so as to get clear of as much sand as possible, after which, it is taken away and calcined in a reverberatory furnace similar to the furnaces used by the United Pyrites Company at Sandhurst, which have been fully described. The roasted ore is then taken and ground with quicksilver in Chilian mills, and afterwards flushed into a separator. This company's battery is fed from self-acting hoppers to every five heads of stamps by having a strong iron bar standing nearly vertical, with a knob on the upper end, and the lower end attached to the mouth of each hopper, so that the centre stamp, in falling, causes the disc to strike the knob, and allows the quartz to run into the stamp-box. It must, however, be remembered that, before the quartz is brought into the hoppers, it goes through the stone-breakers, and is reduced to the size of road metal. The false bottoms in the stamp-box, as well as the plates in the jaws of the stone-breaker, are all made of wrought iron. The company finds this a great saving, and it answers much better than the hematite bottoms that were used in former years, and which are generally used still in New Zealand. The nature and extent of this company's crushing, amalgamating, and concentrating plant, and the manner in which the quartz is treated from the time it is taken from the mine until the gold is extracted from it, may be better understood by the following particulars:—

Tramway from the Mine.

Appleton Stone-breakers.

Short Tramway from Stone-breakers to Self-feeding Hoppers.

Self-feeding Hoppers.

Stamping Battery.

Riffle and Quicksilver Wells and Copper Plates on Tables.

Pyrites taken out of Buddles and Stacked.	Waste Sand and Tailings, with water, flowing away in Shoots.

Reducing Buddle.

Reverberatory Furnace.

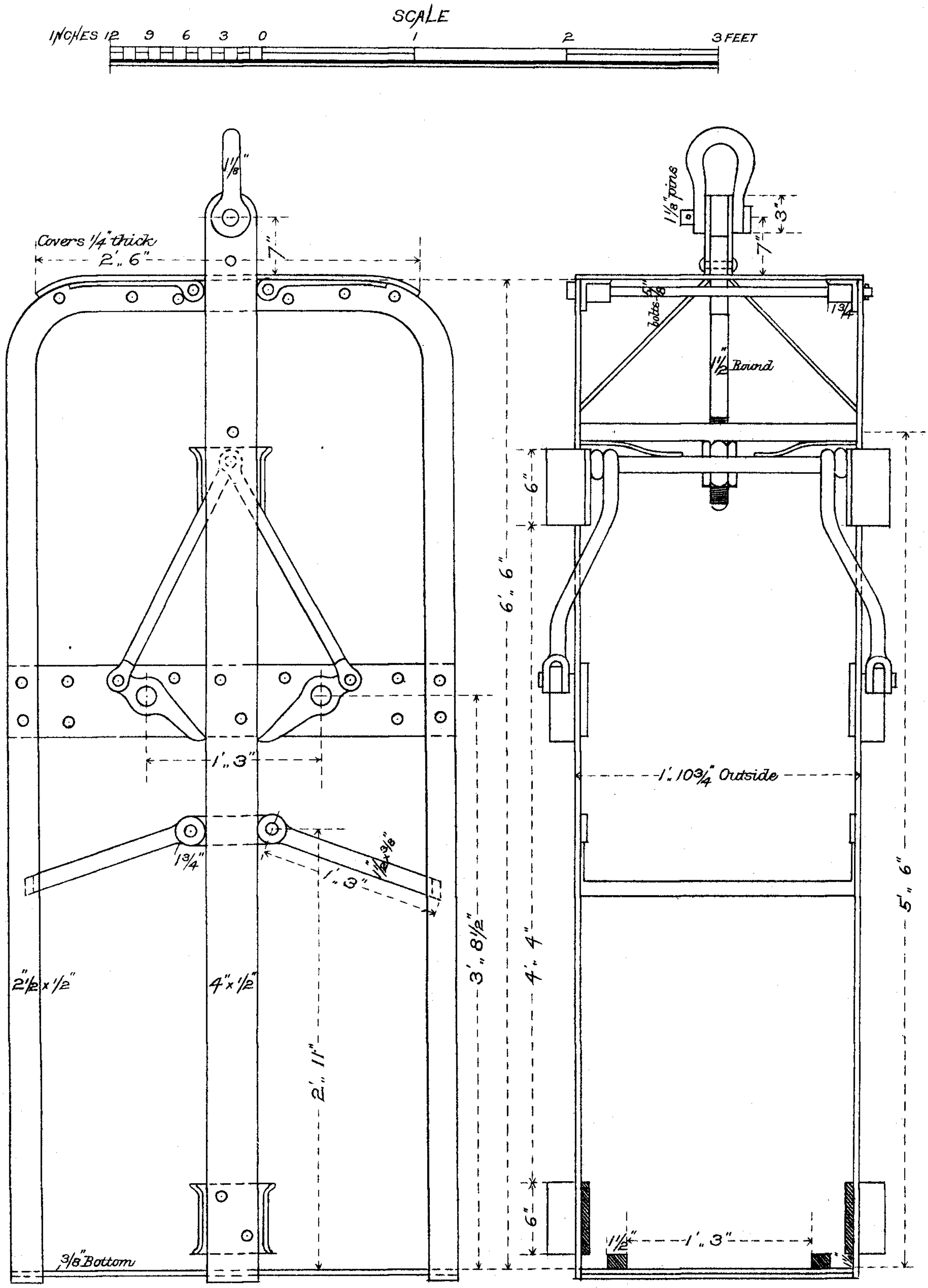
Chilian Mills, for Grinding Roasted Pyrites.

Separator.

Retorting and Smelting Furnace.

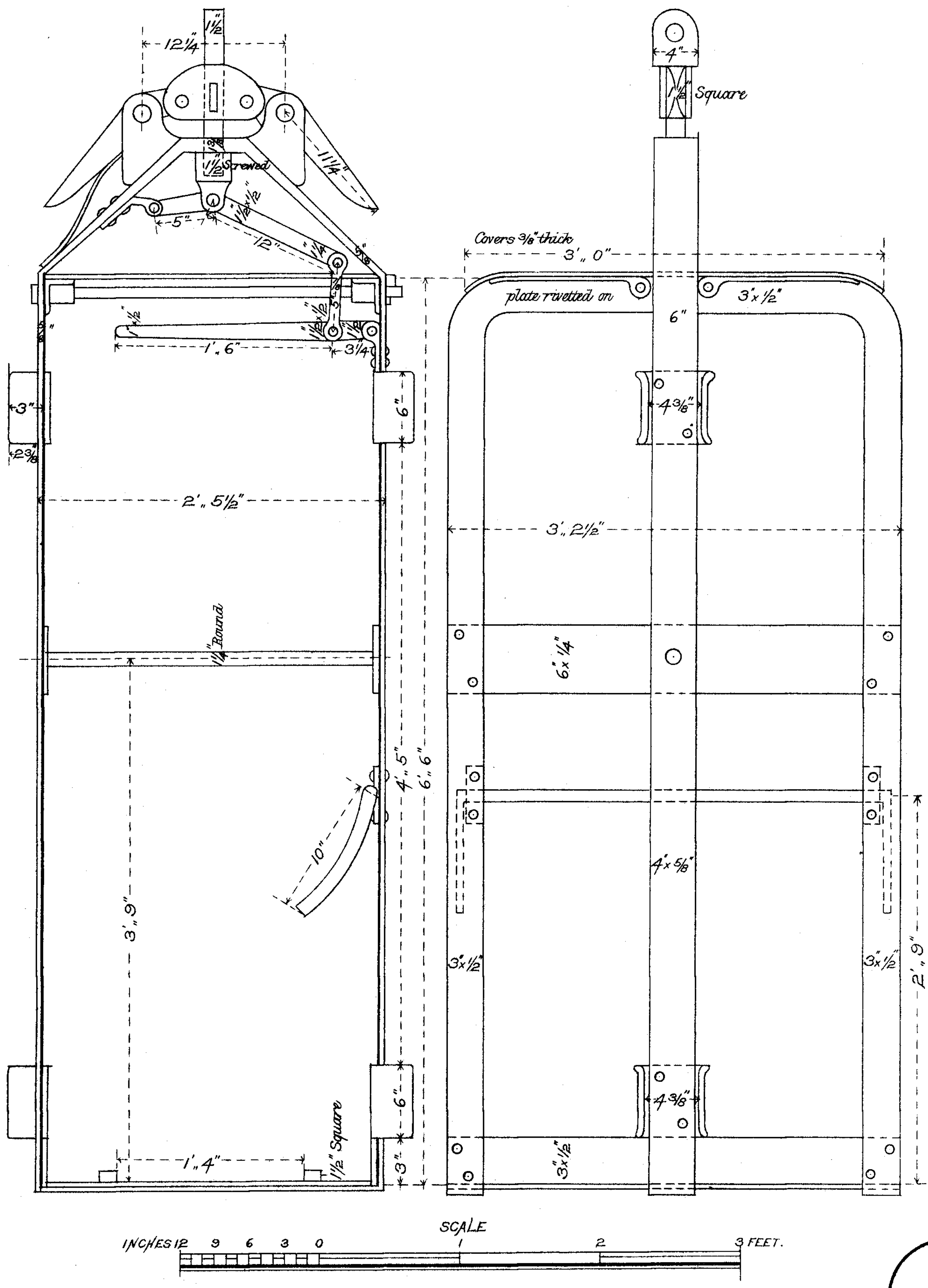
DRAWING No 1

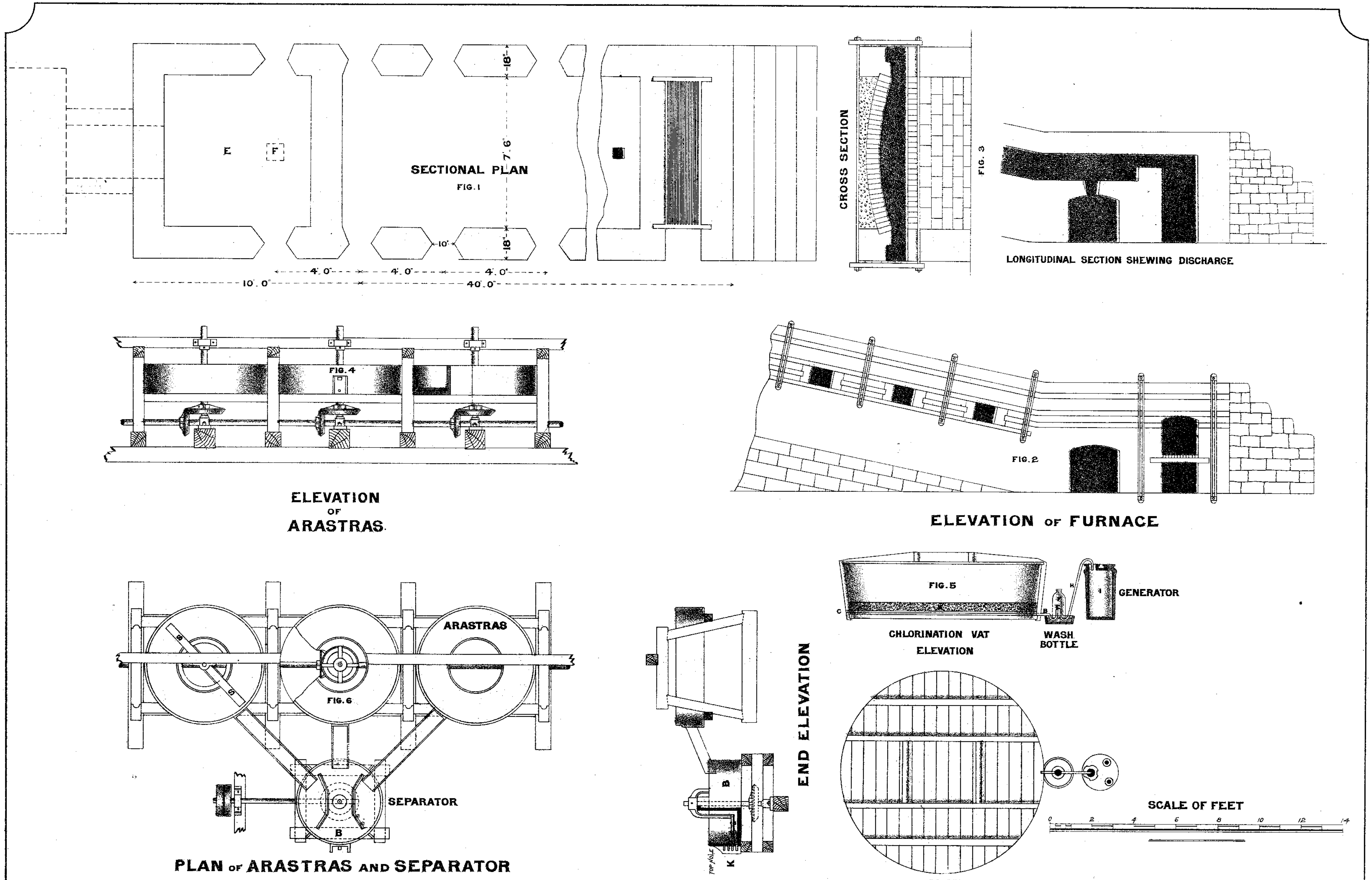
MINING CAGE
FITTED WITH
WEBB'S SAFETY APPLIANCES



DRAWING No 2

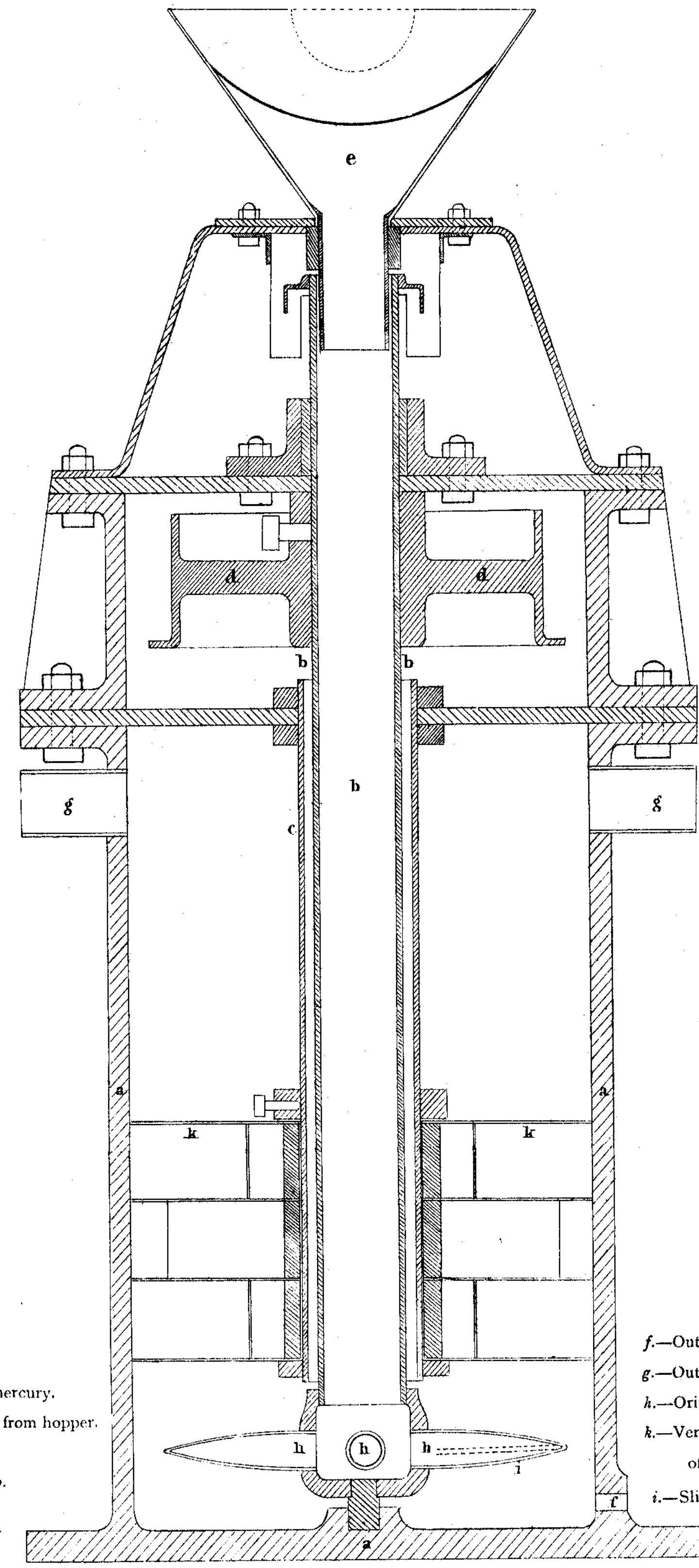
SEYMOUR'S PATENT SAFETY CAGE





THE UNITED PYRITES COY'S WORKS, SANDHURST.

HUNTINGTON AND KOCH'S
AMALGAMATOR



a.—Cast-iron basin which is filled with mercury.
b.—A hollow shaft into which ore passes from hopper.
c.—A stationery pipe or sleeve.
d.—Driving-pulley fixed on hollow shaft *b*.
e.—Hopper in which ore is placed.

f.—Outlet for drawing off mercury and amalgam.
g.—Outlets at top of basin where tailings are discharged.
h.—Orifice where ore passes through into mercury.
k.—Vertical and horizontal screens to prevent the rotation of the amalgamating metal.
i.—Slits in orifice *h*.

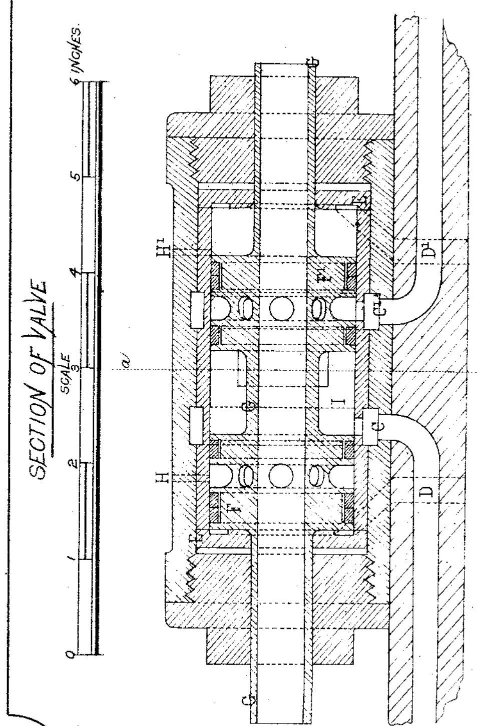
SECTION
through centre
Scale 3 In to 1 Ft

INCHES 12 9 6 3 0 1 FOOT

DRAWING No 5.

NAYLOR & THORNTON'S PATENT

ROCK DRILL.



SECTION OF VALVE

Fig 2

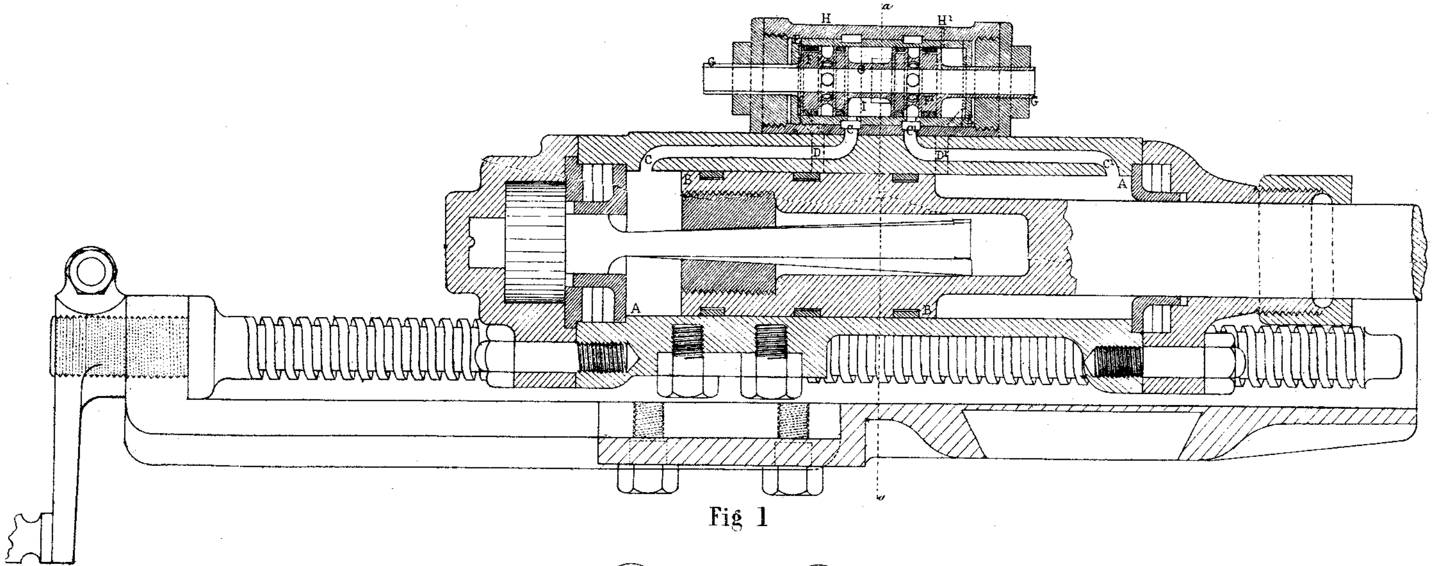


Fig 1

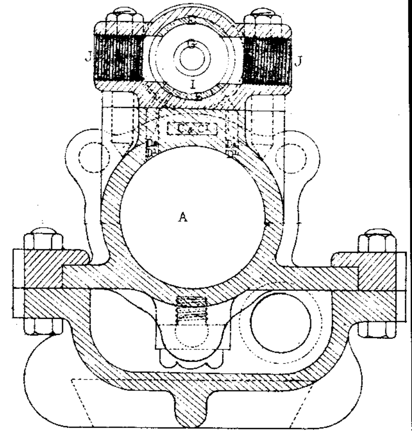


Fig 4

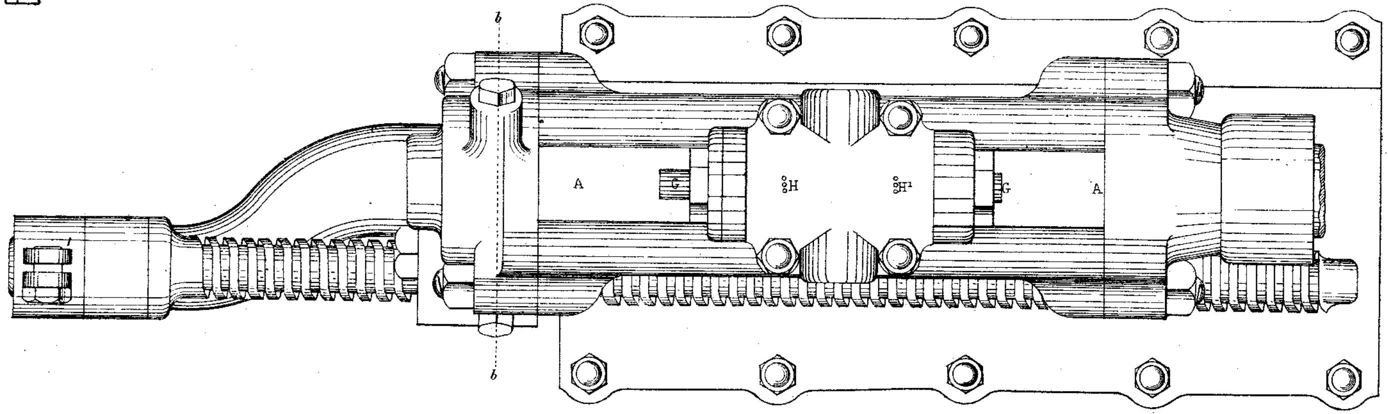


Fig 3

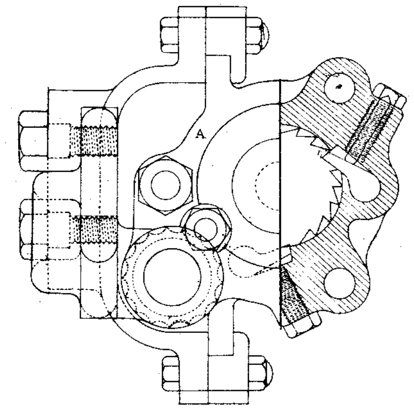
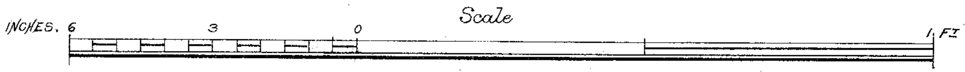


Fig 5



A little lime is mixed with the roasted pyrites, which tends to keep the quicksilver clean and in a better state for amalgamation. Any flowered quicksilver that is collected is put into a revolving cast-iron barrel, globular in shape, into which there is a jet of steam, and by this means it is brought back to its original condition. Mr. R. H. Bland, the manager of this company, has kept very accurate returns, which are made monthly, of the quantity of quartz crushed, the percentage of gold that is obtained in each process, the duty done by each description of stamps, and the quantity of fuel consumed in working the crushing-battery. The first battery of stamps was completed and got to work in May, 1857, which consisted of 20 heads of square stamps driven by a 12-in. cylinder steam engine. These have from time to time been increased, until in 1877 the plant consisted of 80 head of stamps, two stone-breaking machines, and six buddles, all driven by a 24-in. cylinder engine, supplied with steam from five multitubular boilers. Since then, the number of buddles has been increased. The two Chilian mills, separator, and other appliances for treating the pyrites, are driven by a separate engine supplied with steam from the same boilers.

The following is an extract from Mr. Bland's report to the shareholders in 1877:—

"The quantity of fuel consumed in connection with working the machinery during the first twenty years the company was at work was 37,255 cords of wood, and the total amount of quartz crushed in same period was 954,139 tons. The consumption of fuel during the first year averaged one cord to every 8 tons of quartz crushed; but the improvements made from time to time in the machinery have reduced the consumption to one cord to every 42 tons of quartz crushed. The amount of gold obtained during the first twenty years was 380,308oz. 8dwt. from quartz, and 27,300oz. from alluvial, making a total value of £1,625,529, and the receipts above the expenditure amounted to £366,166; out of this amount was paid £243,500 in dividends to shareholders, and £123,666 to the proprietors of the freehold on which their mine is situated as royalty.

"Finding in the early period of the company's operations that there was a considerable loss of gold on the stamping process, careful examination of the waste sand proved the greatest loss to be in connection with the pyrites. Attention was at once turned to the best means of concentrating this material and extracting the gold from it. Commencing with a produce of 1oz. of gold to the ton of pyrites, being 26 per cent. of the assay, the process was gradually improved until over 90 per cent. of the assay contents has for a lengthened period been obtained.

"The total quantity of pyrites saved and treated from 1862 to 1877 was 4,790 tons; total yield of gold 16,670oz., which left a balance of profits over and above the cost of saving and treating of £50,737 6s.

"The total costs connected with mining and crushing the quartz for the twenty years averaged £1 3s. 3d. per ton. This includes the cost of machinery; and it must be borne in mind that in the earliest period of the company's operations the expenses were very great. The cost connected with crushing the quartz alone, during the first six years, amounted to 19s. 3d. per ton. During the last twelve years the mining and crushing has averaged 18s. 6d. per ton, and this includes £12,000 expended on machinery account."

The total quantity of quartz crushed from the commencement up to October, 1884, was 1,281,835 tons, and the amount of gold, including alluvial, was 506,220oz. 4dwt. 1gr. The general average for the quartz during this period was 7dwt. 10gr., and the total profits divided have been £339,572 17s. 4d. paid to the shareholders, and £138,877 11s. 7d. to the proprietors of the freehold as royalty.

My object in giving a lengthened description of this company's works is to show the amount of gold that has been got out of the pyrites alone, and the profits obtained, in order to direct attention to the large amount of waste that there is in some of our mines. The following is a table showing the return of pyrites treated by this company since they commenced to save it in the beginning of 1863 to the end of 1880. I could not get the returns up to 1884:—

Year.	Tons.	Gold.			Average per Ton.			Proceeds.			Profits.		
		Oz.	dwt.	gr.	Oz.	dwt.	gr.	£	s.	d.	£	s.	d.
1863	562	467	7	0		*		1,817	8	8	*Nil.*		
1864	76	201	0	0	2	12	9	749	18	6	417	0	0
1865	271	762	13	0	2	16	6	3,031	4	0	2,255	17	0
1866	268	796	0	0	2	19	4	3,169	7	9	2,131	17	10
1867	215	960	13	0	4	8	8	3,807	15	0	3,033	17	0
1868	369½	1,322	13	0	3	12	4	5,217	3	7	4,157	18	6
1869	401½	1,515	11	0	3	15	11	6,087	2	2	4,899	3	0
1870	456¾	1,420	6	0	3	3	6	5,732	2	2	4,571	18	0
1871	561	2,290	1	0	4	1	15	9,248	13	11	7,668	1	5
1872	368	2,061	9	0	5	11	22	8,522	11	8	7,208	6	9
1873	294	1,268	17	12	4	6	7	5,182	3	9	4,211	2	4
1874	330	1,024	0	0	3	1	22	4,178	6	2	2,770	8	9
1875	236¾	946	16	0	4	0	5	3,868	14	7	2,637	4	2
1876	224¼	937	7	0	4	3	14	3,819	13	9	2,687	18	1
1877	321½	1,549	0	0	4	16	8	6,312	3	3	4,818	2	8
1878	339¼	1,935	7	0	4	16	23	7,886	11	0	6,144	7	0
1879	421	2,018	1	0	4	15	20	8,223	19	0	6,334	4	3
1880	390	1,625	2	0	4	3	8	6,624	1	5	5,028	10	6
											70,975	17	3

* Badly dressed.

This shows that, during the eighteen years the company have been saving and treating the pyrites, the profits from this source alone have been £70,975 17s. 3d., or an average of £3,943 1s. 1d. per annum; but, if the first year be deducted, which is only reasonable, seeing that the company was experimenting in a great measure on the treatment, and had not got into the proper method of dressing the pyrites, then the average profit for the seventeen years has been £4,175 1s. per annum; and to take the value of the pyrites plant, which cannot amount to more than £4,000, it would give over 103 per cent. on the outlay.

The average quantity of quartz crushed, according to Mr. Bland's returns of each description of stamps in twenty-four hours, is as follows: 8-cwt. stamps, 4 tons 2cwt.; and the 6-cwt. stamps, 2 tons 4cwt. 12lb; but it must be borne in mind that this is due to the rough quartz going through the stone-breaking machine before passing to the battery. Each of these stone-breaking machines is capable of reducing 70 tons per day.

It may be of interest to give a copy of Mr. Cosmo Newberry's (the Government analyst) report on an analysis of samples sent him to test from the Clunes, two assays being made of every parcel as under. These will enable comparisons to be made with any assays of New Zealand pyrites that may hereafter be made—

Sample (1).—First Assay: Raw Pyrites.—*(a)* 4oz. 19dwt. 23gr. per ton; *(b)* 4oz. 19dwt. 23gr. per ton.

Upon analysis the sand gave:—

	(a.)	*(b.)*
Silica	27·60 ...	27·10
Oxide of Iron $e_2 O_3$)	59·90 ...	61·40
Sulphur	13·57 ...	14·48
Lime (CaO)	2·10 ...	Not estimated.
Carbonic	Not estimated.	

The mean of the two analyses gives 24·43 per cent. of iron pyrites (FeS_2), 44·35 per cent. of oxide of iron. This is present as ferric oxide ($Fe_2 O_3$), magnetic oxide ($F_2 O_4$), and as carbonate (Fe CO), and some sulphate of iron.

Sample (2).—Roasted pyrites, upon assay, gives gold results equal to (*a*) 6oz. 17dwt. 4gr. per ton; (*b*) 6oz. 17dwt. 5gr. per ton.

Upon analysis it gives—

	(a.)	*(b.)*
Silica (slightly coloured by iron)	43·00 ...	41·70
Sulphur	0·52 ...	0·57
Oxide of iron	60·45	Undetermined.

A large portion of the iron is present as magnetic oxide.

Sample (3).—Amalgamator's overflow gave, upon assay, 16dwt. 8gr. of an alloy of silver and gold; 6dwt. 12gr. being gold or gold value of 11·14 carats.

Sample (3).—Pyrites in Quartz. The pyrites was separated, and gave upon assay gold equal to *(a)* 11oz. 8dwt. 16gr. per ton; *(b)* 11dwt. 22gr. per ton. The variation in assay is due to a little quartz retained in the pyrites grains; the value of the gold was 23·01 carats.

Sample (4).—Pyrites in quartz, gave on assay gold equal to 5oz. 4dwt. 12gr. per ton, and the value of the gold, 23·24 carats. The value of the assay yields of samples 1 and 2 was 23·31 carats.

A record has been kept for a number of years showing the percentage of gold obtained in the various stages of crushing, and the average for eighteen years was 61·67 per cent. in the stamp-boxes, 23·25 in the riffle-boxes, 8·26 on the blanket-tables, and 7·78 per cent. from the Chilian mills, the latter being the return from the pyrites.

The quartz obtained from this mine of late years has been of a poor quality, and the great depth (1,215ft.) at which they are now working, combined with the extra quantity of water there is to contend with, increases the cost of raising the quartz; and, although the average yield is equal to that in former years, it has caused a loss on the working of the mine last year of £693 2s. 5d. The manager informed me that from the depth they are at present working it would take nearly 6dwt. per ton to pay working expenses.

There is likewise adjoining this company's mine the New North Clunes Company and the South Clunes Company. The former company is only prospecting at present. The North Clunes Company's crushing plant, which is very complete, is on the same principle as the Port Phillip Company's, with the exception that the battery consists of 40 head of revolving stamps. They have one of Root's blowers for ventilating their mine, which is the best, with the exception of Baker's blowers, that I have seen; these blowers being both on the same principle may be considered about equal in their results.

The South Clunes have a battery of 60 head of revolving stamps, and have similar appliances to those of the Port Phillip for saving the gold. The manager, on being asked his opinion with regard to the use of thick copper-gratings having only 84 holes to the square inch, replied that they were by far the best and cheapest grating that he had used, and that, if the stuff was required to be crushed fine, the lower edge of the grating required to be kept a little higher than usual above the bottom of the stamp-box, or have a bar put across the lower side to prevent the tailings discharging. However, on such a field as the Thames, where the gold is much finer than on any field in Victoria, these gratings are by far too coarse; I have not the least doubt of their being cheaper than the thin iron gratings, but then they are only suitable where the character of the gold is tolerably coarse.

Ballarat.

Band of Hope and Albion Consols.—This is the principal leading quartz mine in the vicinity of Ballarat, and it is one of the oldest in the district. It was originally an alluvial mine, where rich leads of gold were discovered, and it is only a few years ago since they ceased working the alluvial deposits. It was in prospecting for one of the alluvial leads that a quartz reef was discovered, and since this discovery, several companies have taken up, and are working mining leases, or claims, on the same line of reef. Their present workings are about 1,100ft. below the surface, and the quartz lode that they are working is an inclined reef from about 3ft. to 4ft. wide, which averages about 18dwt. of gold per ton. The system of working the ground, timbering the stopes, passes, or levels, is similar to that adopted in the principal quartz mines in New Zealand, therefore a description of these systems would not be of any interest. Their crushing-battery consists of 50 head of revolving stamps about 8½cwt. each, with keyed discs instead of being screwed, which the manager of the battery informed me was far superior to the screw, and not so costly. They use the same description of copper gratings as is in use at Clunes, with stamp-boxes discharging back and front, the discharge from the back being brought round the end of each 5-head battery into the quicksilver riffle wells. The first set of tables are covered with copper plate, and below these are placed the blanket-tables, at the bottom of which is one of Haley's percussion-tables for concentrating the pyrites. The battery is fed by a self-acting hopper, but the battery manager informed me that this was no saving on hand labour, as the number of men employed was the same, and that there was a good deal of wear and tear on the lower ends of the hoppers, caused by the constant striking of the disc of the stamp on the top of the iron bar which is attached to them. The pyrites collected in the percussion-tables is roasted in a reverberatory furnace and then ground in Wheeler's pans; it thence runs into a concentrating-pan or separator, where all the gold is collected. The waste product runs into two pits, placed one after another; the stuff in the first pit is much coarser than in the second, as the further it travels the finer it gets. The material in the first pit is taken out and sold as knife-polish, and it is likewise used at the foundries, for polishing the bright parts of engines and machinery. The fine sediment in the second pit is collected and passes through a paint-mill, being ground up with linseed oil, and afterwards sold for paint. The manager informed me that the company gets £8 per ton for the material as it is taken out of the pit, or £1 for every 5-gallon drum when made into paint. In addition to getting the gold out of the pyrites, the company utilizes the whole of the oxide of iron that the pyrites contain, and they likewise collect the arsenical fumes and condense them in chambers, or recesses in the flue, between the furnace and the chimney. This is done by having the flue constructed in a serpentine form, or, what the manager stated was better, a series of Vs in the bottom of the flue, with doors at the bottom of each V, so that they can be cleaned out when necessary, and to have a jet of steam or small spray of water, falling over the top of each V, but not sufficient to retard the draught. The amount of pyrites in the quartz is about 2 per cent. and the average amount of gold obtained from the pyrites is about from 1½oz. to 2oz. per ton. There is about 1 ton of crude arsenic collected from about 25 tons of pyrites, and the value of the arsenic in this state is about £6 per ton. It may be well to state that, in grinding the roasted pyrites, there is about 28lb. of lime mixed with every ton of ore to assist in keeping the quicksilver clean and lively; and when the quicksilver gets dirty it is cleaned with sodium amalgam. They estimate the entire cost of treating the pyrites at £2 per ton.

I visited the Black Hills and other companies' workings, but there is nothing special to note about them, as they are all on the same principle as the Band of Hope and Albion Consols Company's works. All the managers concur that there is no saving by using self-feeding hoppers.

Stawell.

The quartz lodes on this field differ materially from any other field in Victoria. There are series of flat reefs, having an inclination of about 1 in 3, branching away from the main or nearly vertical lodes, and it is on these flat reefs, especially near the junction with the main lode, that the best shots of gold are found. The farther away from the junction the gold keeps steadily decreasing until the lode wedges out altogether; but these flat reefs in many instances run for a long distance carrying payable gold, and they average from 2 to 4 feet in thickness. In some of the mines I visited the quartz from these flat reefs, near their junction with the main lode, and for a considerable distance back, contained 9oz. of gold to the ton, as was the case in the Oriental Company's Mine; but the main lode in many places is 25ft. thick and generally contains low grade quartz, which, in many instances, does not pay to take out.

The system of working these reefs is likewise slightly different from inclined or vertical ones; it necessitates having to use a great deal of mining timber to keep up the roof, which is generally put in as sodgers and caps. Wherever the levels are constructed stone walls are built, having openings on the upper side to get down the quartz. The timber used is necessarily very heavy, and when one is passing through the old workings it looks like a forest of timber squeezed up to such an extent that heavy props are split and twisted about like small strips of wood, similar to those used in making the bottoms of old-fashioned wooden riddles. All the passes are likewise logged up with very heavy timber, which looks, when first constructed, strong enough to stand any pressure, but the flat nature of the reef prevents the ground from being filled in as the quartz gets taken out, so that the whole weight of ground overhead is standing on narrow walls, pillars, and props.

The rock of the hanging- and foot-walls is extremely hard. In many instances it has the appearance of elvan rock, and is very costly to work. Many of the mines could not have kept going so long as they did were it not for the use of the compressed-air rock-drills. The deepest shaft in the Australian Colonies is in this district—namely, the Magdala Company's shaft, which is about 2,400ft. deep; but no quartz of a payable nature has as yet been found at that depth. At the present time the Magdala Company is prospecting at the 1,500ft. level. The Oriental and North Cross Companies are working about 1,500ft. below the surface, and still continue to find stone of a payable character.

None of the quartz companies in this district have crushing-plants of their own, with the exception of the Moonlight Company, which is likewise a public crushing company. There are several companies owning nothing but a crushing-plant, and these charge on a sliding scale a certain rate per ton for crushing, in proportion to the quantity of gold there is in the stone, ranging from a minimum of 5s. to a maximum of 9s. per ton. If the quartz does not average above $4\frac{1}{2}$dwt. per ton the charge is 5s., and it gradually increases until the quartz averages 8dwt. per ton, when the maximum charge of 9s. is made.

The crushing-batteries in this district have nothing worthy of note to mention. They are fed by self-acting hoppers, which are considered by the managers here, as well as in other districts, no saving on hand-feeding. The stamp-boxes have gratings at both sides, and discharge the tailings back and front; but this system is not considered to have any advantage, as the tailings gets through the front gratings, as quickly as the quartz gets crushed. The ordinary quicksilver wells and riffle-tables, covered with copper plates, are next the battery. Next to these are tables covered with blankets, which are washed out at intervals, the sand collected and put into concentrating-tables, where the pyrites is saved. Afterwards the pyrites is ground in the raw state in small berdan basins about 2ft. 6in. in diameter, with a round cast-iron ball. The sand that runs away from the concentrator is collected in pits and stacked, and afterwards again put through the stamps; but there is no attempt made to save the pyrites beyond that which the blankets catch. I observed at some of the batteries here that rocking-tables, similar to those in the Maldon District, had at one time been in use, but they have been discarded, and are now used as stationary-tables, covered with blankets. The manager did not consider the rocking principle of any advantage.

Diamond- and Rock-Drills.—In this district every one speaks in the highest terms of the use of the compressed-air rock-drills, and asserts that these drills have been the means of a large amount of quartz being worked that would not otherwise have been remunerative; but, although the diamond-drills have been used considerably here, the miners do not seem satisfied with the results. They state that they sometimes mislead companies in passing through a layer of quartz, which, if of the same thickness as the drill indicated, would be of a highly-payable character, but in boring it is found, not only that the drill passes through the lode obliquely, but is deflected from the true line of direction. My attention was specially directed to a bore in the Oriental Company's mine that exemplifies both of these defects in the use of the diamond-drills. A bore of 400ft. in depth indicated a quartz lode of about 2ft. thick, but, when driven to, the supposed lode was only a few inches in thickness, and the bottom of the hole was 50ft. out of the position of the initial direction of the bore. This was not discovered until the company sunk their shaft and put in a level to work the lode, and when they came to the place where the hole ought to have been, could not either find the bore or any trace of a hole. After driving in several directions for some time, a plan was determined to try and test the direction where the bottom of the hole was by a clinograph and gelatine put down the bore-hole. They were successful in this, and found the vein where the hole went through, but it was too thin to pay for taking out. They therefore consider that, taking everything into account—especially in boring through silurian rocks, where there are hard and soft seams, that have always a tendency to make the drill run away from its initial direction—that very little more expense would prospect the ground far more satisfactorily in the ordinary manner with compressed-air rock-drills. There is no doubt in many instances cases like this would occur, and perhaps lead companies into more expense than they necessarily would have done, and cause people to buy shares at a price that the value of the mine did not warrant, as I understand was the case in this particular company; but, at the same time, diamond-drills have been successfully used in boring for coal, and through basaltic rock in finding alluvial leads of gold. But it is questionable whether they can be profitably made use of in testing quartz lodes, especially in New Zealand, where there are so many blocks and horses of mullock and barren quartz in the lode, and a drill might as readily go through one of these; and yet the lode, if prospected by a drive or tunnel, might be payable for working. Appendix A contains a report of the Acting Secretary for Mines and Water Supply, recently published by the Victorian Government, which gives a deal of useful and valuable information respecting the use and cost of working diamond-drills.

The use of compressed-air drills has been well tested, and they have proved to be a valuable appliance in both working and in prospecting for quartz lodes; and these drills are used by almost every company in Victoria to a large extent. Those most favoured in the Stawell District are Wayman and Kay's and Naylor and Thornton's. (The latter is largely used in the Reefton District, and gives great satisfaction.) Before these drills came into use, the National, Eclipse, and Ingersoll drills were employed; but it was found that from the extremely hard nature of the rock in this district it was difficult to get either of these drills to stand; indeed, several of the mine managers drew my attention to this, and showed me some of those drills completely smashed up by ordinary work; at the same time they informed me that the local-made drills stood and gave every satisfaction, while they are simpler in construction and lighter to handle. The lightest drill is that of Naylor and Thornton. It is manufactured by Robinson Brothers, South Yarra Bank, Melbourne, and costs about £90, with duplicate parts. Drawing No. 5 shows plans and sections of drill, and the principal improvements claimed by the patentees. The improvements in this drill are principally in the equilibrium valve, which the patentees claim enables the drill to be worked with a much less quantity of compressed air than any others to do the same amount of work. This valve (fig. 2) is an equilibrium circular valve made of cast steel, with double piston, with steel rings at each end, as shown. The valve cylinder is lined with cast-steel bush, and the air for driving the drill is admitted into the centre of the valve-box I, as shown in section, and is regulated with the main cylinder by the action of the piston, as follows: When the valve is at the end, as shown, the port C is open, and the cylinder of the rock-drill admitting air at the back of the piston drives the drill forward to strike the blow, and when the piston passes the port D, leading from the cylinder to the valve, the air rushes through the back of the valve, and forces it to the other end of the valve-cylinder, opening port C to exhaust-holes in the valve-piston, which allows it to exhaust through both ends of the hollow spindle of the valve. The other port CI is then opened to admit air from the valve to bring the drill-piston back after striking the blow, and so on it continues to make the drill go at a very rapid rate. The air used for driving the valve is exhausted through small ports

H and HI, about ½in. in diameter. At the end of each stroke the valve can be moved readily by pressing with the hand on the spindle when full pressure of air is turned on, so that the drill can be started at any point. In adopting this class of valve all tappets are avoided, and the full elastic force of the air is directed to the operation of the drill without any deterioration to the blow, thereby no doubt effecting a saving in the consumption of air. This drill causes very little vibration on the pole when it is at work, and its weight complete is 156lb. The patentees, therefore, claim that their drill is lighter than any other, that it stands the work better than American drills, that it will accomplish more work with less air than any other drill now in use, and at the same time all the working parts being made of the best material and simple in their construction, the repairs can be effected with very little cost, bringing the wear and tear to the lowest possible minimum. The patentees for the Wayman and Kay drill claim that their drill is much lighter than the National, and costs far less to keep in repair. Without giving a minute description of the different working parts of this drill, Drawing No. 6 will show the general design in plan and sections, which will be easily understood.

At the North Cross Reef Company there are four drills at work—one of the National, one Eclipse, and two of Wayman and Kay. This company instructed their engineer, Mr. Troutbeck, to keep an accurate account of the cost of keeping each of these drills in repair, and, from the figures supplied by him, the cost of repairs was as follows: National, £138 for 682 days' work; Eclipse, £73 for 325 days' work; No. 1 Wayman and Kay, £105 for 732 days' work; No. 2 Wayman and Kay, £97 for 724 days' work.

From this it will be seen that the Wayman and Kay drill cost about one-half either of the others to keep in repair, the cost of Wayman and Kay No. 1 being 2s. 8d., No. 2 2s. 10d., National 4s. 5d., and the Eclipse 4s. 5d. per day; and, from information received from the mine managers, the distance bored by Wayman and Kay's is equal to from 25ft. to 33ft. in eight hours; but it must be borne in mind that the rock in this district is of an extraordinarily hard nature, and what the miners here term "elvan rock." Mr. Troutbeck informed me that he made several experiments to ascertain whether the air consumed by these drills compared favourably with the others; and, after working each of the drills for four hours, the result was, the National consumed 97, the Eclipse 82, and Wayman and Kay's 70 cubic feet of air per minute; but some of the other managers state that Wayman and Kay's drill requires 10lb. more pressure of air than the National to do the same amount of work, at the same time they acknowledge that the breakage is at least 25 per cent. less than the National. The unanimous opinion of mine managers and others interested in mining throughout the Colony of Victoria is that by the use of rock-drills the saving effected in the cost of candles, steel, charcoal, and blacksmiths' time in sharpening drills more than compensates for the cost of the fuel used in compressing the air and the wear and tear of the rock-boring plant. Some of the managers in the Stawell District state that before compressed air-drills were in use the cost of sharpening and consumption of coal amounted to about 2s. 6d. per ton of stone raised, whereas now it is reduced to about 6d. per ton.

Air-Compressors.

There is a great difference of opinion with regard to the most useful, economical, and compact air-compressors that are in use. Some prefer Ford's, others the National, and in the Stawell District a few of Wayman and Kay's are used. The patentees of Wayman and Kay's drills furnished me with a plan of their compressor, which gives entire satisfaction wherever it has been employed. Drawing No. 7 shows its general design. From what I have seen of the different forms of compressors, the National, to my mind, is by far the most compact, and everywhere gives satisfaction. The cylinder of the steam-engine is fitted on the same bed as the air-compressor, and the same piston-rod works both pistons. The only difficulty experienced with the National is that the steam has to be kept up at a high pressure in the boilers to work the compressor so that four drills can be supplied with air; but this is easily obviated, if the cylinder of the steam-engine is made an inch more in diameter than the cylinder of the compressor. Mr. J. W. Naylor, a mechanical engineer and manager of several mines in the Stawell District, states that he has had one of the National compressors at work for several years; and I quote his own words: "It gives us every satisfaction; it supplies air for driving four rock-drills constantly at work, and I have not heard any complaints about the want of air. The simplicity of its construction and the little care required in attending to its working, together with the rapidity with which it compresses air, compels me to give it first place in my estimation compared with any air-compressing machine I have ever yet seen."

One of Wayman and Kay's compressors has been at work at the Northern Cross Company's mine since January, 1882, and all that has been done to it since its erection was to pack the ram once in twelve months, and change the clacks about every three months. All the working parts are in water, and will leak water, and not air, should the packing of the valves be out of order. The valves are simple, and easily changed, and are similar to a leather pump-clack. The area of the ram is 144 square inches, with 3ft. 6in. stroke, and it is driven by a steam-engine with cylinder 20in. in diameter and steam pressure at 25lb. The engineer of this company states that the compressor has to run for a little over two and a half hours to supply air for working three rock-drills for eight hours.

In concluding my remarks on the quartz mines in Victoria, I would observe that the lodes have a far more permanent appearance than they have in New Zealand. The country where the quartz reefs are situated is not nearly so broken, the lodes run more regularly, and there is not the same amount of breaks and slides that occur in our lodes, which are generally found in bunches and detached blocks; but the same feature occurs in the Australian quartz lodes with regard to the gold, which runs in shots and streaks through the lodes.

As it may prove interesting to those who have had no opportunity of visiting the Australian mines to see plans and sections of the several reefs, so as to obtain a better idea of their nature, and to enable a comparison to be made, plans and sections showing some of the lines of reefs in the Sandhurst and Stawell Districts are hereto attached. These plans, together with geological maps of Sandhurst, Ballarat, and Stawell, were supplied by the Mines Department of Victoria, and they will give a much better idea of the formation of the lodes than can be conveyed by a mere written description.

Alluvial Mining.

Creswick Creek.

This is a district where deep alluvial mining is being worked. I inspected the underground workings of the Madam Berry Company, which are on a similar principle to the deep workings at Ross, but with this difference, that the shaft is put down outside the gutter or lead, and, after the chamber is constructed, a main tunnel is driven, cutting the gutter or lead at about right angles; then, when the centre of the lead is reached, a main tunnel is constructed on both sides of the tunnel coming from the shaft, following as nearly as can be ascertained the centre of the gutter. The main tunnels are constructed some distance under the washdirt in order that the ground may be worked over head, having the main roads always kept good, and when the strike of the bottom on which the washdirt lies comes to the level of the main tunnel that determines the distances, that the ground can be taken out from the one level. The dip or inclination of the gutter being determined beforehand, there is always a sufficient amount of bottom or reef allowed below the washdirt to carry the main tunnel in to such a distance, that it is considered economical to work from one shaft. As soon as the main tunnel is a sufficient distance from the cross tunnel leading to the shaft, or about 100ft., a jump up or uprise is made from the side of the main tunnel into the washdirt, and when this is completed, and the ground secured over head, it is converted into a pass for holding washdirt and a ladder-way for the workmen to get up and down, by being partitioned off. A cross-drive is now made at each side of the pass until the reef on the outside of the gutter or lead is reached. Afterwards a drive at right angles to this cross-drive is made, following the edge of the gutter, and the ground is then blocked out from the back. When the gutter is a great width other drives are made running parallel with the blocking-out drive, a considerable distance apart, and, when these drives reach the end of the block intended to be worked from this pass, another cross-drive is made towards the outer edge of the gutter, and the ground blocked out in two directions. Not more than one drive at a time is allowed to go forward in one face, so that the roads are always alongside the face of the solid ground. When the main tunnel gets in about 100ft. or so further another pass is constructed, and so on, until the fall is entirely run out, or to such a distance as it is considered advisable to work from the one shaft. The main tunnel is constructed wide enough for a double line of rails, so that the empty trucks can go up one line and the full ones come down the other; and at intervals, near the different shoots, there are points and crossings, or in some instances flat sheets, for changing the empty trucks from the one line to the other. In blocking out the ground 7ft.-caps are used, and the timber that is used for blocking out is generally pretty light, as it only requires to keep up the ground until the men get a short distance from it before it breaks down. As there are scarcely any stones in the washdirt there is nothing with which to pack up the ground as it gets worked out. The depth of this company's workings is about 500ft. The washdirt is hauled up in cages to the top of the brace, emptied into puddling machines, and, when it is sufficiently puddled and a fair collection of gravel left in the machine, a trap-door is opened under the bottom of the machine, and the gravel falls down a shoot on to another brace or platform, and from there hand-filled into sluice-boxes and sluiced in the ordinary manner, the sluice-boxes being fitted with false cast-iron perforated bottoms. This company is sinking a new shaft further down the lead and has experienced considerable difficulty in getting it down, as there is about 60ft. of drift-sand to go through. About 350ft. of basaltic rock has to be gone through, underneath which there is about 50ft. of clay, then the drift. The method adopted for sinking through this drift is by three sets of cast-iron cylinders, sunk down side by side with compressed air. There is first a chamber cut into the basaltic rock, into which are placed heavy beams to hang the remainder of the timber in the shaft. The timber from this point downwards through the clay is made 12in. square, and all hung together with ten 2-in. iron bolts. Underneath this timber, about 20ft. from the bottom of the layer of clay, there are placed two heavy wrought-iron girders, 3ft. 6in. in depth, and under these are placed two cross-girders, 3ft. in depth, to act as a butt for the hydraulic ram, that presses down the cast-iron cylinders, which is capable of exerting a force equal to 1,000 tons. A frame is placed in the shaft for guiding the ram, the piston of which is about 3ft. in diameter, fitted with angle-leather rings. Directly above the top of the drift or quicksand a platform is made, and a horizontal face-plate laid down on which the cylinders are bolted together. The hydraulic ram forces the cylinders down as the ground gets excavated, and when it is out to its full stroke, which is about 6ft., the ram is lifted up again by a jet of water and another cylinder slipped from the face-plate on to the top of the previous one, and the whole forced down from the top as before. Two of the cylinders are 6ft. in diameter and 1¼in. in thickness, which are intended as winding-shafts, having double cages; and the other cylinder is 4ft. 9in. in diameter, which is to be used as a pump- and ladder-shaft. Each cylinder is made in segments, with the flanges inside, having the edges or joints all planed, and the top and bottom ends or joints are all faced in a turning-lathe, so that when they are bolted they form a water-tight cylinder. The cylinders are taken down the shaft in segments, set on their ends on the horizontal plate, and bolted together, the face-plate being for keeping the top and bottom joint true during the time that the segments are being bolted to each other. An air-lock is fixed on the cylinders, and the sinking continued by compressed air supplied from one of Ford's compressors. The extra precautions taken by this company in sinking through the drift is in a measure due to the adjoining company having lost their shaft in trying to get through.

Chiltern.

There has been a great deal of mining carried on in this district, but at the present time there is very little doing, with the exception of the Chiltern Valley Gold Mining Company, who have about 175 men employed, exclusive of those engaged in procuring firewood and mining timber. The depth of their workings is 312ft., and the principle on which the ground is worked and taken out, the washdirt puddled and sluiced, is similar to that described in the Madam Berry Company's mine at Creswick. The amount of washdirt that they take up is about 10,000 trucks weekly, each truck holding about seven cubic feet, and they estimate three of these trucks to the load. This company's mine is ventilated by two air ducts, which are simply two square wooden boxes, the inside one acting as a plunger, the outer box has a pipe coming up through the bottom of it, and it is filled with water; the box that acts as a plunger works down over the top of this pipe, the upward motion draws in air from two valves in the side near the top edge, and the downward stroke forces the air down the pipe. This system is found to be quite sufficient for keeping the mine well ventilated.

Sluicing Operations.

Beechworth.

There is very little mining now carried on in the district, and what little there is doing is principally sluicing; but the term sluicing in this district gives one very little idea of the large quantity of stuff that can be taken away with a good head of water. I visited the principal claim in the district belonging to Mr. Fletcher, a very old resident in the place. He has a head-race capable of carrying what he terms twelve heads of water, but these heads differ very materially from the sluice-head in New Zealand. What they term a sluice-head is a stream of water flowing from a box 6ft. long set on a level, having an aperture at the lower end 12in. wide and 1⅛in. high, with a board giving it a head or pressure of 6in.; this would be capable of discharging about 21 cubic feet per minute, or about one-third of our sluice-heads. The quantity that Mr. Fletcher uses, when the water is available, is about eight heads; the greatest pressure he has for working his ground is about 130ft., and the fall of his tail-race, which is paved with stones, is 2½in. to every 12ft. in length. The wages paid to the workmen employed in his claim are 7s. per day for Europeans and from 5s. to 6s. per day for Chinese. There is very little water sold on this field; the only water sold in this district to the miners is sold by the Beechworth Town Council, and that is only when there is a good supply in the reservoir. The price charged for a Beechworth head (21 cubic feet per minute) is from 37s. 6d. to 40s. per head per week of twelve hours per day, or, when the quantity is compared to our sluice-heads, it would be equal to 112s. 6d. to 120s. per head.

Before summarising the improvements in machinery employed in Victoria for working the mines and extracting the gold from the matrix, it will be as well to continue my observations on the mines in the Colony of New South Wales, and finally to summarise the various systems of mining machinery and processes employed in mining and extracting the different metals. I also propose to give a short description of the systems adopted in each of those colonies for conducting the mining surveys, as well as a few remarks on the general organization of the Mines Departments.

NEW SOUTH WALES.

The gold-saving appliances, such as crushing-batteries, quicksilver-tables, concentrators, and the mode of treating pyrites are not so complete in New South Wales as in Victoria. That is due in part, no doubt, to the small yield of gold inducing less attention to the subject. More attention is devoted to other minerals—namely, silver, copper, tin, coal, and diamonds; and, as far as its mineral wealth is concerned, New South Wales is much richer than Victoria; almost everywhere minerals exist. The coal fields are of immense extent; the vast lodes of copper, tin, and silver, together with large fields containing an abundance of stream tin, gives a stranger visiting the country an impression that its mineral wealth is almost inexhaustible. I therefore, in this colony, gave my principal attention to the working and methods of treating and extracting minerals other than gold.

Tin-mining.

Emmaville and Vegetable Creek.

This is a district where large quantities of stream tin have been found, and where a number of miners are still employed. Tin was first discovered here in 1874, on a large flat through which Vegetable Creek flows. The claims were first taken up in such a form that each had a frontage to the creek running for a considerable distance back into the flat. The sinking was from 3ft. to 8ft., but after the shallow ground was worked out a lead was discovered about two miles further on in deep ground. I was informed that some of the claims that were at first taken up yielded as much as £200,000 worth of tin. But the principal portion of the shallow ground is now worked out, and attention is being directed to the deep leads, which are about 220ft. in depth, having from 3ft. to 5ft. of washdirt. Mr. Alfred Cadell and Mr. Flannery, two gentlemen interested in tin- and silver-mining in this district, accompanied me over the field, and gave me a deal of information and assistance, the former gentleman giving me a collection of valuable specimens and stones, which he had made from time to time. The tin found in the alluvial ground is of the purest quality, and the mode of extracting it is somewhat similar to that of box-sluicing auriferous dirt. Sluice-boxes with false bottoms are placed near some water hole or creek; the water is lifted by a small Californian pump into a tank at the head of the sluice-box, whence it flows from the tail of the boxes into the hole again. The greatest trouble to contend with here is to preserve the water, and not to allow any of it to run to waste.

When the tin is collected from the sluice-box it is put in bags and taken to the refining and smelting works at Tent Hill, about three miles from Emmaville, which belong to the Glen Smelting Company. This company is likewise working a tin lode on the same principle as that of working a quartz-reef containing gold. The stone is taken from the mine and crushed in a stamping-battery, the same as crushing quartz. Afterwards the crushed material goes through a process of jigging and concentrating to separate the sand from the ore. Through the courtesy of Mr. John Reid, the manager and part proprietor, I had every information as to the different modes of treatment fitting the ore for market. A description of these works is as follows: The crushing-battery consists of ten heads of stamps, about 6cwt. each, making 70 blows per minute, to which is attached jigging and concentrating buddles of the most modern design. The tin ore is brought from the company's own mine, as well as from the various mines in the district, and deposited on an elevated floor in front of the battery, from which it is hand-fed, into the stamping-box, and crushed in the ordinary manner, a stream of water continually flowing into the stamp-box on the same principle as the water supply for a quartz-battery. The ore is crushed and discharged through gratings varying, according to its nature, from 64 to 144 holes to the square inch, into a shoot from 4ft. to 5ft. long, that carries the ore and sand into a V-shaped separator or classifier, which is constructed with an inverted Λ to contract the current in such a way as to cause the whole of the crushed material to reach the lower point of the box, where an upward current of water, with regulated pressure, meets the downward stream, thus forcing upwards and onwards the lighter particles of ore and sand, leaving the heavier particles, as well as those of a uniform specific gravity, to descend into a pipe that has a lower outlet than that where the sand and light particles of ore are discharged, thus collecting the crushed ore that has grains of a uniform density; and as the grains of sand are generally much coarser than those of tin, the work of separation becomes in a great degree modified. The coarse material is conveyed by a pipe from the separator or classifier into aprons, which are connected with a pair of double-jiggers. These consist of a large box divided into four compartments, the outer compartments being for the sieves or screens, which are a little coarser in the mesh than the gratings in the stamp-box. Upon these sieves are placed a layer or bedding of ore 2½in. in thickness, having such a degree of coarseness as to prevent it passing through the sieves. The inner compartments are for pistons or plungers working in. The downward motion of the pistons are given by means of a rocker, which is connected with a crank, and the upward motion by means of a strong steel spring attached to the piston-rod or shank. Each piston-box is connected with the compartment in which the screens are placed, and the box being filled with water, which is kept continually flowing in, the downward motion of the pistons causes the bedding on the sieves to lift up, and the upward motion draws in such grains of ore as will pass through the sieves, which, by proper adjustment, produces clean ore from the first set of jiggers. The waste material is then run into a second pair of jiggers, and undergoes a similar treatment, only that as the desire is rather to exhaust the tin ore from the gangue, a considerable portion of the latter is drawn through with the ore, and therefore this product has to undergo another treatment, which, in this case, is done on what is known as the Rittinger shaking-table. The stuff enters these inclined tables (which are about 9ft. in length) on one corner, and the water being continually flowing over the whole table, the shaking motion, which is in a rectangular direction to the incline, throws the down-running stuff into the current of water. The heaviest parts advance most, and, when the stuff arrives at the lower edge of each table, the current is divided, and the stuff runs into different receivers. The action of the tables can be regulated, according to the stuff under treatment, by means of altering the incline, the quantity of water, and also by the length and form of the rectangular motion, which is adjusted by steel springs. These tables work automatically, and thus save manual labour.

The stuff passing from the upper outlet of the first classifier passes into a second, and then undergoes similar treatment, the coarse grains passing over a Humboldt jigger, which is similar in principle to the other jiggers. The enriched product from the Humboldt jigger is in turn conveyed to Rittinger shaking-tables, and there undergoes further treatment. What is known as "slimes" is conveyed over a series of V-shaped settling-boxes, from the bottoms of which the thickened material is carried by a launder and deposited in a large receiver having an outlet at the bottom, through which the heavier particles flow into a rotating-table, which is about 12ft. in diameter, having a convex surface, so that all the stuff passes down from the centre towards the outer edge. This table revolves slowly, and is supplied with jets of water at different parts, so as to insure efficient concentration. The material, which is fine sediment, is carefully fed into the tables, and by the addition of clean water the lighter particles are washed off and become waste, while the product remains until washed off into a receiver and sent back to be treated by the Rittinger shaking-table.

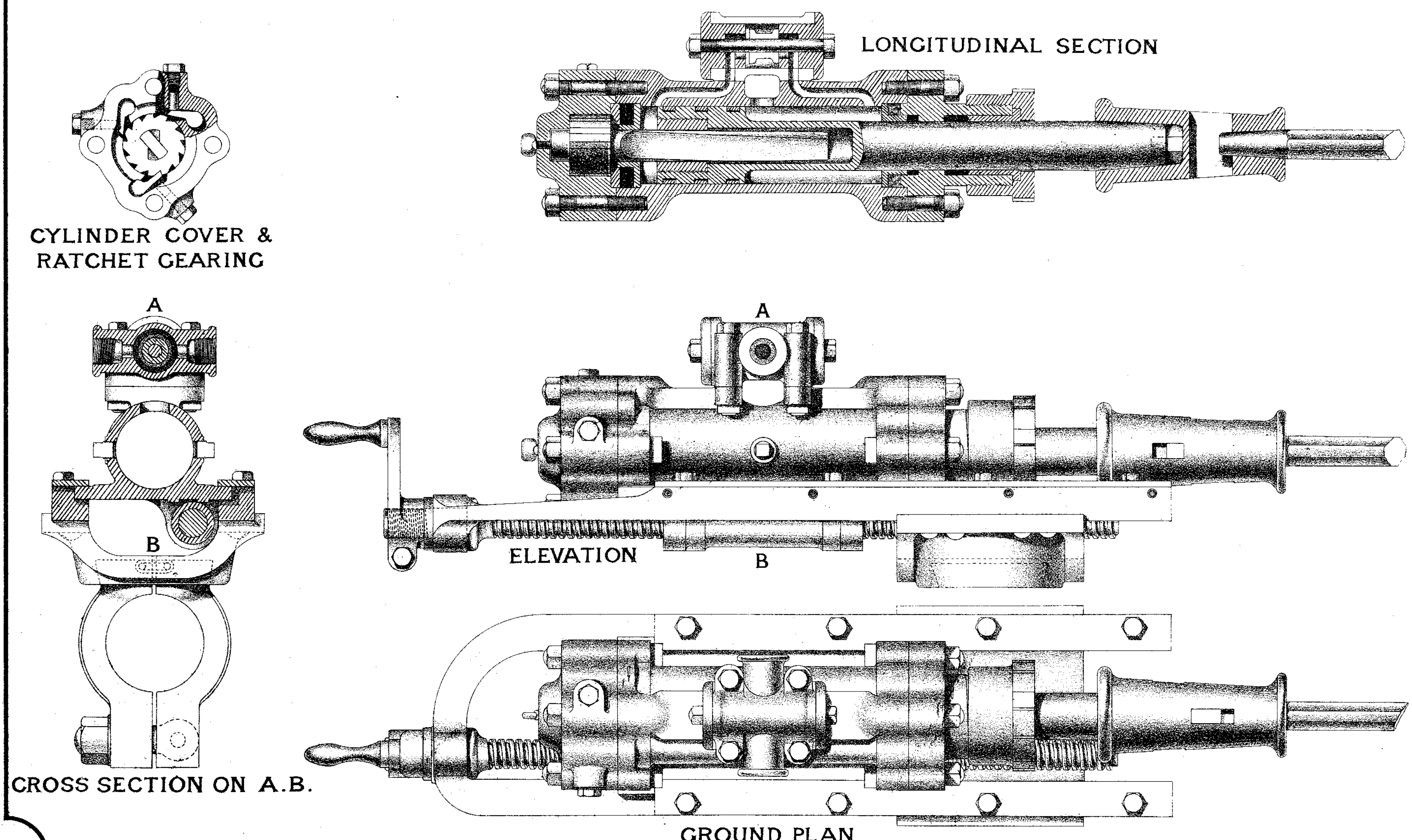
The dirty water, flowing onwards from the separators or classifiers, passes over a self-acting table; and here any minute particles that may have remained in suspension are deposited, which, at even intervals, are washed down by a tank of water working automatically, and the water returns to the dam in a fairly-clarified condition.

The tailings are deposited in a very careful way, so that, if any ore should miss the several machines, it can be collected and sent back for further treatment; but the machinery is now perfected to such an extent that very little stuff has ever to be handled twice. The tailings are run over convex buddles having about 7ft. of an inclined plane, and afterwards into pits, from which they are lifted into trucks and run away into a gully below the dam, where the surplus water in flood time washes them away. A few weeks before visiting these works about 1,500 tons of tailings were carefully ground-sluiced; but the quantity of ore found was very small, and could only be recovered by a finer reduction of the gangue.

One buddle is kept for general use, as is also a straining-box, over which all the ore passes before being sent to the furnace. Water is elevated by means of a 4-in. centrifugal pump, and the whole of the plant mentioned, together with a brick-making machine and charcoal-grinder, is driven by one of Marshall and Son's 16-horse power double-cylinder portable engines. From 50 to 60 tons of ore is passed through the battery weekly, yielding in black tin from 5 to 10 per cent.

DRAWING No. 6

WAYMAN & KAY'S
PATENT
"DUKE" ROCK BORER
SCALE, 1/6th FULL-SIZE



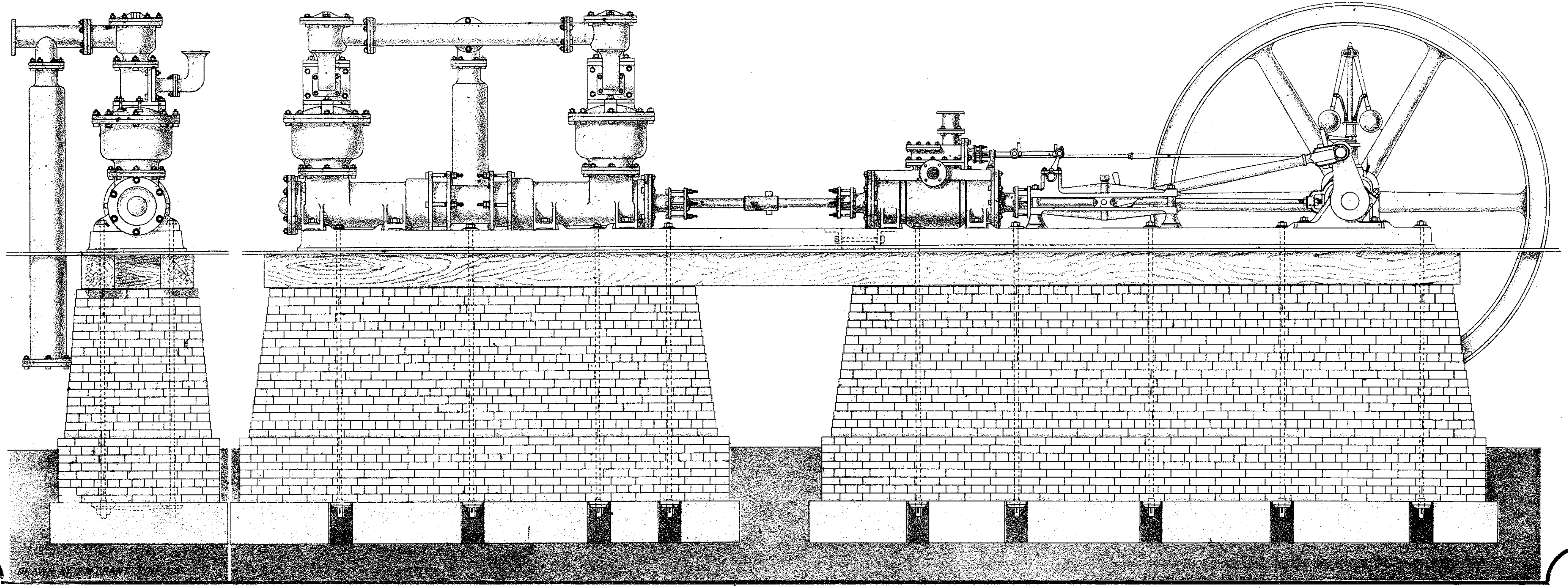
DRAWN BY T.M. GRANT. JUNE. 1885.

DRAWING No 7.

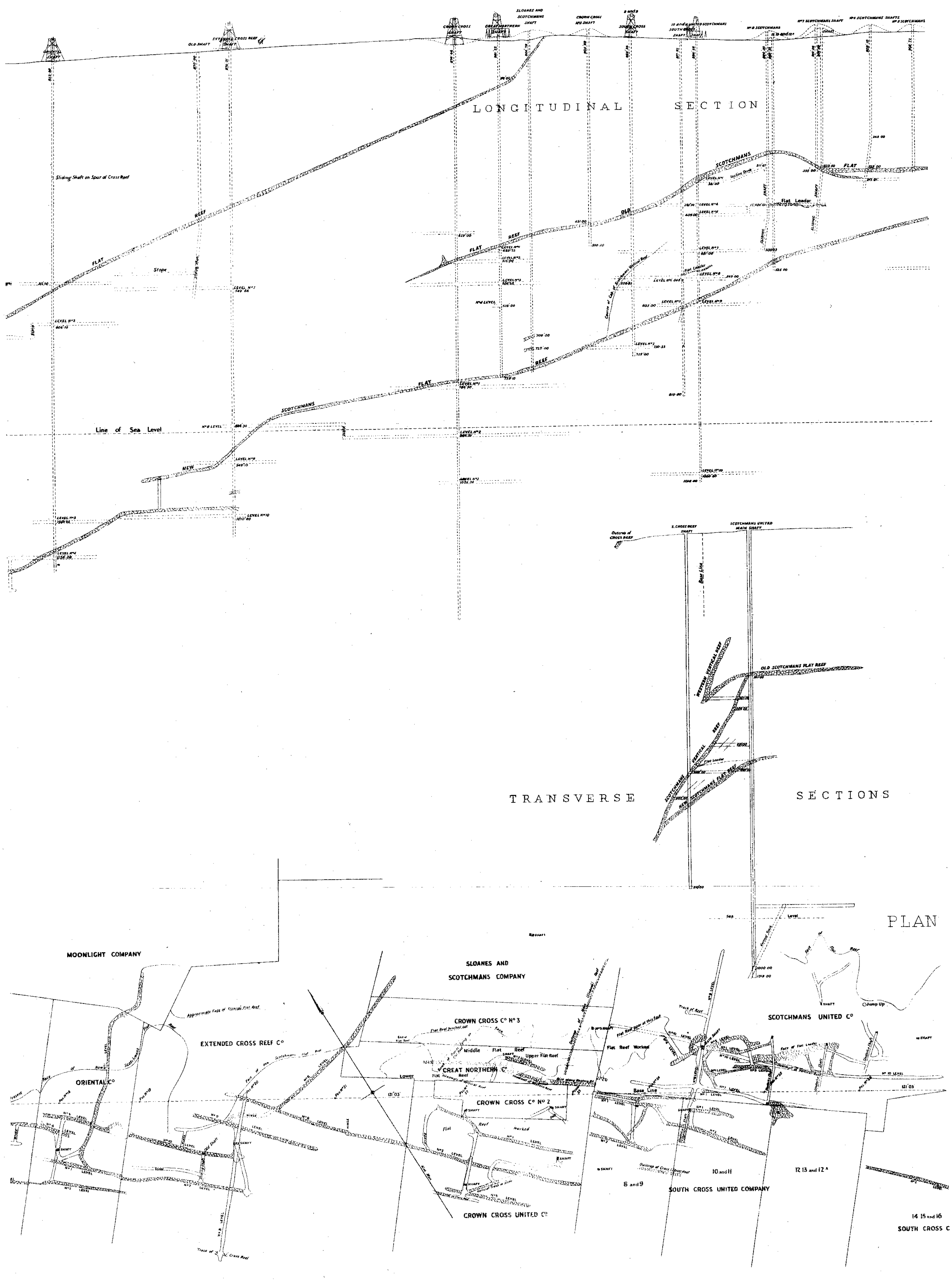
WAYMAN & KAY'S
AIR COMPRESSOR

SCALE OF FEET

1 0 1 2 3 4 5 6 7

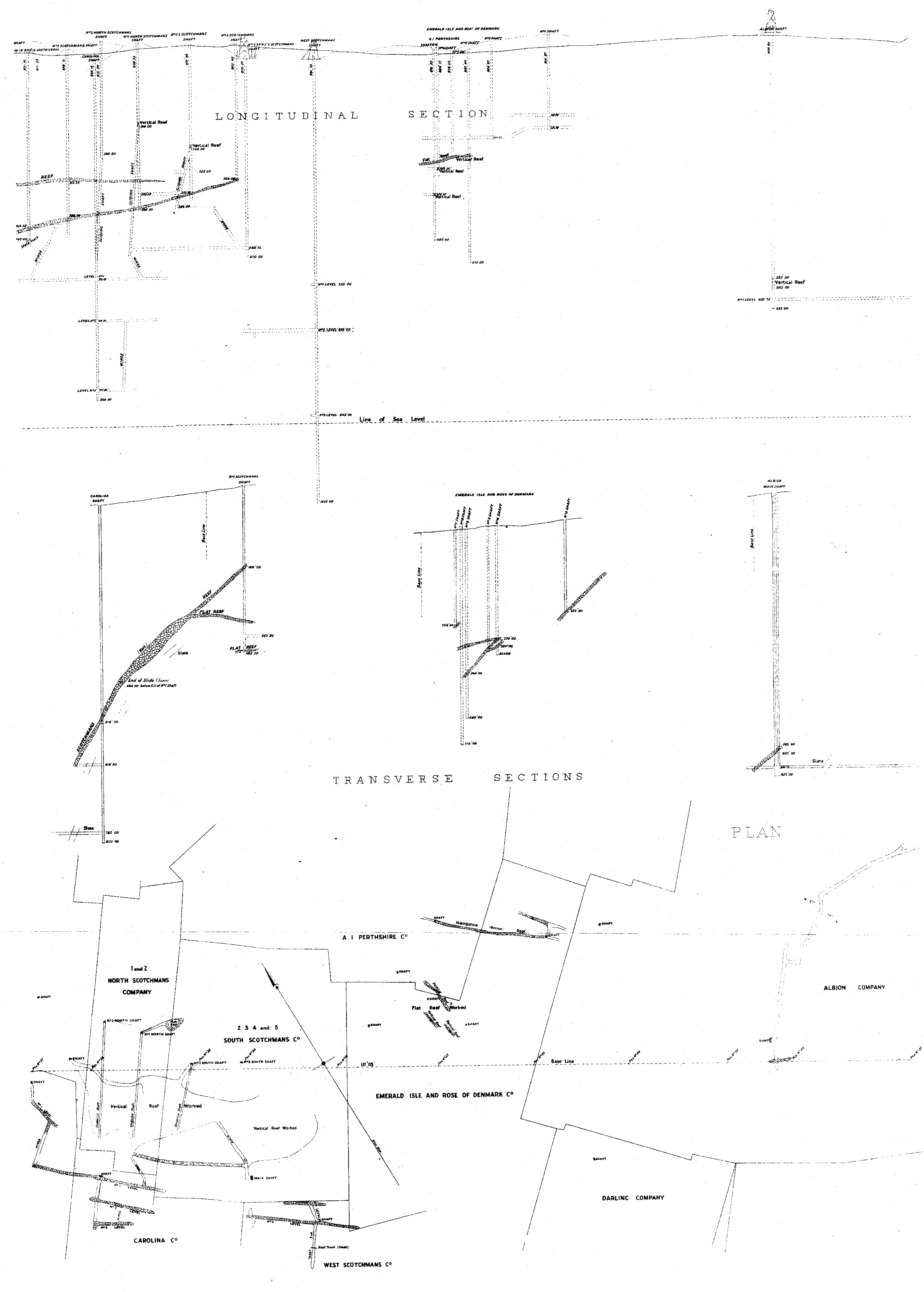


UNDERGROU

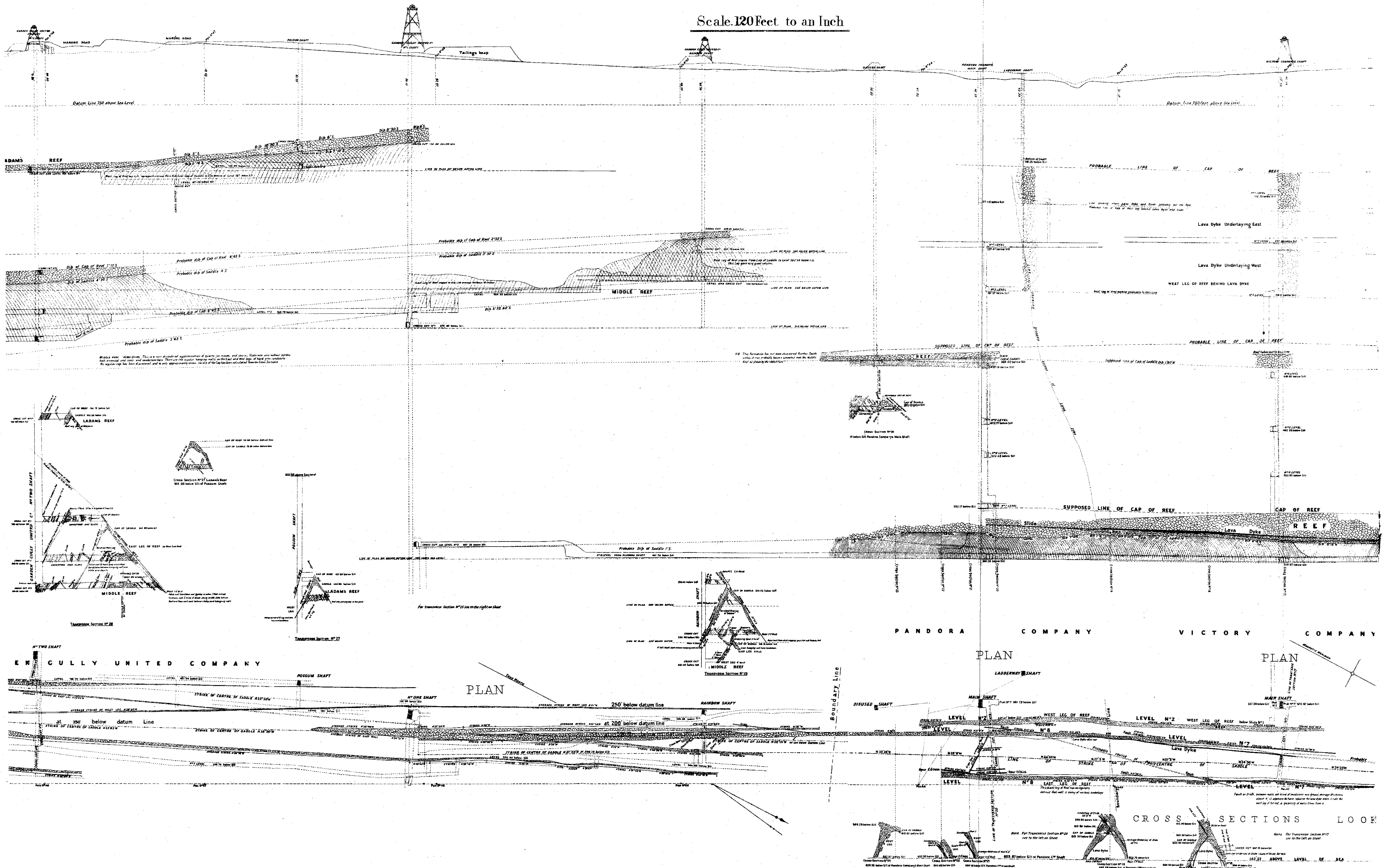

LONGITUDINAL SECTION
Sliding Shaft on Spur of Cross Reef
FLAT
REEF
OLD
SCOTCHMANS
FLAT
Flat Leader
Stope
Line of Sea Level
NEW
SCOTCHMANS
FLAT
REEF
TRANSVERSE SECTIONS
OLD SCOTCHMANS FLAT REEF
WESTERN VERTICAL REEF
VERTICAL REEF
NEW SCOTCHMANS FLAT REEF
PLAN
MOONLIGHT COMPANY
SLOANES AND SCOTCHMANS COMPANY
EXTENDED CROSS REEF C^o^
ORIENTAL C^o^
CROWN CROSS C^o^ N^o^ 3
Middle Flat Reef
Upper Flat Reef
Lower
GREAT NORTHERN C^o^
CROWN CROSS C^o^ N^o^ 2
Flat Reef Worked
Base Line
SCOTCHMANS UNITED C^o^
CROWN CROSS UNITED C^o^
6 and 9
10 and 11
12 13 and 12 A
SOUTH CROSS UNITED COMPANY
14 15 and 16
SOUTH CROSS C
Trace of Cross Reef

ND SURVEY OF THE PRINCIPAL MINES AT STAWELL

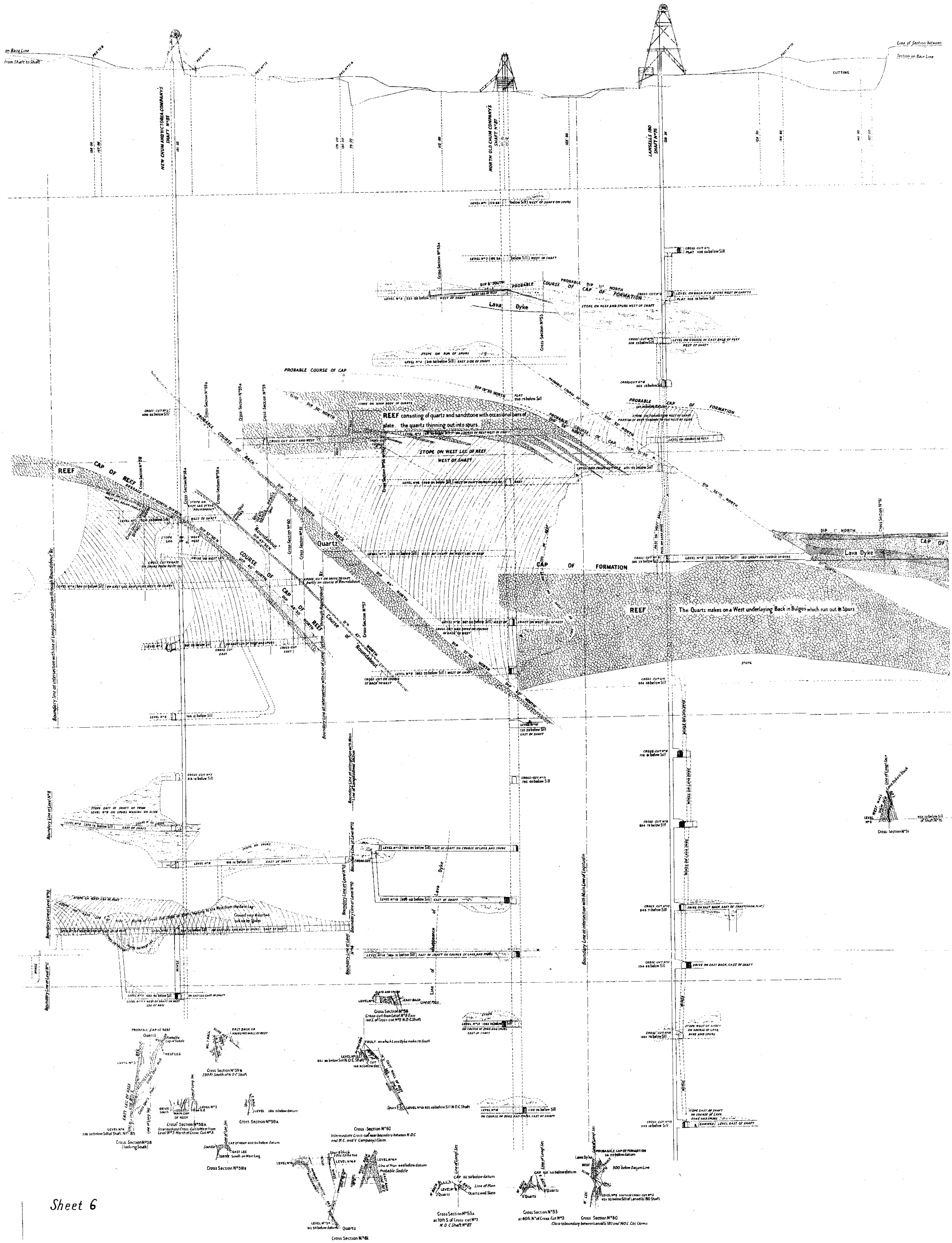
Scales 60 Feet to an Inch



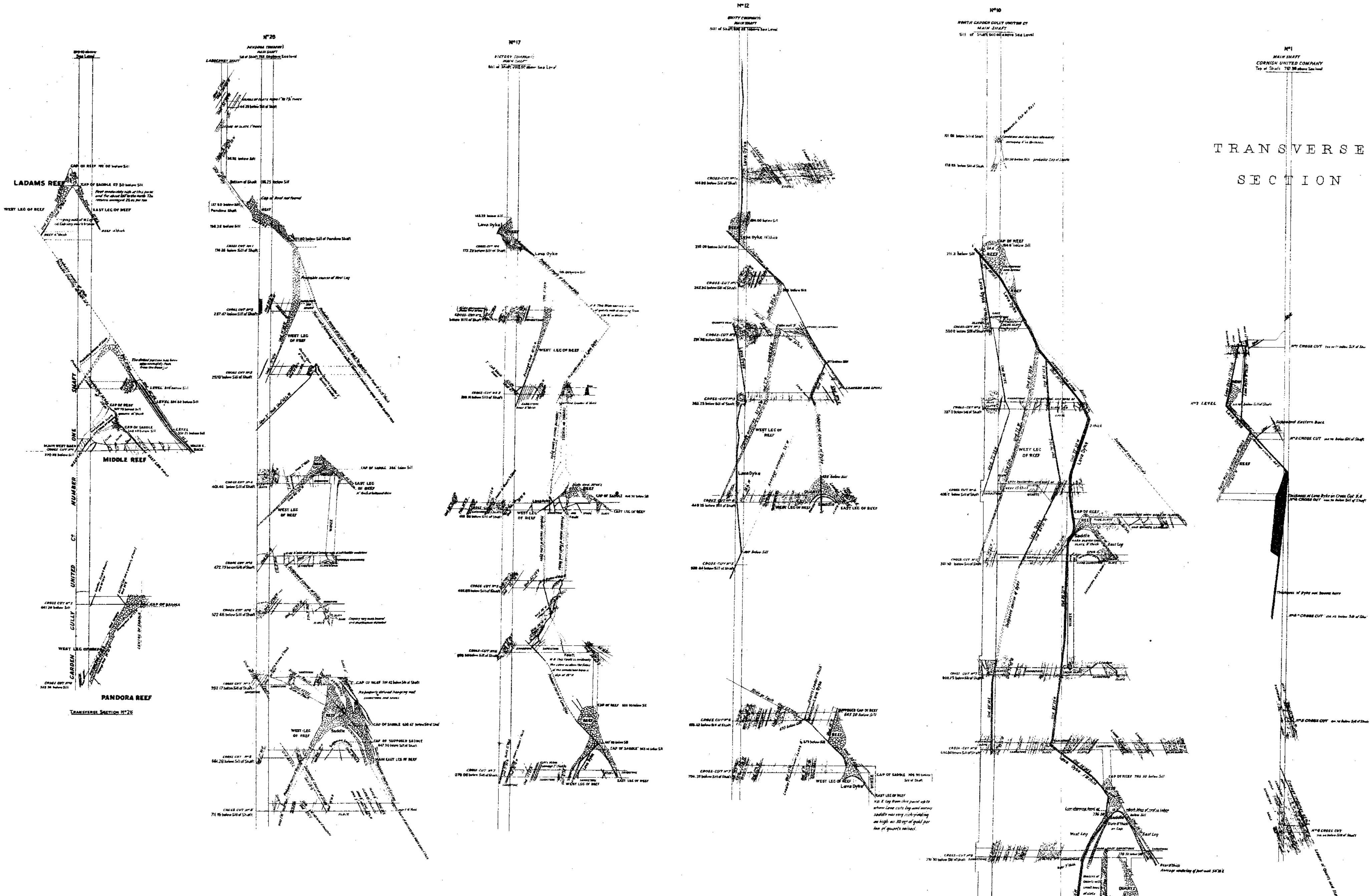
UNDERGROUND SURVEY OF MINES SANDHURST GARDEN GULLY LINE OF REEF.



LINE OF REEFS.



Sheet 6



TRANSVERSE SECTIONS

(Referring to Shafts on Longitudinal Section)

Caleb Thomas C.E.
Mining Surveyor

Surveyed under the direction of Thomas Couchman, Secretary for Mines and Chief Mining Surveyor for the Colony of Victoria. Drawn by Arthur Everett. Mining Department Melbourne April 1879.

This company not only treats the black tin for others, but they likewise purchase the stream tin from the miners, giving them value for it according to assay. It may be well to mention here that the company assays all the ore brought to their works, and likewise makes from time to time assays of the tailings to ascertain if much ore is lost.

The ore from battery, and likewise the stream tin, is put into a reverberatory refining-furnace and smelted. This furnace is oblong in shape, being about 18ft. long and 10ft. wide in the widest part, which is in the centre. The inside floor of the furnace has a slight dip towards the centre and likewise towards one side, in order to draw off the ore when melted and sufficiently roasted to free it from impurities. There is a long furnace or fire-box at one end in which firewood is used, having a bridge of about 14in. high dividing it from the furnace where the ore is put. The top of the reverberatory furnace is kept as low as possible in order that the flames coming over the bridge from the fire-box may pass directly over the surface of the ore. There is a flue leading from one side of the furnace on the opposite end to the fire-box, into a large brick chimney, and on the end of the furnace opposite the fire-box there is an opening where the ore is puddled and the slack skimmed off before the melted ore is taken out of the furnace. The furnaces are all bound by strong iron bars, and they are constructed so that the crown on the end next the fire-box is much higher than on the opposite end, so as to allow plenty of room for firewood to be used as fuel. The great object is to get a large fire and to keep the flames as close down on the surface of the ore as possible. At intervals during the time that the roasting of the ore is going on small quantities of charcoal are thrown into the furnace over the surface of the melted ore, so as to keep up a high temperature.

After the ore is drawn off from this furnace it undergoes another process of refining by melting it in large cast-iron pots or basins. The tin bars from the smelting-furnace are put into these basins or pots, and the melted ore is kept in a boiling condition for some time; when the tin is melted pieces of green saplings are stuck in among the hot metal, which emit gas or steam, thereby causing the tin to keep always in a bubbling state. When the tin is considered to be sufficiently pure it is taken out of the pots with ladles and run into ingots fit for the market.

Silver Mining.

Emmaville.

A silver lode was recently discovered in this district at Little Plan Creek, about nine miles from the township. A company termed the Webb Silver Mining Company has taken up a lease of 240 acres, being 84 chains along the lode, and commenced to work it. The lode runs in a northerly and southerly direction, and has an inclination or dip towards the west. The rock on each side of the lode is a metamorphic clay slate, having a brown appearance with yellow or chrome-coloured veins running through it. The lode is from 2ft. to 4ft. thick, but it has a peculiarity which I have not observed in any other silver lode in New South Wales, in having no well-defined foot- or hanging-walls: the ore and rock seem to merge into each other. There is very little work done on this lode yet, the deepest shaft being only about 22ft. On the south end of the lode there is a good deal of galena ore mixed with blue carbonate of copper, but the shaft at the north end shows a different sample of ore, and in some places I observed chloride of silver. None of the ore has been tested except by assay, but it is anticipated that a great portion of it will average from 130oz. to 200oz. per ton. At the time of my visit about 8 or 10 tons of ore were about to be forwarded to Boorook Silver Works to be tested; these works are about ninety miles distant.

Boorook Silver Works.—These silver-reducing works belong to Messrs. Hall Brothers (who are largely interested in the famous Mount Morgan Mine, in Queensland, near Rockhampton), and are situated about thirty miles to the eastward of Tenterfield, near the Queensland border. They are managed by Mr. Thomas G. Davey, a gentleman who has had eight years' experience in the silver mines and reducing works in Spain. These works are said to be the most complete in New South Wales for treating refractory ores. It may be mentioned that, previous to Mr. Davey taking charge of them, they were an utter failure; the quantity of silver left in the tailings after treatment was far greater than that originally extracted from the ore; however, the amount now obtained is nearly equal to that got in making assays.

Mr. Davey not only understands the manipulation of the various descriptions of silver ore, but he likewise has a knowledge of chemistry, assaying, and metallurgy; and he makes assays of all ore previous to treatment as well as of the tailings after treatment; and if by chance there is a sufficient percentage of silver left in the tailings they are taken from the pits and treated a second time, but this scarcely ever happens unless it is by the carelessness of the workman. The first process when the ore arrives at the works is to put it through the pulverizer or stone-breaker, which reduces it to the size of small road-metal. It is then taken to the stamping-battery, crushed dry, and discharged through gratings having from 100 to 140 holes to the square inch. This crushed material is taken to a floor, mixed with a small quantity of common salt, and then placed in a reverberatory furnace and calcined in order to free the ore from all sulphur and arsenic. When sufficiently roasted it is drawn out and allowed to cool; afterwards it is taken and put through a revolving screen, which has 2,500 holes to the square inch. The dust that comes through this screen is afterwards amalgamated with quicksilver in four of Wheeler's pans and one berdan basin.

Mr. Davey kindly furnished me with a description of the works and the nature of the silver ore in this locality, which is as follows: The silver here occurs in a variety of forms and combinations—viz., in argentiferous iron, copper pyrites, blende in abundance, a little galena, flexible and brittle sulphurets of silver, and at present a little chloro-bromide of silver. Therefore, it will be seen that the ore is most refractory, requiring great care and attention in its treatment in the various processes it has to undergo in order to insure satisfactory results. The ore as it comes from the mine is tipped over a strong iron screen to separate the fine from the coarse stuff. The coarse material is then hand-sorted and stacked into heaps—*i.e.*, best ore, seconds (which have to be crushed and concentrated), and waste. The heaps of best ore, varying in quality from 50oz. to 140oz. of silver and from 10dwt. to 1oz. 10dwt. of gold per ton, are then carted to the reduction works, a distance of about one and a half miles. The mode of treatment is that known as the "chlorinizing and amalgamating process," and it is based on the fact that all soluble salts of silver act on and decompose substances containing chlorine in such a way that the free silver and chlorine are liberated. These, through their great affinity to one another, combine, forming chloride of silver (75·25 per cent. silver, and 24·75 per cent. of chlorine); mercury, having also a great affinity for silver, easily combines with it when brought into contact with the chloride, thus forming an amalgam when dry of 84 per cent. of mercury and 16 per cent. of silver.

The reduction-plant consists of one 24-horse power horizontal steam-engine, which drives a battery of ten heads of stamps, a pulverizer or stone-breaker, four of Wheeler's pans, one berdan basin, one revolving-screen, and a force-pump to lift the water from a creek a little below where the machinery is placed. In addition to the foregoing, there are two reverberatory double-bed chlorinizing furnaces, each 26ft. in length by 11ft. in width and 6ft. in height; also a melting furnace, retort, assay office, and laboratory. The ore is first put through the pulverizer, after which it is taken to the stamping-battery with stamps of 6cwt. each, lifting nine inches and averaging seventy blows per minute, where it is crushed, dry, and sent through a smut wire grating having from 100 to 140 holes to the square inch, according to the nature of the ore to be operated on. A sample is taken from each wheelbarrow-load of the crushed ore taken from the battery to the mixing-floor in order to obtain a perfect average sample of the parcel for subsequent assay in the laboratory. The mixing-floor is level with the top of the reverberatory furnaces, so that the ore may be conveniently charged into them. When the value of each of the various crushed parcels is known by assay, they are intimately mixed together in one large heap of a convenient quality for treatment, ranging from 70oz. to 140oz. of silver, and from 14dwt. to 1oz. 10dwt. of gold per ton. This heap is now ready for chlorinizing, and is weighed out in charges of about 6dwt., according to the specific gravity of the ore, and is placed in the furnaces. Each furnace has two beds, which are termed respectively the hot and cold beds; the former being nearer to the fireplace. The cold bed is a little higher than the hot one, so as to facilitate the passing of the ore from the one to the other. At a part opposite to and further from the fireplace, there are two holes 8in. square to convey the smoke and fumes into the flues and thence to the chimney, which is a large brick stack 50ft. in height. The flues are 100ft. long, and are so constructed as to enable them to be readily opened for the purpose of taking out the dust which is continually passing from the furnaces and accumulating therein. The ore is first placed on the cold bed and spread over the floor, and is kept in motion by means of a long iron rake dragged to and fro by a man at the working door, so as to expose every particle of ore to the action of the heat. The ore is kept on this bed from one and a half to three hours, according to its nature and the quantity of sulphur, arsenic, and other volatile matter it may contain. If much sulphur is present, the surface of the ore is covered with a blue flame, and sparks are emitted in all directions in about three-quarters of an hour after the furnace is charged. When most of the sulphur has been volatilized, the charge is passed to the hot-bed from inside by means of long iron scrapers, where the last traces of sulphur, &c., disappear very soon under the increased temperature. During this process all the sulphides and arsenides of the metal contained in the ore have been decomposed and transposed to sulphates, part of the sulphur liberated combining with the oxygen forms sulphuric acid, which in its turn combines with the iron, copper, zinc, &c., and forms sulphates of these metals. On passing the ore to the hot bed a quantity of common salt (chloride of sodium) is added, varying in proportion to the weight of the ore from 2cwt. to 16cwt., according to the quality of silver contained, and also to the amount of iron, zinc, &c., present, as these metals also combine with chlorine, thus robbing, as it were, the more precious metal of part of that gas. It is therefore necessary to add more chlorine than is really required by the silver so as to insure the perfect chlorination of this metal. Under the influence of increased heat the sulphates formed on the cold bed are decomposed and the metals thus liberated, some as oxides, others in the free state. These sulphates, acting at the same time on the salt, decompose it, liberating sodium, which, combining with oxygen and sulphuric acid, forms sulphate of soda and chlorine gas; these instantly combine with the metals forming chlorides and perchlorides. The ore is also kept in constant motion throughout this process. About two hours after the last traces of sulphur have disappeared the chlorination should be complete. The ore is now drawn out into barrows and spread on the cooling-floor until cold enough to sift. As each charge is removed from the cold bed on to the hot one, a fresh charge is dropped in from the top on to the former bed, and so the process continues.

When cool enough the ore is elevated to a hopper which leads to a large circular screen, 9ft. in length by 2ft. 6in. in diameter. The first 6ft. are covered with fine wire gauze containing 2,500 holes to the square inch, and the remaining 3ft. with gauze containing 625 holes to the square inch. A feeder or bevelled roller is adjusted at the bottom of the hopper, so as to regulate the quantity of ore which falls into the screen and thus prevent a rupture. The dust which passes through the fine gauze is ready for amalgamation; the fine grit which sifts through the 625-hole gauze is again crushed through fine gratings, and is then also ready for amalgamation; but the coarse grit which falls at the end of the screen is not only crushed through fine gratings, but has to pass through the furnaces again for one and a half to two hours, as the silver contained in these coarse particles would not have been exposed to the action of the chlorine gas. When cool this is also ready for amalgamation.

The reason for not crushing fine in the first instance is that it is advisable to have a little grit in the ore so as to render it porous while in the furnace, and thus aid the free circulation of the chlorine gas throughout the mass.

A sample is taken of each charge as it is drawn from the furnace in order to ascertain whether the chlorination is perfect, as any silver not chlorinized would remain in the tailings after amalgamation.

The amalgamators consist of four of Wheeler's pans, each of which holds about 7cwt. of ore per charge. Each pan is first filled with about 4in. of water; then the ore is put in by ordinary buckets while the muller is in motion (which makes about sixty revolutions per minute), until the whole of the 7cwt. has been charged, and as soon as it becomes a moderately thick slime, or rather a pulp from 150lb to 200lb. of mercury, according to the quantity of the silver per ton, is added, and in two hours 10lb. more mercury is filtered through a small calico bag into the pan, so as to cause a perfect dissemination of mercury throughout the mass. In four hours after charging the amalgamation of all the silver contained in the ore should be complete. Care has to be taken to keep the pulp at a proper consistency, as the successful result depends on this. If too thin the mercury remains at the bottom of the pan and will not circulate through the mass, and if too thick there is a danger of flouring the mercury, thus causing a heavy loss. The mass is kept at a temperature of about 130° Fahr. by the introducton of a jet of steam at intervals. As all the ore is charged in a state of fine dust no grinding in the pans is required, thus avoiding the expense of wear and tear of dies, shoes, and mullers.

At the end of four hours the pans are filled with water and allowed to run in this state for about fifteen minutes, during which the pulp is reduced to a very fine liquid slime, and the mercury, carrying with it the silver, sinks to the bottom of the pan. The pans are then stopped, and the slime discharged through the upper hole, which is 6in. from the bottom, into a shoot or conduit which leads to an iron vat 6ft. in diameter by 5ft. in height, called the "separator." Here the slime is further thinned by an addition of water, and kept continually in motion by means of rakes attached to four arms, which are driven by a vertical shaft connected with the main driving gear, making 25 revolutions per minute; any mercury or amalgam that may have escaped from the pans is thus collected at the bottom. After keeping this separator in motion for about three hours the slime is discharged into tailing-pits or into the river, according to circumstances. It may be well to add here that, during the time the separator is at work, samples of the slime are taken out and assayed to ascertain how much (if any) has not been amalgamated.

The pans are again charged as before, except only from 10lb. to 20lb. of mercury is added (through a calico bag), and another 10lb. about two hours afterwards.

When the amalgam commences to cling to the sides, mullers, &c., in thick layers, the pans should be cleaned out by running off the mercury and taking out the amalgam. The mercury is discharged through the bottom hole of the pan into a small iron vat or separator, 3ft. in diameter and 3ft. in height, which is furnished with a vertical shaft and arms on the same principle as the large separators. The sides of the pan are then cleaned, as also the shoes, dies, and muller, by means of small scrapers. And the amalgam thus obtained is allowed to run for a few minutes in a berdan, together with a quantity of mercury, and in a short time the hard amalgam will be ground up and mixed with the other mercury. Any slime or scales of iron are washed out of the pans, which are again ready for another charge. The amalgam has now become thin, and it is taken out of the berdan by means of a ladle, and any skimmings, consisting of an amalgam of mercury and base metals, such as zinc, iron, lead, &c., are afterwards retorted to save the mercury and any silver it may contain. The skimmings are carefully removed, until the surface of the mercury is left quite bright. The mercury is now poured into a strong canvas bag or filter, when the free mercury passes through the pores into an iron basin below, leaving the hard amalgam in the filter-bag. When the bag is full of amalgam it is carefully beaten with a wooden roller until no more mercury is seen to pass through the pores of the canvas. The bag is now emptied of its contents into a convenient vessel for weighing, and eventually taken to the retort.

The mercury in the small vat is drawn off by a tap into the canvas bag and filtered, as before described. All slime from the bottom of the separator is passed through the berdan in order to save any amalgam or mercury it may contain.

The amalgam is then retorted in the ordinary way, and when all the mercury is passed over to the condenser, the retort is allowed to cool. The silver in a porous state is taken out, broken in pieces of a convenient size, melted in a plumbago crucible, and run into ingots weighing about 50lb. each. The bullion from this company's mine varies from 0·850 to 0·900 fine, and contains about 1 per cent. of gold.

The seconds from the sorting of the ore at the mine are concentrated in ordinary German hand-jiggers, and the resulting ore, averaging about 90oz. of silver and 18dwt. of gold per ton, is then treated in the manner before described. This mode of concentration, although primitive and slow, is very effective, all the silver being saved. One man at a jigger can produce about 5cwt. of good ore per diem of eight hours.

The present depth of the mine that this company is working is 300ft. For the first 75ft. the silver was found as chloride, and chloro-bromide; below that depth to 140ft. argentiferous iron pyrites, and blende with spots of silver glance; under this level to the present depth the silver is principally found as flexible sulphide of silver. The lode varies in thickness considerably; in places it is not more than 2ft., while in other parts it is 19ft. thick; but generally when the lode is thickest the stone becomes poorer, in which case only the best part of the lode is taken out.

For the first 200ft. the formation on each side of the silver lode is a brown metamorphic slate highly impregnated with iron pyrites; below that to a further depth of 30ft., common greenstone feldspar and hornblende; beneath this, again, metamorphic slate occurs to a further depth of 50ft., when it changes to a syenite formation. The lode has always been found richest in the metamorphic slate, and generally poorest where the syenite occurs.

Sunny Corner.

The Sunny Corner Company's mine is situated at Sunny Corner (a small township that has sprung up within the last two years owing to silver mines being discovered in the locality), about twenty-five miles south of Bathurst, and contains one of the largest mineral lodes that I have seen in New South Wales. Some years ago it was worked on the outcrop for gold, the stone being crushed in the ordinary manner with stamps, and the gold collected on riffle tables; but on sinking deeper on the lode it was found to contain a large percentage of silver, which could not be collected by the ordinary process adopted for saving the gold. The former owners of this mine sold it to a company in Sydney. Before taking any steps to erect works to treat the ore, they further prospected the ground to ascertain the extent of the lode. On sinking, the amount of gold in the quartz got less, while the percentage of silver and galena gradually increased. This led to a new process being adopted, by which the gold, silver, lead, and copper are extracted and made marketable.

The lode on the surface is composed of burnt-looking quartz mixed with gossan, resembling the appearance of the stone where gold is obtained in the Mount Morgan Mine in Queensland; but, on sinking on the lode the quartz changed in character, and got mixed more with silver, galena, and gossan, presenting a dark-brown appearance. After sinking on the lode for a considerable distance, a tunnel was driven from the face of the hill, so that it would be about 300ft. below the surface when it got under the crown, and from this tunnel cross-cuts were made to cut the lode at short intervals, so that it might be accurately tested by assay.

The method adopted for getting an average sample for assay is to take from each truck or barrow load of ore samples, which are mixed together, and an assay made from them. This system is likewise adopted in taking out the ore from various parts of the mine, each truck supplying its quota of the sample heap, from which assays are afterwards made. An assayer is employed on the works testing the value of the ore, and likewise the slag that comes from the smelting furnace as well as the dust that accumulates in the flues, to see that the different minerals are all extracted.

On each side of the lode there is brown metamorphic slate, having yellow veins through it, and on the hanging-wall there is about 2ft. of soft pipeclay.

It was found after starting the tunnel that the lode, although presenting the same appearance and character, apparently running in a slight inclination from the vertical under foot, that the upper portion had at some time been turned over, lying almost flat, presenting a perfect quarry, in many places 50ft. in thickness. On the upper portion of this flat lode the ore contains a large percentage of silver, galena, argentiferous iron pyrites, and gossan; but, towards the bottom or foot-wall, it is mixed to a considerable extent with carbonate of copper, and is not so rich in silver. Everywhere throughout the lode is mixed with large quantities of gossan. In some places there are caves or cavities in the lode, with iron stalactites and stalagmites, presenting a beautiful and picturesque appearance. The manager of this mine, Mr. Hurley, who has had many years' experience in the silver mines of Nevada, states that he has never seen any lodes before of this particular character, and although he has been over two years in charge of this mine in opening it up, the appearances of the ore in many instances deceived him. What he supposed to be poor ore in some instances proved on assay to be rich, and what he sometimes took for good ore turned out to be poor.

The opening of this mine has been conducted in an intelligent manner, and with care not to involve the shareholders in a great expenditure without first ascertaining the reasonable prospects of the mine paying. On this point I will quote Mr. Hurley's words: "It is the business of every mine manager to have the mine he is connected with thoroughly prospected, and assays carefully made to ascertain that the quantity of ore to be obtained is carrying such a percentage of minerals as will amply reimburse the shareholders for any money that may be expended in erecting plant."

The plant of this company consists of two smelting-furnaces, together with refining-furnaces, pulverizers, and all necessary machinery to work the same.

The smelting-furnaces consist of one known as the "Pacific" and the other as the "Probert," the latter being a new patent by Messrs. La Monte and Kahlo, of Sydney. These two furnaces are constructed with water-jackets. The principal difference between them is that the Pacific has an enclosed water-jacket, and is made in two segments; while the Probert has an open water-jacket, and is made in several segments, so that in the event of one segment being damaged it can easily be taken out and replaced with another without much loss of time. This furnace is likewise considerably larger than the Pacific, and consequently smelts more ore.

The Pacific furnace is made of steel plates about one quarter of an inch in thickness, in two segments, with an enclosed water-jacket all round it, the space between the inside and outside plates being about 4in. Each segment is closely riveted together and made thoroughly watertight. The water-jacket portion of it stands about 5ft. high, and is of an oval shape, being about 4ft. diameter in one direction and 3ft. in the other. At one side, and at the bottom of the furnace, there is an opening through which to draw out the slag as it melts. There are also openings in the water-jacket, for the tuyeres to pass through into the furnace, for the blast. The furnace is set on a foundation built of fire-brick, which is bound round with strong iron bands, and in the centre of this brickwork there is a well built in the shape of an inverted cone, capable of holding from 30cwt. to 2 tons of lead and melted metal; and from the bottom of this well there is an opening built to allow the melted lead and other metals to rise in a small well which is left on the top at one side of the foundation and outside the blast-furnace, in order that the height of lead and metal may be seen as it rises in the inside well during the time the furnace is at work, and likewise to enable the metal to be lifted with ladles into moulds, and prevent it rising above the top of the inside well. The foundation is considerably larger than the furnace, so as to allow room for cast-iron columns to stand to carry the upper portion of the furnace, which is built of fire-brick. The water-jacket portion of the furnace is set over the top of the well, which is built in the centre of the foundation and on top of the water-jacket; the furnace is built up with fire-bricks in the same manner as a cupola for melting cast iron; but, instead of the chimney going straight up, there is an iron hood over the top of the furnace, made with an elbow at an acute angle, on which is fitted a wrought-iron pipe, about 2ft. in diameter, to convey the smoke and fumes down to the chambers near the bottom of the chimney, which is about 50ft. distant from the smelting-furnace. In this pipe there are recesses left with down-casts for the fumes to deposit after they are condensed, and doors fixed so that anything deposited can be withdrawn.

The blast for the furnace is produced from either a Root's or Baker's blower, either of which is vastly superior to the ordinary fan-blasts, as they produce a greater blast, while the power required to drive them is considerably less. A continual stream of cold water is forced into the water-jacket at several points around its bottom, and the heated water is discharged by pipes leading from its top. The great advantage of the water-jacket is that, as soon as the slag begins to melt, it forms a coating or crust on the steel plates, thereby preventing them from being burnt by the fierce heat, the slag acting as a lining of fire-brick. The principle of the furnace having now been described, the next thing is to describe the mode of operation in treating the ore.

The ore is brought down from the paddock where it is stacked, and put through the pulverizer, or stone-breaker, which breaks it in pieces of about 1in. in diameter. After this it is taken to the mixing-floor and mixed with lime, iron, and silica, in order to make it run freely in the furnace. When there is not a sufficient quantity of galena in the ore, it is forced through a molten lead bath, so as to distribute the lead among it in small particles. The fuel used here for smelting is charcoal, but coke would be preferable if it could be obtained at a reasonable price. There is an opening in the brick portion of the furnace, on a level with the mixing-floor, through which to feed the furnace. The fire being kindled and the blast in motion, the mixed ore is fed into the furnace, having a layer of charcoal and ore together, and so on. The furnace is kept going night and day by three shifts of men.

As mentioned before, there is an opening at the bottom of the blast-furnace, through which to draw off the slag. This opening is closed up with clay, and the clay is tapped with an iron bar when the slag is sufficiently melted. The slag is run into iron-pots, which are fixed on two-wheeled hand-trollies and are run away as soon as they are full, and the molten slag is then allowed to stand in the pots for a short time to cool sufficiently without running, before it is emptied. Portions of it are afterwards broken up and taken again to the mixing-floor to mix with the ore. As soon as the well or bath at the bottom of the furnace is filled with molten lead and metal it is taken out of the side well in ladles, and run into bars ready for the refining furnace. Care has to be taken not to allow the molten metals to get above the level of the top of the well, and so on the process continues. This furnace is capable of smelting from 20 tons to 25 tons per day, according to the character of the ore that is treated.

The Probert furnace is made on the same principle as the Pacific, only, as already stated, it is made in several segments, and instead of the water-jacket being closed at the top it is open, thus allowing the steam that is generated by the heating of the water in the jacket to escape freely. The furnace that is erected here is circular in form, but the new furnaces that are now being made by the Mort's Dock Company, at Sydney, are oval-shaped, like the Pacific. The reason for this is that, in a large circular furnace the tuyeres for the blast have to project beyond the inner edge of the furnace, and thus becomes more liable to get burnt and damaged. There is likewise a slight difference in the circular iron flue, which, in this patent, projects horizontally from the top of the furnace into the chimney, having condensing-chambers or recesses and down-casts to collect the oxides, which goes away in fumes. This flue differs from the flues in the new furnaces which the Mort's Dock Company are constructing, the flues in the new furnaces being below the opening where the ore and charcoal are fed from the mixing-floor. A plan of the improved furnace is annexed. (See Drawing No. 8.)

The lead well or bath at the bottom of the furnace is capable of holding about five tons of molten metal, and the quantity of ore that the furnace is capable of smelting was expected to be 60 tons per day. However, Mr. Hurley informed me that 25 tons was as much as it had averaged since it had been at work.

It may be well to state that in order to establish the superiority of this furnace Messrs. La Monte and Kahlo entered into an agreement with this company to erect one of their furnaces and work it for three months continuously, giving a guarantee that it would smelt 60 tons of ore per day and save 90 per cent. of metals found by assay, before being paid for it. They have, therefore, an independent manager, Mr. Stearns, from America, who is conducting the smelting and refining operations, and if the results are equal to the guarantee, at the end of the period agreed on the company will take over the whole plant. I subsequently learned that the furnace has given every satisfaction, with the exception that it does not smelt the quantity of ore as guaranteed; but this was owing to the water-jacket being too short; but they were supplying a longer one of the same length as all their new furnaces are now made, and there is every reason to believe that when this new jacket is fixed and other improvements made, it will do the work guaranteed. I was likewise informed that this process gave about from 95 to 96 per cent. of the metals as per assay, which is satisfactory. The cost of the La Monte furnaces, ready to attach all connection with blast- and water-pipes, in Sydney is about £750 for a furnace that will smelt 25 tons of ore per day, and £950 for one that will smelt 45 tons; but if the whole of the machinery be included for the latter sized furnace it will cost from £4,000 to £5,000.

The refining works consist of reverberatory furnaces, in which are placed large cupels, having cast-iron skeleton frames filled up with bone-dust. The bars of metal from the smelting-furnace are put into the cupels and roasted until all the lead and base metals are oxidized, and nothing but the precious metal left. The fumes from these furnaces pass through a flue, where a small jet of steam is inserted at the junction with the chimney, which condenses the fumes and causes the lead to be deposited in the bottom of the chimney as litharge. When sufficient roasting has been done, which takes about four hours to oxidize all the base metals, there is a hole bored with a brace and bit from below into the bottom of the bone-dust cupel until nearly through. Afterwards a trolly with moulds placed on the top is run in below the cupel, and the hole, partly bored, is then tapped with a rod punch, and the precious metal run into ingots fit for market.

The minimum cost of the smelting process up to the time I visited these works was a trifle over £2 per ton with the Probert furnace, and between £2 and £3 with the Pacific. It must, however, be remembered that this is the lowest cost for any week that the furnaces were at work, the maximum cost being nearly £4 per ton. The difference in cost appears to be that the Probert furnace is larger, consequently smelts more ore, and only requires about the same number of men to work it. However, Mr. Hurley contemplates, when all the improvements he is now making to the Pacific are completed, he will be able to treat the ore for about £2 per ton. This company has smelted about 4 tons 6¾cwt. of silver from the commencement of the year to the 29th of March, the ore averaging 45ozs. per ton. Since my return to New Zealand I have received a copy of the Directors' special report of the 8th April last, with reference to the working of the mine and smelting operations with Messrs. La Monte and Kahlo's "Probert smelter," from which the following is an extract: "Your directors deem it necessary to advise you specially of the reasons of the non-payment of a dividend. In the report of the 3rd December last you were informed of the work expected of the Probert smelter. It was estimated that it would smelt 60 tons of ore per day, instead of which it has only averaged 25 tons. If the Probert smelter, during the ninety days that have elapsed since it commenced smelting for this company, had performed the work your directors had a right to expect, it would have treated 4,950 tons of ore, yielding bullion of value, say, £50,128, at a smelting cost of £5,940, with coke at Sydney prices, whereas the actual results show the total quantity of ore treated by the Probert smelter to the 23rd March, 1885, to be only 1,915 tons, yielding £19,639, at a smelting cost of £5,752, a sufficient explanation of the nonpayment of a dividend. A total of 140,794ozs., or 4 tons 6cwt. 2qrs. 21lbs. of silver has been shipped to London since the commencement of the year to the 29th March. There was also at the mine on the 29th ultimo 29,882ozs. of silver, already smelted, awaiting refining, which will come forward weekly as 'finished' for shipment. The cost of smelting the ore from which the silver was produced was £13,921, or equal to £3 4s. 2¼d. per ton. The value of the whole quantity exported and on the mine is £40,535, thus leaving a surplus of £26,614 above cost of treatment. The average value of the ore already furnaced has proved to be 45ozs. to the ton, or, at 4s. 6d. per oz., equal to £9 2s. 6d. value. It has hitherto cost to mine, smelt, and refine, say, £4 per ton, leaving a net profit of £5 2s. 6d. per ton. There are now furnaced weekly 300 tons of ore, which will give a weekly profit of £1,537 10s. The four new smelters to be erected will have an actual capacity of 20 tons per day each, which would, exclusive of the Probert smelter, and allowing an average of one smelter to remain idle for repairs, give a weekly reduction of 560 tons of ore, returning, at 45ozs. to the ton, a weekly profit of £2,870, or £149,240 per annum."

There are several other mines in this district which promise to give good returns; but, as silver mining is only a new industry in the colony, very little has yet been done to erect plants to treat the ore.

Silverton.

This is a township recently sprung into existence owing to rich silver lodes having been discovered in the district. It is the head quarters of the mining population, said to amount to about three thousand at the time of my visit. It is the most extensive mineral district I have seen in either Victoria or New South Wales. It is situated in the north-western portion of the New South Wales territory, close to the boundary of South Australia, in the Barrier Ranges, being about 850 miles by road from Sydney and 330 miles from Adelaide. The railway on the South Australian side is within 180 miles of Silverton, but the New South Wales railway is not within 400 miles of this place; therefore all the supplies at the present come from Adelaide.

The large extent of metalliferous formations in this district, together with the rich silver lodes that have been discovered, will in a few years make this field capable of supporting a large mining population; but at the present time there is very little being done beyond prospecting. It will require a great amount of capital to open up the mines before they are properly developed and to erect plants on the ground to treat the ore.

There is a great deal of speculation in taking up mining leases of 40-acre blocks (in the vicinity of a known lode) in the hope that prospecting may reveal payable ground. During my stay in Silverton Mr. Wilson, one of the principal legal managers of the mining companies, kindly took me to some of the principal mines that were at work, and afforded me a deal of information respecting the field. He likewise gave me a number of specimens from the various mines that I visited. As illustrative of the extent of the field, I may mention that Mr. Wilson informed me that a party of miners had just arrived in Silverton to make an application for a lease of ground where they had found some rich ore about a hundred miles distant to the northwards.

The mines I visited were the "Broken Hill," "Pinnacles," "May Bell," "Day Dream," "Apollyon," and the "Umberumberka;" but, as some of these mines are forty miles distant from each other, the time at my disposal would not admit of visiting more. The chief object was to see the various descriptions of ores and the formation of the lodes.

The Broken Hill Company's mine is situated in the Mount Gibbs District, about twenty miles in a south-east direction from Silverton, on a rocky broken ridge which stands about 200ft. above the level of the surrounding country, forming a conspicuous feature in the landscape. It is on the crest of this ridge where the lode crops out, presenting a dark-brown rugged mass of ore, which can be traced for a long distance on the surface. The outcrop of the lode varies in width considerably; in some places it is 10ft., whilst in others it is over 100ft. in width. It likewise varies considerably in character in different places along the outcrop, consisting of ferruginous quartz, felspar, gossan, and oxide of manganese, having in some places crystallized carbonate of lead. Shafts have been sunk on the lode in various places, the deepest of which is 120ft.; but, as the underlie of the lode dips about 50°, the principal sinking was on the rock adjoining the lode. It afforded me a good opportunity of seeing the character of the rock, which was highly micaceous slate regularly stratified. A cross-cut was put in through the lode at 20ft. from the bottom of this shaft, showing it to be 14ft. thick, and the character of the ore was slightly altered. It contained large masses of argentiferous gossan and more galena than was shown on the surface. I was subsequently informed that the ore taken from the cross-cut proved on assay to be considerably richer than it was on the surface.

The great body of ore that is found in this company's lease—which contains by far the largest lode in the district, even although it should prove only of a poor quality—will make it a very valuable property.

The Pinnacles Company's mine is situated about eight miles in a south-west direction from the Broken Hill, and fifteen miles from Silverton. It is called after two conical hills, which stand from 300ft. to 400ft. above the level of the undulating plain surrounding them.

This company has several lodes in their lease, but nothing has been done to test their value below the depth of 7ft. At this depth one of the main lodes is about 4ft. in thickness, and consists of ferruginous crystallized quartzite with galena intermixed, and patches of yellow gossan. Assays have been made from average samples taken from the whole width of this lode, which gave at the rate of 78oz. 8dwt. of silver per ton, and 33½ per cent. of lead; and from the yellow gossan 22oz. 1dwt. of silver per ton, and 3 per cent. of lead, with traces of gold a little under 2dwt. Assays have likewise been made from samples taken from the whole width of the lodes at other places, which gave at the rate of 137oz. of silver per ton, with traces of gold; and some assays made from the lode stuff gave at the rate of 1,504oz. 6dwt. of silver per ton, and a percentage of lead.

The chief character of the ore is galena, argentiferous gossan, with very little chlorides, and the formation of the country where the lodes are found is mica schist, having, in some instances the hanging-wall of the lode of ferruginous chlorite rock. This company is at present making preparations to erect one of Messrs. La Mon e and Kahlo's smelting furnaces (a great portion of which is on the ground) to treat the ores. Mr. Moore, the manager, who has had many years' experience in silver mining in Nevada, speaks highly of these furnaces, they being similar to those used in America; but the great drawback to smelting in this district is that coke for fuel will have to be brought from Adelaide, a distance of about 340 miles, 190 miles being by horse teams.

The May Bell Company's mine is situated about two and a half miles from the Mount Gibbs Station, and about thirty miles from Silverton. The character of the ore is entirely different from either the Broken Hill or the Pinnacles. The lode consists of quartz, gossan, chloro-bromides, chlorides, and ferruginous carbonate of lead, containing horn silver, and is extremely rich. A shaft has been sunk following the underlay for about 70ft., and at this depth the lode is about 8in. in thickness, but the lode averages from the surface downwards from 12in. to 15in. in width. On each side of the lode the formation is mica schist, but here the schist rocks are intersected in all directions by dykes of granite, passing from clay slates to mica-schist and gneiss. Assays have been made from mixed ore taken from this mine that gave 3,241oz. of silver per ton and 32 per cent. of lead. Mr. Wilson, who is legal manager of this company, informed me that they had sent 25 tons of ore to England, which realized £13,000 while they have not yet spent £1,000 on the mine and expenses connected with it.

The Day Dream Company's mine is situated about nine miles in an easterly direction from Silverton on a low hill of mica-schist and sandstone, traversed by granite dykes and quartz reefs. The lode differs in many respects from any others that I have seen on this field, as it lies very flat, dipping about 1 in 3, and in one place it appears as a saddle lode, dipping in opposite directions—it is about 4ft. 6in. in thickness; but it becomes broken in places, and splits into two lodes, having a horse of mullock between them. The lode is composed of argentiferous porous gossan, crystalline specular iron, galena, and carbonates of lead and copper, intermixed with rich chlorides, chromates, and grey ore. This company has worked down, following the underlay of lode for about 200ft., and they are employing the largest number of workmen on the field, having at the time of my visit 103 men employed. They have hitherto been sending their ore to England for treatment, but have now made arrangements to erect one of La Monte and Kahlo's furnaces on the ground.

The Apollyon Company's mine is situated about two miles northwards from the Day Dream. The lode runs very regularly, and is well defined by the hanging- and foot-walls, which are of mica schist. It varies in thickness from 2ft. to 5ft., consisting of quartz, brown iron ore and ferruginous mica schist, containing carbonate of lead, chlorides of silver, and grey ore. The company has followed the lode for about 130ft., but the quantity of water at that depth became troublesome to haul up the underlay. They have now sunk a shaft to the depth of 220ft., about 300ft. eastward from the outcrop of the lode, and they were engaged at the time of my visit in driving a tunnel from near the bottom of the shaft to cut the lode. As the shaft is sunk in the bottom of a gully, below the outcrop on the face of the hill, the tunnel will cut the lode about 300ft. below the surface. The dirt is hauled up by one of Tangye's steam-engines, which works the pumps in the shaft, and the water that is lifted is condensed for domestic purposes, it being slightly brackish.

This company has hitherto been sending their best ore to London and Freiburg for treatment, one parcel realizing in London £670 per ton; but they have now made arrangements for erecting one of La Monte and Kahlo's furnaces on the ground, where they will be able to treat the poorer lode stuff as well as the best ore. A considerable portion of the poorer stuff is stacked ready for treatment.

The Umberumberka Company's mine is situated about two miles west from Silverton, and was the first mine opened in the district, consequently a considerable amount of work has been done. They have worked down for 131ft. on the underlay of the lode, and stoped out a good portion of the reef. The country here is very broken, the strata being turned and twisted in all directions, and the lode is very irregular, it being in bunches here and there; in one place on the bottom level it splits and forms two parts, with a horse of mullock between. The width of the lode varies from 4ft. to 10ft., and it consists of mica schist, gossan, carbonate of lead, galena, and baryta. The ore yields from 50oz. to 120oz. of silver to the ton, the silver being principally in the galena, which is distributed in irregular masses through the lode. About 500 tons of ore have been raised from this mine, and Mr. Evans, the manager, informed me that they send it all home to Freiburg for treatment.

This field, as I have stated previously, is an extremely large one, with metalliferous lodes cropping out in all directions, but it will take a number of years to develop the mines and unbosom their wealth, as there are considerable drawbacks to contend with. There is no mining timber of any consequence to be had nearer than Menindie, which is seventy-six miles distant from Silverton, and in dry seasons there is scarcely any water. The Government has done a good deal in boring for water, but so far they have not been successful in finding any which is not brackish. The fresh water in dry weather is confined to the soakage in creek beds. However, there is no doubt but these difficulties will be overcome, and that this field will ultimately produce immense wealth.

Mr. C. S. Wilkinson, F.L.S., F.G.S., the Geological Surveyor in Charge, New South Wales, made an examination of this country last year, and his report to the Government contains valuable information with reference to its geological formation and character of the various lodes he examined.

Copper Mining.

The only copper mine that I visited was the Cobar Company's, which is situated at the Township of Cobar, about ninety miles west of the Western Railway line at Nyngan, where all the copper that is smelted on this company's works is brought to be forwarded to Sydney for shipment.

This mine has been steadily worked for a number of years with good results, but at the present time the price of copper is so low that very little profit, if any, can be made.

The main shaft for working the mine is sunk to a depth of about 450 feet, but the deepest workings are about 270 feet, where a level is constructed and stoping carried on between this and the next level at 228 feet, the lode above this being all worked out to the surface.

The lode runs in a northerly and southerly direction, having an underlay to the east, and is from 20ft. to 30ft. in width, having clay-slate walls on both sides with a casing of soft slate, which appears to be intermixed with some form of magnesium or lime. The lode is formed in horizontal beds: for instance there may be a layer of gossan 2ft. thick, then a layer of some other description of ore for a certain distance—thus: gossan, grey ore, black oxide, native copper, grey ore, red oxide, gossan. A good deal of carbonates were found on the upper levels near the surface, but where the workings are confined to at the present time the character of the ore may be classed as grey ore, red and black oxide, and native copper. Under the level of the present workings the ore gets into sulphides and sulpherets, and is not so rich. I was informed that the whole of this lode stuff gave from 10 to 15 per cent. of payable ore.

Very little timber is used in this mine unless for passes, which are formed of logs; the system adopted in stoping is to fill each stope as it is taken out, timber only being used as props for holding up the roof if it appears dangerous.

The ore is hauled up to the surface in trucks by means of ordinary cages. The trucks are emptied on the sorting-floor, where all the ore is hand-picked by boys who are paid from 2s. to 2s. 6d. per day. The ore is next put through the pulverizer, when it is broken up into pieces of about 1in. in diameter, and thence taken to the smelting works.

These works consist of sixteen reverberatory furnaces, eleven of which are used for reducing, four for roasting, and one for refining. There are likewise two new furnaces, which have recently been erected, to treat the ore in such a manner as will dispense with the process of skimming, and thereby save labour, but, so far, they have not come up to expectations. These new furnaces are built with fire-brick, of the same shape as a cupola for melting cast iron, with this exception, that there are two openings left near the bottom—one for drawing off the melted ore, and the other, which is a little higher up on the opposite side, for drawing off the slag. As the melted ore is tapped it runs into another furnace termed a "converter," or "roaster," and thence, in turn, it runs out of the converter into the refining furnace, the object being in this new process to save fuel and labour. This is to some extent the system of smelting that Messrs. La Monte and Kahlo adopt in treating silver ore; but the principle of the La Monte furnace is entirely different from the furnaces erected here, and this company will require to make great alterations in the furnaces before they will ever be able to work them economically.

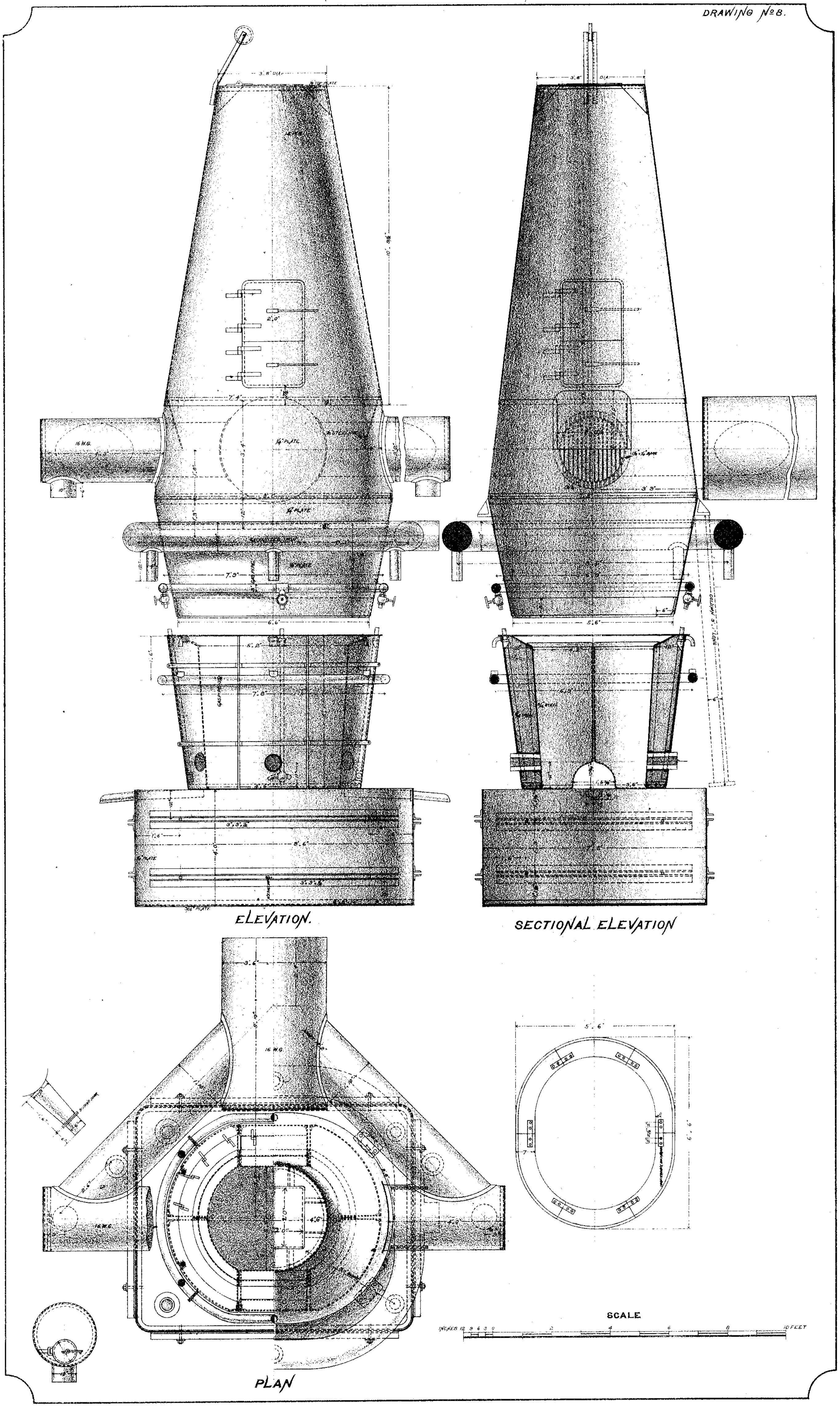
At the other works the smelting operations are conducted as follows: The ore is brought from the pulverizer at the mine and stacked in large heaps, from which it is taken and mixed with slag, charcoal, and limestone, in proportion of one truckload of slag and charcoal to four truckloads of copper ore. This quantity is deemed sufficient for a charge to put into one of the reducing furnaces.

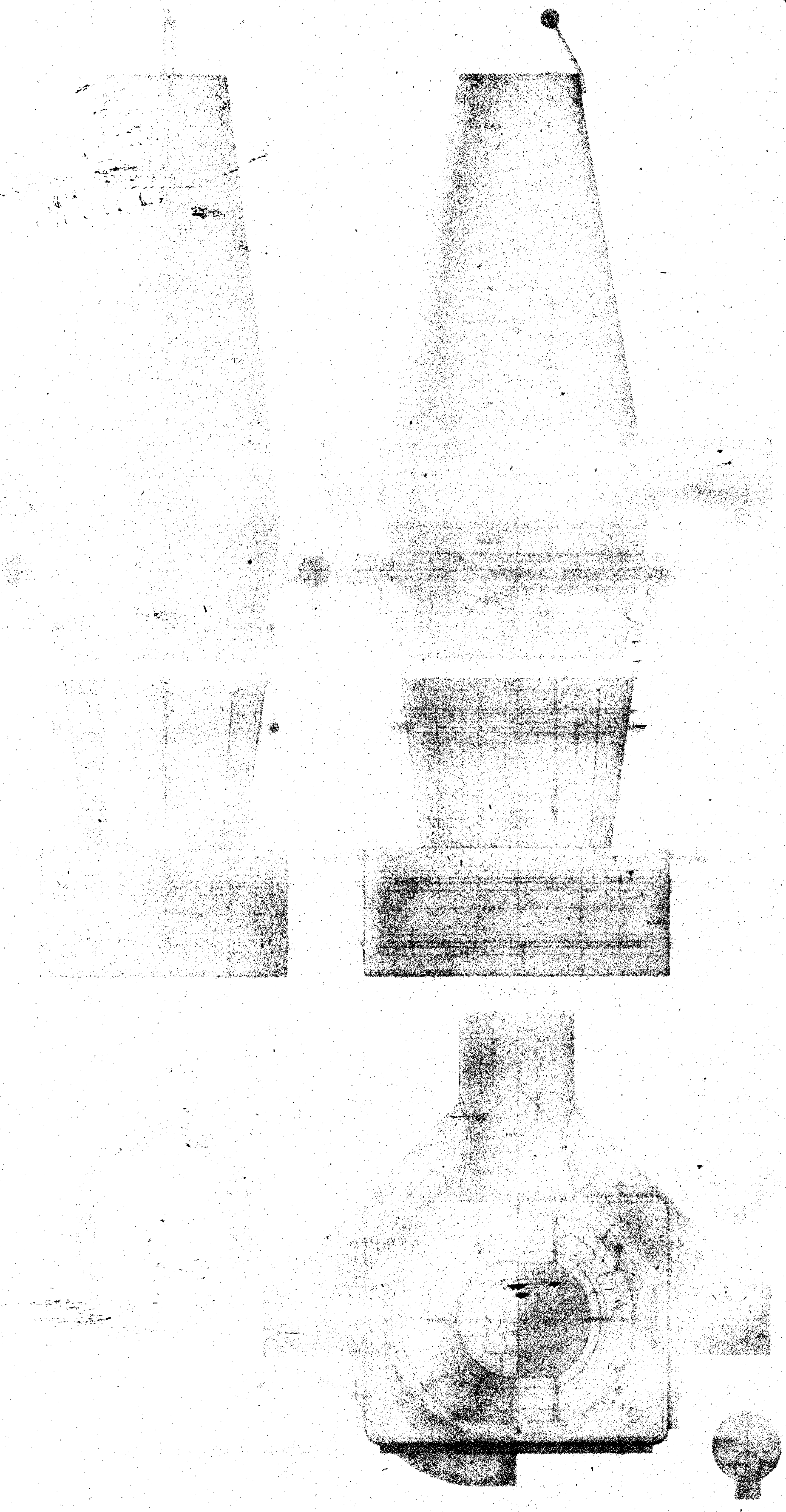
The reducing furnaces are built of fire-brick, and bound together with strong iron bolts and clasps. They are oblong in form, or more like the shape of an egg with a little taken off at both ends. At one end of the furnace there is a fire-box about 5ft. to 6ft. in length and 2ft. 6in. in width, having a bridge about 14in. high between it and the furnace, where the ore is smelted. The floor of the furnace is made with a little fall towards the centre, and to one side, in order to draw off the metal when required. At the opposite end from the fire-box there is a small opening to allow the ore to be stirred up and the slag skimmed off before the metal is allowed to run out at the side opening. The stirring is done with scrapers having a long iron handle, which are drawn over the surface of the molten mass, hauling the slag out at the same hole where the scrapers are worked. The slag is then run into open sand-moulds, and when cool it is taken away to the slag heap, a portion of it being again broken up to mix with crude ore. When the slag is skimmed off as clean as it can be got, the hole in the side is tapped, and the metal drawn off and run into similar moulds to cool before going through the next process. The metal in this state contains about 33 per cent. of copper; it breaks up very freely, having a steel-grey appearance. The time a charge is in this furnace varies a little according to the character of the ore, but it is generally from five to six hours. These furnaces, as well as those for roasting, are about 18ft. long and 10ft. wide inside, having a height at the end next the fire-box much greater than at the opposite end, where there is a flue on

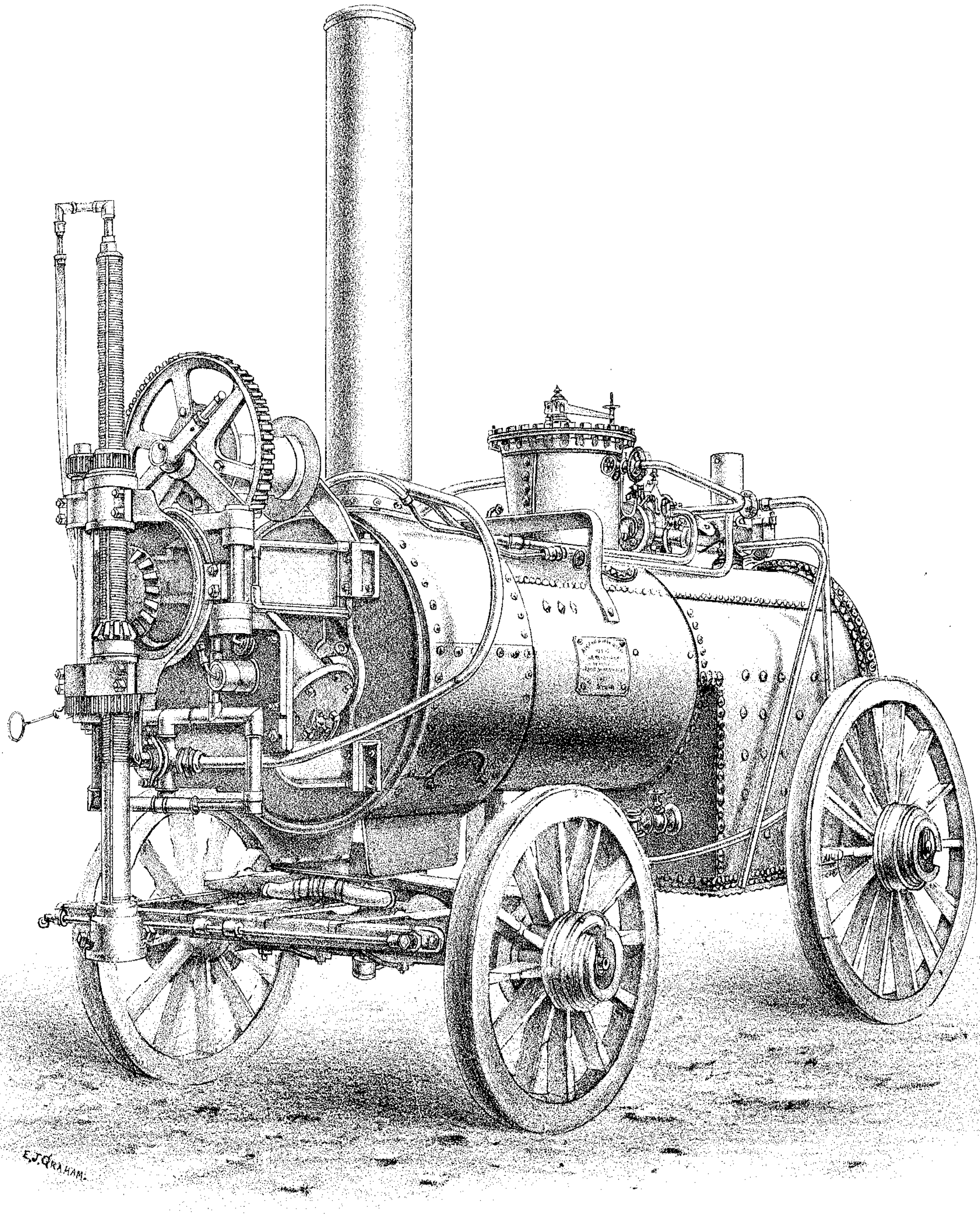
PLAN OF

LA MONTE'S SILVER SMELTING FURNACE.

(SMELTS 25 TONS PER DAY)







SURFACE DIAMOND DRILL MANUFACTURED BY MORTS DOCK CO. SYDNEY.

one side leading to the chimney to carry off the smoke and fumes. The object in having it lower at the end next the flue is to keep the flames as close down on the ore as possible, so as not to waste any heat. At the end next the fire-box, on the angles of the furnaces, there are two openings, which are fitted with small iron doors, to enable the state of the ore to be seen while undergoing this operation. As soon as the metal is drawn off, another charge is ready to drop in, as there is an iron hopper placed over the top of each furnace capable of containing the requisite quantity of mixed material for a charge, an opening being left on the crown of the furnace to allow this to be done, and, as soon as the charge is in, the hole is again closed up with clay.

The roasting process is the next operation. The pigs or slabs of metal that come out of the reducing-furnace are broken up and placed with flux in a furnace of a similar description as the reducing-furnace, there to be subjected to a great heat from twenty to twenty-four hours. The slag is again carefully skimmed off the surface of the metal, and the regulus, which at this stage contains from 90 to 95 per cent. of copper, is run off into open sand-moulds.

The slabs of regulus, from 5cwt. to 6cwt. each, are now put into a refining-furnace, which is somewhat similar in construction to the others, only being considerably higher and having a special opening on one side to charge it, which is done by placing the slabs on an iron slice having a strong iron handle and sliding them in, one on top of another, until the charge is complete. A charge consists of from 5 to 6 tons of regulus. The side-opening is now closed up, the regulus melted, and again subjected to a great heat for several hours, after which it is taken out by ladles from a small well in front, having the floor of the furnace dipping towards it, and run into ingots of about 21 lbs. each, fit for the market.

It was very difficult to obtain any definite information with regard to the cost of treatment. The cost of smelting depends entirely on the character of the ore. The richer the ore the more costly it is to treat, but, so far as I could learn, the cost of treating the ore from this company's mine is about £2 per ton.

The large quantity of firewood this company consumes has cleared off the bush within a radius of from ten to fifteen miles. They have a light railway and specially-constructed light locomotives for bringing firewood and other mining timber from a distance of over twenty miles.

The Hunter River Copper Works.

This company's works are situated on the Hunter River, near Newcastle, and is one of the most complete smelting plants in the colony. The plant belongs principally to the proprietors of the Wallaroo and Moonta Mines, and a great deal of the ore from these mines is shipped here for treatment. The system adopted here for treating the ore is somewhat similar to that adopted by the Cobar Copper Company, with the exception that the whole of the furnaces, twenty-one in number, are reverberatory, likewise that the ore goes through an additional process of calcining before it is put into the reducing-furnaces; and further, that the fumes from the roasting-furnaces go through about 700ft. of flues before they reach the chimney.

The calcining process is done by putting the crude ore into a furnace similar to that described for roasting pyrites at the United Pyrites Works at Sandhurst, at page 4, and subjecting it to dark-red heat for about six hours, keeping it constantly stirred to free it from sulphur and arsenic; after this it is drawn out and mixed with flux before putting it into the reducing-furnaces. When the furnaces are at work they consume about 6 tons of coal daily. During last year 2,050 tons of copper were smelted, and at the time of my visit there were about 1,000 tons of ingots on the works, ready for shipment.

Mr. Thomas, the manager, accompanied me, with Mr. J. S. Mackenzie, F.G.S., and Examiner of Coalfields in New South Wales, and explained to me the various processes that the ore had to undergo before it was fit for market. He drew my attention to the great length of flues from the works to a large brick chimney, 150ft. in height, which he had recently constructed at an outlay of nearly £7,000, in order to save the oxide from the fumes as they became condensed. The main flue is 9ft. wide by 11ft. in height, and follows a very tortuous course; the more bends and elbows there are the better for condensing the fumes. Mr. Thomas stated that the amount of oxide he saved since the construction of these flues, about twelve months ago, was sufficient to pay all the outlay of erecting them.

I observed here, as well as at Cobar, that for some distance all around the smelting-works the country was devoid of any vegetation. No doubt this is owing to the poisonous fumes condensing in the atmosphere and falling on the ground.

Coal Mining.

The coal measures in this colony occupy an immense area, a great portion of which is situated in such a position that it is comparatively easy to get the product of the mines sent to market. Mr. C. S. Wilkinson, F.L.S., F.G.S., Geological Surveyor, estimates that the coal fields occupy an area of 29,950 square miles, and that the seams now worked cover an area of 3,228 square miles, being about half the area of the coal-fields in the United Kingdom. He also estimates that, after deducting one-half of the contents of the seams for waste, &c., there is about 14,370,000,000 tons available for use; but, be this as it may, the great thickness of the seams, and the facilities there are for working and sending the coal to market, will make this industry one which will employ a large population.

The Wallsend Mine.—This mine has the largest output there is in the colonies, being about 500,000 tons per annum, or more than at present comes out of the whole of the mines in New Zealand. There are about 640 actual miners employed underground, or 1,050, including surface- and truck-men.

The system of working adopted is that known as "bord-and-pillar," the bords being about 7 to 8 yards and pillars from 4 to 5 yards wide. In this mine the main tunnel goes in from the side of the hill, following the dip of the coal, which is very regular, having an inclination of about 1 in 10. On each side of the main tunnel there are back headings with stentons driven between them and the main road; and it is from these back headings that the coal is brought out by means of horses into the main tunnel. The coal is first cut up into large rectangular or square blocks of, say, 100 yards or more in length and width by running a series of headings through them, and from these headings the bords are driven each way, meeting about the centre of the block. In first opening out from the headings the bords are cut as narrow as possible in order to keep the headings good; they are afterwards gradually widened out to the whole width at which the bord is intended to be worked. The blocks are first traced by a network of bords, having longitudinal pillars running parallel with each other; and if these pillars are afterwards taken out they are blocked out in the following manner: A cross-cut or opening is made in the centre of the pillar and blocked out towards each heading; but very few of the pillars in this mine have been taken out, the object being to keep the pillars as narrow as possible consistent with safety, and to leave them until the whole of the area of coal intended to be worked from the main tunnel is cut up into pillars and stalls, so that the blocking-out may commence from the back end and worked towards the mouth. The regular dip or inclination of the coal seams admits of the coal being cut up in very regular square or rectangular blocks and the bords all parallel to one another.

When one of these blocks is taken out the headings remain protected by safety-pillars, which are not worked until the whole of the pillars to within a short distance of these headings are exhausted.

Haulage.

The underground haulage appliance is that known as the "tail-rope" system. This expression refers to the simultaneous employment of two ropes, one in front of the train of trucks or skips and the other behind, being attached to the last truck or skip.

The engine for working this rope is placed on the surface, and it works two winding-drums, on which are placed round winding-ropes made of steel-wire about $\frac{7}{8}$in. in diameter. The rope termed the "tail-rope" travels on pulleys overhead in the tunnel, and the other rope, which is attached to the front end of the full train, is carried on pulleys and rollers on the ground. At every angle of the road there are pulleys to guide the hauling and tail-ropes and keep them always in the line of the haulage; these ropes are coupled to the front and back truck of the train, with detaching hooks, so that they can be disconnected at a moment's notice during the time the train is in motion. All the skips or trucks are coupled together with ordinary couplings. Each skip holds about 12wct. of coal, and from fifty to seventy of these skips are brought up in one train, travelling at a velocity of about ten miles an hour. The wheels of the skips are mostly all cast-steel, about 12in. diameter, and the rails used seem to be about 24lb. per yard.

The great advantage of the tail-rope system of haulage is, that only a single line of rails is required in the main tunnel, and that the train can be made with no trouble to travel round a very sharp bend or curve, whereas the endless-chain system requires a double line of rails and long curves before it will work. Nevertheless there is less wear and tear on the endless-chain system, although expensive in the first instance; it is well adapted for underground haulage, especially where the main tunnels are tolerably straight, and can be worked at a less cost than the tail-rope system.

Ventilation.

This mine is divided into several districts, and each district is ventilated by a furnace. The furnace that I inspected was 22ft. in length, 9ft. in width, and 6ft. 6in. in height. It had fire bars the whole width, and for 18ft. in length, and had five openings or furnace-doors, where coal was put in to feed it. At the end of this furnace there is a brick chimney 10ft. in diameter inside at the bottom, and built up for a considerable height above the surface of the ground. All around the furnace and chimney the coal was taken out, and the roof lined with iron, having old railway rails running longitudinally below the iron, thence cross-rails which were supported with iron standards to the floor. The opening where the furnace was built, had the appearance of a strong iron chamber, which the manager informed me was necessary to guard against the possibility of the heat from these furnaces setting the coal on fire.

A furnace of this description is capable of supplying 93,000 cubic feet of air per minute when in full work. The manager informed me that he always endeavoured to allow 100 cubic feet of air per minute for every man, boy, and horse employed in the mine.

The air-courses are divided off, having over-casts across the main tunnels and headings, so that each portion of the district where the men are employed may receive as nearly as possible an equal supply of fresh air.

This company's mine is all freehold property. The greater portion of it is known to contain a good coal seam. It averages about 9,000 tons of coal an acre, and they have yet about 3,000 acres to work, or about 27,000,000 tons of coal unworked, so that at their present rate of output it will take fifty-four years to work out this seam.

Considerable difficulty was experienced all over this district some time ago in dealing with the miners, as they struck work for an advance of wages, and formed themselves into an association; but this difficulty is now overcome, an arrangement having been entered into between the miners and employers that a certain percentage per ton, according to the price the proprietors get for the coal delivered on board the vessels at the Newcastle wharf, shall be paid. If this price is only 9s. per ton, the miners receive for hewing and filling it into the skips or trucks 3s. 6d. per ton; and if the price goes up to 12s. per ton, the miners receive 4s. 6d. per ton; and a sliding-scale between these two rates is fixed in proportion to the price that the proprietor gets for the coal. The average price at the present time for coal is 11s. per ton, and the manager stated that the average wages the miners have made during last year was 13s. 6d. per day.

In order that the miners may know what they are making, they employ one of themselves to see the different skips weighed as they come up, each having a tally or tin number attached to it, which indicates where it comes from. A skip is picked out promiscuously from each party of miners, and the weight of that skip is taken for the average weight of skips for the day. This system makes the miners very careful to see that all the skips they send up are about the same weight, as they do not know what skip may be taken and weighed until after their shift is over.

The Australian and Agricultural Company's Mine.—This company are working from two shafts, one of 171ft. and the other 197ft. in depth and 13ft. in diameter, having double cages in each shaft. Their system of haulage is similar to that adopted by the Wallsend Company, which the manager prefers to the endless-chain haulage, he having had experience of both systems. The quantity of skips hauled out in one train is about 60, carrying about 12cwt. of coal each, and the rope is $\frac{7}{8}$in. in diameter, made of steel wire. There are 556 men employed underground and nine horses; the total number of men on the works is 840, and the quantity of coal raised per day is about 1,000 tons. There is a little water in this mine, which is lifted by three Tangye pumps, but, with the exception of one which is 10in. in diameter and lifts the water 197ft., the rest are all small and only lift the water about 40ft. There is no safety-hook employed nor any safety appliances on the cages, they being all of the ordinary type.

The Wickham and Bullock Island Coal Company.—This company is sinking a new shaft with cast-iron cylinders made in segments 1in. thick of such a weight as can easily be handled. These are all bolted together with the flanges inside; the shaft being 10ft. in diameter in the clear is now sunk to the bottom of the coal seam, which is 19ft. thick and 227ft. below the surface. These cylinders are all put on from the top and pressed down as the sinking is carried on. The average cost of the shaft, including cylinders and all expenses connected with it, has been £27 per foot. This seam is one of the best in the district, being what is termed the "Bore" hole seam, and is the same as that on which the Wallsend Company is working.

The Maryville Coal Company.—This company is likewise sinking a new shaft which is lined with 14in. brick work, having wooden combs every 7ft. apart in order to bolt the whole lining together. The brick lining is built on the top as the sinking goes on and the whole is pressed down. This shaft is likewise 10ft. in diameter, and is now down 145ft., having cost up to the present time £10 per foot.

Katoomba Coal Mine.—This mine is situated in the Blue Mountains, about one and a half miles from the western line of railway, near the Katoomba Station. I had no opportunity of visiting the underground workings; but the machinery employed on the surface, and the mode of haulage from the mine to the railway is that known as the endless-rope system with low velocity. There is a light iron tramway following to a certain extent the inclination of the ground, with the exception that there are viaducts built on trestles across the gullies that intervene between the mine and the shoots, which are alongside the railway line. The tramway is worked by an endless steel-wire rope, travelling at the rate of about two miles per hour. The skips as they come out of the mine are made fast to this endless-rope by two short pieces of chain at each end of the skip. The slow motion at which the rope travels admits of this being done without stoppage, and the long distance between the skips give ample time for a boy to meet the empty skip coming back and loose the chain at both ends before it comes up to the pulley; and in the same way, when the full skip is ready, the boy gives the front chains two or three turns round the rope, which is sufficient to set it in motion; after the front end of a skip is made fast to the endless-rope the tail chain to the same skip is made fast, by this means the skip is kept steady either going up or down an incline. The endless-rope is worked by a steam-engine at the mine. The coal from this mine is much inferior to the Newcastle coal, having more the appearance of brown coal.

Hydraulic Cranes, Newcastle.

The systems of loading vessels with coal are, with one or two exceptions, done by hydraulic and steam cranes. The bodies of the waggons, which are detached from the frame, are lifted and brought over the hatchways of a vessel, when the trip-bolt is loosened and the bottom of the waggon, which is hinged, falls down, thus allowing the coal to drop into the hold.

The pressure to work the hydraulic cranes is got by a stationary engine forcing water inside a vertical cast-iron cylinder 20in. in diameter, having metal 4in. in thickness. This cylinder is of sufficient length to admit of the ram or plunger being forced out 26ft. There is a stuffing-box and gland at the upper end of the cylinder packed with vulcanized indiarubber so as to be perfectly water-tight, with a pressure of water up to 700lbs. per square inch.

Attached to the head of the ram is a wrought-iron tank about 22ft. in depth and 11ft. in diameter; this tank has also an inside cylinder like the fire-box or flue of a Cornish boiler, and has the appearance of a steam boiler with a circular flue in the centre, being open on the upper end. There is a cross-head on the top of the ram which works in guides to keep it moving up and down in a truly vertical position. This wrought-iron cylinder is hung to the cross head of the ram, and the inner cylinder or centre portion of it is large enough to move up and down over the cylinder of the ram, it being kept vertical by working in the same guides as those in which the cross head of the ram works. The wrought-iron cylinder being in position, it is filled with about 90 tons of copper slag, and this acts as an accumulator and keeps the pressure on the hydraulic cranes always the same. When several of the cranes are working at once the stationary engine would not keep up the same pressure, but as the water is used for the cranes the accumulator moves down, forcing the ram down with it, and thereby keeps the pressure always the same. There are two pairs of double steam-engines, which can be used when required to force the water into the cylinder, but only one pair works at one time, the other pair is kept in case of accident. The engines have 14in. cylinders and 2ft. stroke, and the plungers for forcing the water into the cylinder of the ram are 3in. in diameter.

The hydraulic cranes are so constructed that the ram can be made to exert a force equal to either 9 or 15 tons by one ram working inside another when the lesser force is required, and by locking the inner ram and allowing the outside one to move the greater force can be exerted. These hydraulic cranes were all constructed by Sir William Armstrong of Newcastle-on-Tyne, and are stationed at different places all along the wharf, so that a number of vessels can be loaded at the same time.

There are two stationary steam cranes at the upper wharf, which lift the wagons equally as readily as the hydraulic cranes, and when these steam cranes are not fully employed they can be worked more cheaply than the hydraulic ones.

The coal-wagons are all made on the hopper principle, holding about 7 tons each, having bodies to lift off the frame. This is certainly a great improvement on the coal-wagons used on the west coast of the Middle Island, which require men to shovel out the coals after the bottom door is opened.

Diamond Mining.

Diamonds are found in the vicinity of Cudgegong and Bingera. I visited Bingera only, which is situated about seven miles, in a south-westerly direction, from the Township of Bingera, a hundred miles distant from the Northern Railway line at Tamworth.

This field was first opened in 1872, but mining for diamonds was soon abandoned, and it was not until November, 1883, when an Australian company took up a lease of the ground and commenced to work, that the value of it became known.

Very little work has yet been done on the field owing to the extremely dry seasons in this district. Indeed, the small patch washed away would not employ four men for more than three months, but, at the same time, there has been a good deal of prospecting, and a small plant erected on the ground with which to puddle the wash-dirt.

The wash-dirt from which the diamonds are obtained resembles gold-bearing wash to a great extent, and contains a little gold, but not sufficient to pay to work for gold alone. The wash is mixed with garnetiferous sand, jasper stones, black tourmaline, and stones of a sedimentary character, such as one would expect to find in a river-bed, which I think the place where the diamonds are found must have been at some former period. The source from which the diamonds originally came must be some, distance from where they are now found, as the stones among the wash-dirt are considerably rounded as though they had been turned over and over for a long distance by the action of water. The wash-dirt lies on a soft sedimentary reef, intermixed with either magnesia or carbonate of lime. The diamonds found as yet are all very small, the largest being about 1½ carats, but the quality is said to be superior to the Cape diamonds, and that they are also said to be very suitable for diamond-drills. Up to the time of my visit the Australian company had obtained 1,100 diamonds from their ground. Mr. Barnes, the manager, who has been connected with the diamond mines at Kimberley, in South Africa, for a number of years, has erected machinery for saving these precious stones on the same principle as adopted there. The process is to empty the wash-dirt into a hopper, which carries it into a puddling machine. This machine is 10ft. in diameter, having the outer sides 16in. in height; the inner circle is 3ft. in diameter, leaving the width of the puddling-trough 3ft. 6in. across. The shaft, which stands vertical in the centre of the machine, carries four arms, in each of which are fixed a row of five teeth; the bottom of the machine is made with a slight inclination outward, so that, by the centrifugal motion of the water and slight angle of inclination of the bottom, it keeps the particles of greatest density always on the outside. As the wash-dirt gets puddled and the water thickened it is allowed to run off from the inner edge of the machine, and it goes through a similar puddler below the top one before the sludge is allowed to run away, care being always taken not to allow too much gravel to accumulate in the machine, but to always have the bottom as clear as possible. When the gravel accumulates it is taken out of the machine and put through a revolving screen, which separates the fine grit from the stones. Afterwards the stones are taken away to a table and all hand-picked. The puddling machines are made of steel plates rivetted together, and, when working, the arms carrying the teeth revolve at the rate of about twelve revolutions per minute. The cost of these machines erected is £500, and Mr. Barnes states that they are each capable of puddling 200 loads of stuff in eight hours.

This company have now arranged to lay down a tramway from the mine to the Bingera River, a distance of nearly four miles, and to shift their plant to that place in order to insure them having a constant water supply. When these works are completed they will be able to keep their puddling machinery fully employed.

PART II.

DIGEST OF THE PRINCIPAL IMPROVEMENTS IN CONNECTION WITH MINING, MACHINERY, SCHOOLS OF MINES, ETC.

Having given a description of the mines and plants that I visited, I will now call attention to the several improvements and appliances that would likely be beneficial to the mining community in New Zealand, and tend to further the development of our mineral resources; also to give a synopsis of the system of conducting mining surveys and the organization of the Mines Departments of Victoria and New South Wales, together with the advantages derived from scientific instructions imparted by the schools of mines.

Mining has hitherto been chiefly confined in New Zealand to gold and coal; but I am fully convinced, from what I have seen in New South Wales, that New Zealand is rich in other minerals, such as silver, copper, and tin. The latter mineral would likely be found near the junctions of the granite and silurian rocks; but, at the present time, the greater portion of our mining community is not sufficiently educated with regard to the different characteristics of those minerals and the various forms in which they are found. The same principle is involved with regard to gold in quartz reefs. The gold may be in the quartz associated with other substances, such as sulphur, antimony, lead, and arsenic, which prevents a large percentage of it from being extracted by the ordinary process now adopted, thus rendering a valuable mine almost worthless.

Gold—Quartz Mining.

The gold-saving appliances in Victoria are superior to those in use in New Zealand. The mining companies in the Sandhurst District have the best class of machinery in the colonies, but even it is nothing like perfect. The great wear and tear connected with stamping-batteries will always make it an expensive mode of extracting ores. From what I have recently read in the *Scientific Mining Journal*, published in San Francisco, the mode of treating gold-bearing quartz is superior to that in these colonies.

Crushing Auriferous Ores.

In extracting the gold from quartz there are three principles involved: (1) To have a cheap and efficient method of crushing the stone; (2) to have a simple mode of concentrating the various minerals that are associated with gold; and (3) to have an appliance that will insure perfect amalgamation.

The most complete plants that I saw in Australia were those of the St. Mungo and the South St. Mungo Companies. A plan of the former is annexed (see Drawing No. 9). This plant consists of a crushing-battery of thirty heads of revolving stamps, weighing from 7cwt. to 8cwt. each, lifting from 8in. to 10in. and making 65 blows per minute. These stamps are arranged so that each ten heads can be started or stopped at will by having a counter shaft geared to the engine-shaft and running parallel with the cam-shafts; these are three in number, one shaft to every ten heads of stamps. The counter-shaft runs along on top of the horses on the side of the stamps next the feeding floor, and the cam-shafts at the side next the tables. On the counter-shaft there are spur wheels turned up to pitch line with saw-toothed clutches to take these wheels in and out of gear with those that are on the cam-shafts. The horses and standards of the battery are of an improved design. The horses do not project in front of the stamp-boxes, and therefore leave plenty of working room at the head of the riffle tables. The plummer-blocks for the cam-shafts are cast on the girder portion of the frames and also plummer-blocks for counter shafting.

The discs on the stamp shanks are known as "Watt's Patent." These as well as the cams are all steel-faced. The shoes of the stamps are of white hæmatite iron, and the false bottoms in the stamp box are wrought scrap iron, having the corners cut off. There are brackets fitted on the frames or standards of each battery to carry the water-pipes for supplying the stamp boxes with water, a jet of water falling down opposite to each stamp. At the discharging side of the battery there are cast-iron quicksilver wells attached to each stamp-box; similar wells are likewise at the lower end of the quicksilver and blanket tables. The quicksilver wells are covered with electro-plated copper plates of 12 B W guage in thickness. The crushed material, after passing over the quicksilver tables, goes over the blanket tables and thence into one of Halley's concentrating tables, one of the latter being placed at the end of each blanket table coming from every five heads of stamps, and on those concentrating tables are collected all the pyrites and minerals of a greater density than the crushed sand. These tables work with small cams, which gives them a short jerking motion, having about three-quarters of an inch stroke and making about 140 strokes per minute. At the lower end of each table a strong steel spring is attached which brings the table quickly forward after the cam has pressed it back, thereby causing all the material of greater density than the sand to collect at the upper end, which is a little lower than the place where the sand is discharged. These tables are cleaned out at intervals according to the nature of the stuff; generally once in about two hours. The waste product coming from the end of the concentrating tables is carried by a shoot into a well in which a tailings force-pump is placed to lift the water and waste material to such a height as will enable them to be carried away in shoots to be further treated by cradling, and thence deposited some distance above the dam where the water is stored. The water then flows back to the dam and allowed to settle before it is again lifted to supply the battery. The whole of the machinery is driven by a 22-in. cylinder horizontal steam-engine, fitted with variable expansion gear and one of Tangye's governors. The manager of this battery states that the pyrites collected from the concentrating tables averages from 4oz. to 6oz. of gold per ton.

The saving of pyrites is one of the things that the quartz-mining community of New Zealand should direct its attention to. It will be seen by reference to the tables compiled from statistics, given me by Mr. R. H. Bland, the manager of the Port Phillip Company at Clunes, that the profits derived from the pyrites alone, during a period of seventeen years, amounted to about £4,000 per annum, and that the amount of pyrites in the quartz is only from 1½ to 2 per cent. This saving alone would make some of our mines pay liberal interest on the capital invested. The large amount of pyrites that is in some quartz reefs in New Zealand—for instance, the Invincible Company's mine, at the head of Lake Wakatipu—would pay large dividends to the shareholders, even should the gold obtained by the ordinary process of crushing only pay bare expenses. On my visit there in December last, the whole of the pyrites was running to waste; but I have recently learned that an arrangement has been entered into for three years for a party to work the tailings, the company to receive 15 per cent. of the gold saved as royalty. Professor Black, in one of his lectures he delivered on the goldfields, stated that he made an assay of pyrites from this company's mine, which gave at the rate of 11 oz. of gold per ton, so that by a small outlay this company might greatly enhance the profits. The gold contained in the pyrites cannot be saved by the ordinary process of amalgamation, inasmuch as it is coated with sulphur and arsenic, which prevents it from coming in contact with the quicksilver; even although this material may be ground up to a pulp, the sulphur will always carry off a large percentage of the gold; therefore it is necessary that the pyrites should be subjected to such a heat that will set the sulphur free before the gold it contains can reasonably be expected to mix with the mercury.

Considerable attention was given to this subject by the Victorian Government in 1873, when His Excellency the Administrator of the Government in Council appointed the following persons to investigate and report upon the methods of treating pyrites, and pyrites-vein stuffs, as practised on the goldfields, and to make a recommendation as to the best and most economical system of extracting gold from auriferous pyrites—namely, Robert Malaehy Sergeant, to be chairman; Rivet Henry Bland; J. Cosmo Newbery, B.Sc., &c.; George H. F. Ulrich, F.G.S., &c.; William Sheris, and J. L. Lewis.

These persons framed a series of questions relating to the subject under inquiry, and copies were sent to mine managers and others interested in the treatment of pyrites in the colonies and in Europe, with requests that their replies might be forwarded to the Board. After taking a deal of evidence, and receiving replies from a number of scientific men in Europe, who treated at great length on the various methods adopted in Hungary, Spain, and Portugal, for extracting the various minerals the pyrites contains, and of utilizing the sulphur for manufacturing sulphuric acid, this Board furnished a valuable report, of which the following is an extract:—

"The important question of the best and most economical method of extracting the gold from auriferous pyrites has been fully dealt with, and the salient features carefully set forth in the report.

"Information has been obtained relative to methods in operation in other parts of the world; and one of these, dealing with the waste products, and which for convenience we call 'Claudet's Process,' we deem sufficiently important to warrant a somewhat detailed description. The results obtained by this system may be considered extraordinary, inasmuch as the gold in the stuff treated, though not found in weighable quantity, on assay, nevertheless yields sufficient to more than cover the cost of the operation. Messrs. Foord and Miller, in their evidence, dwell strongly on the merits of this method (the former gentleman terming it *a complete process without waste products*). The special expense of extracting the precious metals by this method is about 6½d. per ton of roasted pyrites, and the net profit about 3s. 6d. per ton, the material operated upon being very poor pyrites, obtained in great part from Spain and Portugal for vitriol manufacturers on account of the sulphur it contains. Mr. Miller, in his evidence, says, 'Should the process prove available here, it would probably give rise to the formation of a new industry in the manufacture of iodine from the seaweeds of the coast.'

"Very little practical attention has yet been given in this colony to extracting other constituents of pyrites, such as silver, copper, nickel, cobalt, and other metals, and also sulphur and arsenic, which from a purely commercial point of view are of vast importance, and capable of adding very materially to the wealth of the colony. Most of the waste products, as they are termed, are such no longer, as their presence has increased the value of, and demand in Europe for, pyrites of all kinds; we have therefore deemed it necessary to dilate at some length on this branch of the subject, from a conviction that any information which tends to open up a new and profitable field of industry is of great use.

"A statement from the annual returns of the Customs Department shows that, from 1869 to 1872, including a period of four years, 1,558 tons of sulphur, valued at £18,528, were imported; and when it is considered that this article could be produced here in large quantities, sufficient not only for our own use but for the supply of other countries, it is time that public attention should be directed to the matter.

"We are fully of opinion that the establishment of large central works for the treatment of pyrites, on the most thorough and approved system, would be a very great advantage to the colony in every respect. Such works would give rise to the foundation of many new industries, besides tending to the production of larger quantities of gold. It would be necessary to establish works in situations easily accessible to railway communication from the goldfields, whence the supply of raw pyrites could be regularly and easily obtained. There could be no objection to the occupation by such establishments of advantageous sites on the ground of injury to public health, as the fumes given off in the process of roasting pyrites would be condensed for the purpose of saving the sulphur and arsenic. The operations to be carried on would be the receipt of pyrites, the extraction of the gold and other metals as well as the sulphur and arsenic contained, the subsequent treatment of the residues, and the preparation of the sulphur, &c., to fit them for the market.

"As portions of the evidence deal with the subject under inquiry in the relation to the effects of pyrites-burning on health and vegetation, and as such evidence has been mixed up with other portions, we have directed the secretary to make a digest of the whole of it. This has accordingly been done, and we think a more ready comprehension of the question will be obtained by reference thereto. Where, however, apparent discrepancies exist, they may be accounted for by the local features in connection with each case. The digest of evidence is subdivided under the following heads:

(*a.*) Advantages and disadvantages of burning pyritous quartz previous to crushing.
(*b.*) Methods of concentration.
(*c.*) Methods of roasting, &c., and evidence as to the best description of furnace.
(*d.*) Amalgamation, including losses of mercury, use of sodium amalgam, &c.
(*e.*) Effects on public health and vegetation, and methods of condensation.

"*Advantages and Disadvantages of Burning Pyritous Quartz previous to Crushing.*

"From the evidence it will be seen that crushing pyritous quartz raw is decidedly the more advantageous method; and on this point the information supplied by the majority of mining managers examined is corroborated by the professional evidence given.

"It is asserted that it would be impossible to thoroughly oxidize the sulphur by burning, and that a lower sulphide would result, which would melt and enclose the fine particles of gold, rendering the subsequent extraction more difficult. Mr. Latta's evidence, which is of a practical nature, is very decisive in regard to the question. He states that roasting has the effect of converting the gold on the exterior of the quartz into globules and covering them with a ferruginous glaze, which is prejudicial to the proper extraction of the precious metal. He has microscopically examined raw and burnt quartz-washings from the lowest blankets, and found most particles of gold in the latter.

"Except in the instances of Messrs. Heywood and Kayser, and the gentlemen examined at Stawell, those of the witnesses who advocate burning do so, not because they believe it to be the more efficacious method, but because there is less wear and tear of machinery, and by such method a greater quantity of stuff can be crushed in the same time; but it will be observed on reference to the Stawell evidence, that barely an appreciable quantity of pyrites (one ton to one thousand tons of quartz) is met with in the main reefs of the district, and consequently little is known there with reference to their treatment. In all cases it is necessary that the cost of fuel be moderate.

"Mr. Heywood considers that many substances are removed during the process of roasting which would tend to interfere with amalgamation, and that the loss of mercury is less. Mr. Kayser thinks that fine gold is run into a globular form during roasting, and is then more easily amalgamated. On the other hand, Mr. John Lewis, the manager of the New North Clunes Company, is very emphatic in his condemnation of burning, for he says: 'I would burn quartz previous to crushing if the pyrites were not to be saved; but if they were needed I would crush raw.' After a careful consideration of this portion of the question, the Board is of opinion that crushing raw is the best method of treatment, except where pyrites are absent; then burning might be adopted, if fuel is easily obtainable, in order to economize wear and tear of machinery in crushing.

"*Methods of Concentration.*

"Dealing with the next question in its natural sequence, we come to the process of concentration (this term meaning, of course, the separation of the various descriptions of pyrites from the crushed material). In one instance the use of shaking-tables is advocated, and in one or two others self-acting jigging machines are regarded as very good; but the great majority of witnesses are in favour of using Borlase's concave buddle, with Munday's patent scrapers. The importance of finding out and directing public attention to the best pyrites-saving machine cannot be over-estimated; and from the information collected in connection with this buddle the Board have deemed it advisable to attach a plan, a section, and a description of the machine to this report, as they believe it the best at present in general use. Some of the gentlemen examined are of opinion that a classification of the sand operated on according to size of grain should be made; but the balance of evidence is to the effect that the use of the buddle renders classification unnecessary, the loss of pyrites not being more than 5 per cent. We are of opinion, however, that classification will ultimately be found beneficial, and must eventually be adopted. An 18ft. or 24ft. machine, making seven or eight revolutions per minute, is recommended.

"*Methods of Roasting.*

"A very important portion of the subject under inquiry, and one which demands great attention, is the best method of dealing with the pyrites after concentration. The evidence on this point is almost unanimously in favour of roasting. One or two witnesses depose to having attempted to extract the gold by grinding and amalgamating raw; but these attempts have almost invariably resulted in a greatly-increased loss both in gold and mercury. The losses occur through the presence of arsenic and sulphur in the material operated upon, causing what is technically termed flouring, by chemical as well as by mechanical action. Mr. Bland, manager of the Port Phillip Company, Clunes, has kindly placed at the disposal of the Board some letters and reports received by him from Dr. Percy and other eminent Home authorities in connection with this difficulty, and copies thereof will be found attached. Some little information has also been obtained relative to the mode of extraction by a metallurgical treatment of the ore, and attention is directed to the evidence of Messrs. Ulrich, Newbery, Quist, Leigh and Moore, relative to this matter; but so little is really known of a thoroughly reliable character regarding it that the Board cannot do more than recommend the process to the notice of persons interested, in the hope that further experiment may demonstrate clearly its actual value.

"It would, however, appear from the evidence that ores containing antimony in large quantities can only be effectually treated by this method. For roasting, reverberatory furnaces, with inclined floors, are almost universally recommended; and, as these appear to be the best at present in general use in the colony, a plan and description of one has been attached to this report. Attention is also drawn to the plan of an inclined cylindrical furnace, on the principle of Hocking and Oxland's patent; the special advantages claimed for this description of furnace over others being on account of the self-acting motion imparted to the pyrites, which motion obviates the continual raking of the "stuff" by manual labour, as at present, and because the gradual presentation of fresh surfaces to the flame is thoroughly and regularly effected. The roasting requires both care and time. It should be carried to the complete decomposition of the arsenides or sulphides, or, in other words, until the arsenic and sulphur are dispelled, and the ores become what is technically called 'sweet.' From twelve to eighteen hours are required for the calcining, the time depending upon the stuff treated, that containing the largest quantity of sulphur and arsenic taking the longest period to calcine. There is a conflict of opinion with regard to the admission of quartz-sand into the furnace with the ores, some of the witnesses asserting that the pyrites should be as pure as possible, as the introduction of quartz causes (in the subsequent process of amalgamation) a great loss of mercury by cutting it up. The balance of evidence is, however, favourable to the introduction of a small percentage of quartz-sand, as tending to keep the charge open, thereby admitting the air, and keeping the pyrites free; or, as Mr. F. B. Miller says, 'to check the agglutination of the particles; for when they have once begun to fuse together it is very difficult, if not impossible, to roast properly.' It must, however, be remembered that none of the present methods of concentration are so sufficiently perfect as to thoroughly cleanse the pyrites, and that in all parcels a small proportion of quartz-sand is found. The evidence is contradictory as to the value of introducing combustible substances, such as charcoal, into the furnace with the pyrites. The majority of practical men examined do not see that any advantages are gained thereby, and they are, to say at the best, of doubtful utility, and decidedly disadvantageous in cases where lead and antimony are present. It is difficult to fix accurately the proportions of fuel required. When wood is used (as is generally the case), much depends on the variety of the timber, the plan of the furnace, and the mode of feeding. As a fair approximate estimate, about one ton of wood to one ton of pyrites may be given. It is not evident that any great amount of care is exercised in feeding the fires, as it was seen at some of the companies' works. The wood was simply thrown on in large logs, and, when almost consumed, fresh fuel added. This is a practice to be condemned, as it causes a waste of fuel and defective roasting, the latter ultimately resulting in a loss of gold and waste of quicksilver. It may be observed that partially-roasted pyrites causes a greater loss of quicksilver than even raw pyrites; therefore the supply at certain intervals of regulated quantities of fuel not only results in a saving of the fuel itself, but insures the more gradual and proper decomposition of the ores. An examination of the various works visited disclosed the fact that far too little attention has hitherto been paid to the regulation of the draught of the furnaces. It is essentially necessary that a steady current of air should be made to pass over the surface of the pyrites under treatment, so as to insure their thorough oxidization. Some systematic and effectual plan should therefore be brought into general operation, by which the regularity of the draught could be insured.

"To summarize briefly the various points embraced in this section of the subject, it appears that careful roasting in reverberatory furnaces, with a thorough draught and a regular and frequent supply of fuel, is the best method of treatment (previous to amalgamation) at present in use in the colony.

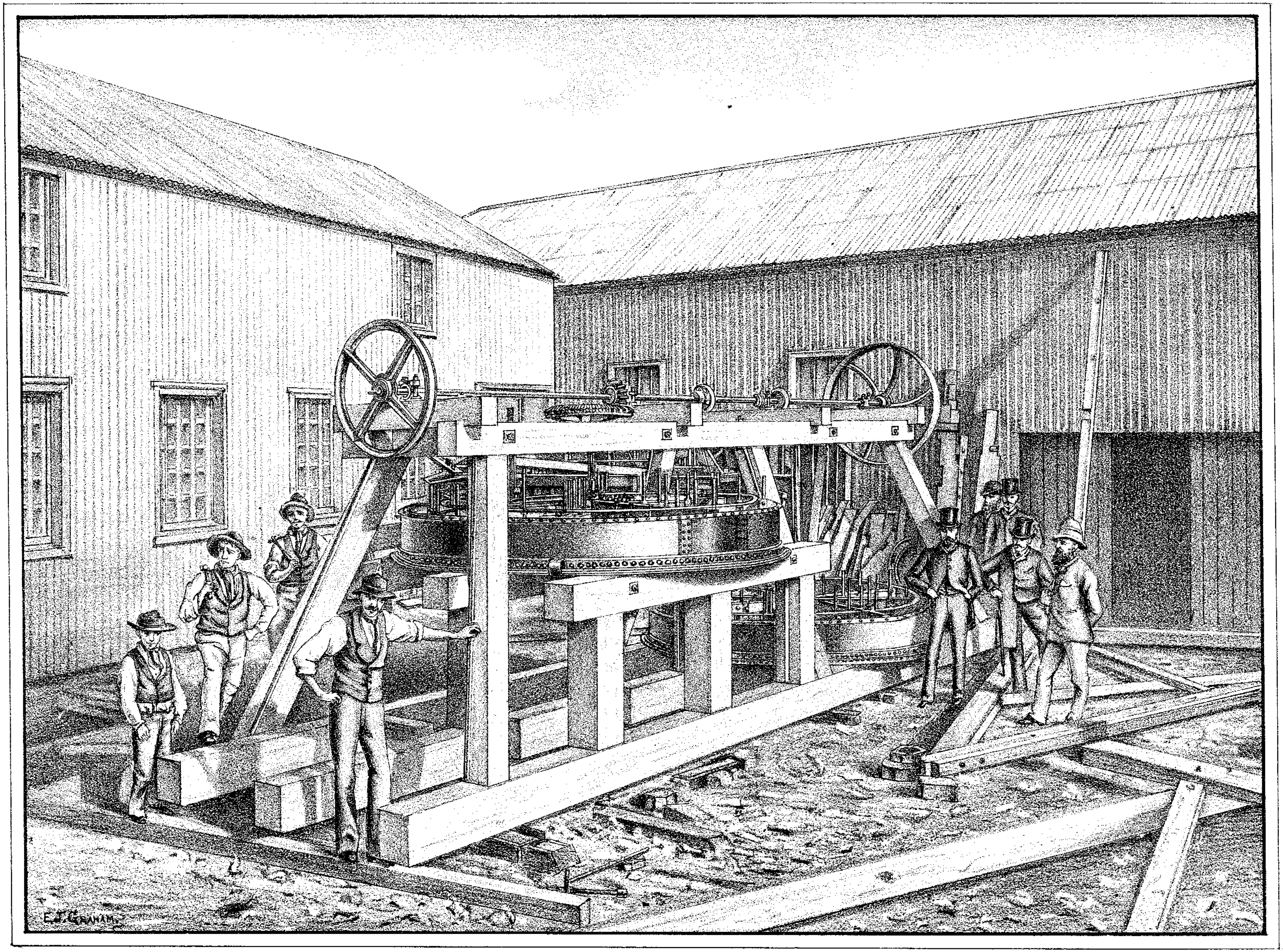
"*Amalgamation.*

"After roasting, the next step in the treatment is amalgamating, which is generally done by grinding the roasted pyrites in Chilian mills, arastras, or Wheeler's pans. After a certain portion of the material is placed in the mills mercury is added, and sometimes certain specifics. (*Vide* Messrs. Ulrich and Newbery's statement attached.) The witnesses are almost unanimous as to the absolute necessity of thoroughly breaking up the quicksilver in order that it may penetrate the stuff operated on, and take up all the gold brought in contact with it. So thoroughly, indeed, should this work be done that, to use the expression of one of the gentlemen examined, 'a pen dipped into the stuff in the mills as into ink should show little globules of mercury.' But these very means which are necessary to secure effective amalgamation also give rise to a form of floured mercury already referred to—in this case brought about by mechanical and not chemical action. The evil is as great, however, in this as in the case where chemical combinations retard the saving of gold, for it appears that during the operation of flushing off part of the floured mercury is carried away with the water and lost. It is found on examination that the loss of quicksilver alone has been as great as 2½lb. per ton of roasted ore treated. This, in addition to a considerable loss of gold as amalgam, renders it evident that if some effectual means of saving both be brought into general use many thousands of tons of tailings now lying unworked, which it would not otherwise pay to operate upon, could be made to yield a considerable profit and open up a large field of labour.

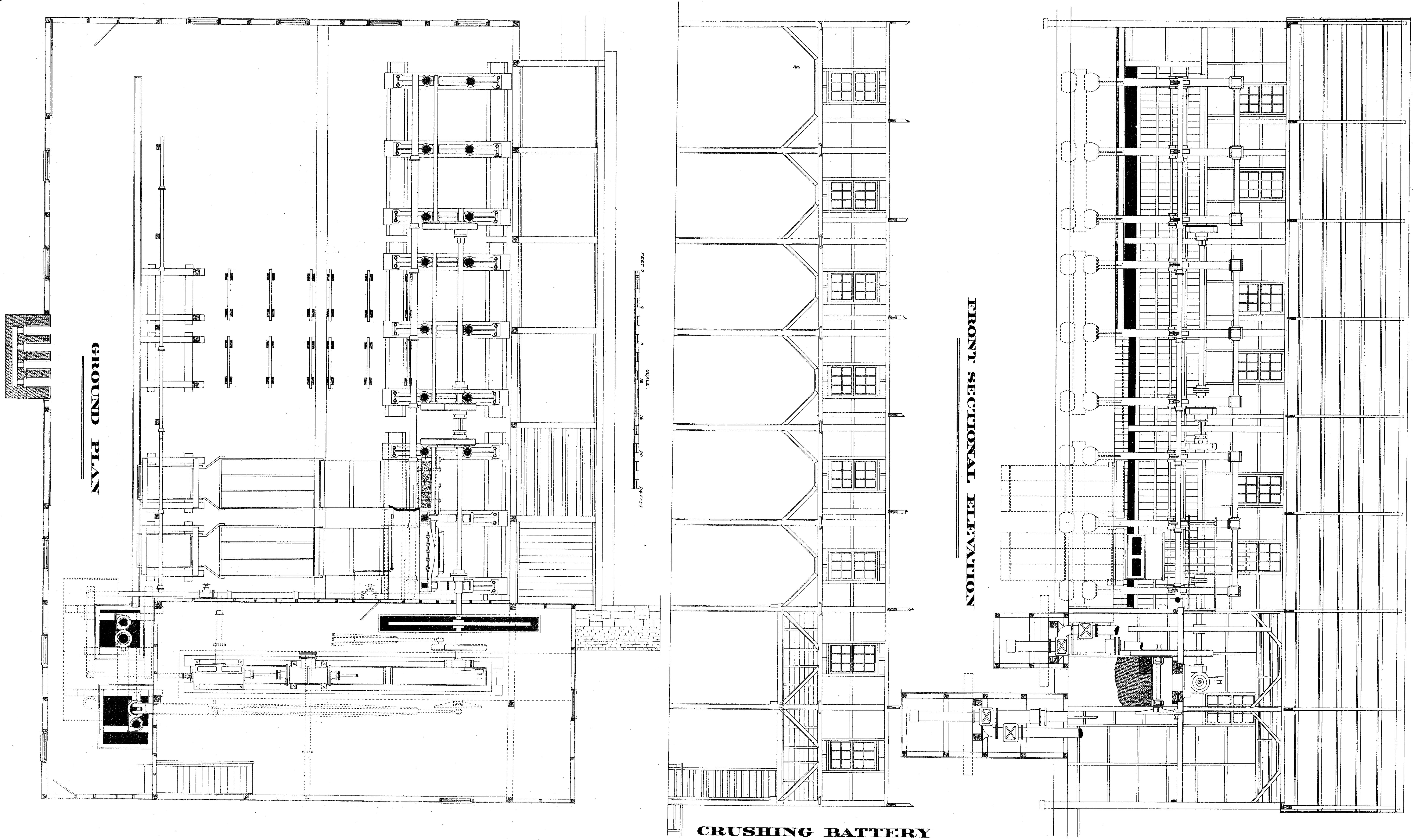
"Some of the gentlemen examined state that they use copper plates, others copper plates and blanket-tables, for the recovery as far as possible of floured mercury. The water is run over these plates and blankets, which retain to a certain extent the particles of quicksilver and gold; nevertheless the loss, even in well-managed works, is still considerable.

"*Effects on Public Health and Vegetation, and Methods of Condensation.*

"It has been a matter of popular belief that the fumes evolved during the process of roasting pyrites are dangerous to health and productive of injury to the surrounding vegetation: on this point the evidence is very contradictory, the witnesses, professional and lay, examined, differing, and their experiences varying greatly. Some of them aver that, with ordinary sanitary precautions, such as washing the body with soap and water, and changing the clothes after work-hours, not the slightest injury is caused to the health of the men employed at the works, and it is stated that no cases of diphtheria have been known to exist in their immediate vicinity. On the other hand, it is alleged that fumes passing over gardens adjacent destroy fruit trees and other vegetation, and the water from the roofs is injurious to health. Where the roofs of houses in the neighbourhood of pyrites works are of galvanized iron, sulphate of zinc is formed by the condensation of the sulphurous fumes; but there is no reason to suppose that arsenical fumes are condensed in this way: on the contrary, there are chemical reasons why water collected on these roofs cannot contain arsenic. It is generally found that complaints are made only against works where no precautions are taken to effect the condensation of the fumes, and it is admitted, where proper condensation is carried out, no injury is occasioned either to health or vegetation. Dr. Bone in his evidence says that when pyrites works were first started at Castlemaine, no means were adopted for the preservation of the public health, and there were undoubted cases of gastric irritation, caused, doubtless, by drinking water from the roofs of houses in close contiguity to the works; that he brought the matter under the notice of the Borough Council, and suggested certain alterations, which were carried out; and since then no further cases of gastric irritation have been brought under notice. He further states,



AUSTRALIAN DIAMOND MINING CO'S PLANT & PUDDLING MACHINERY.
BINCERA.



CRUSHING BATTERY

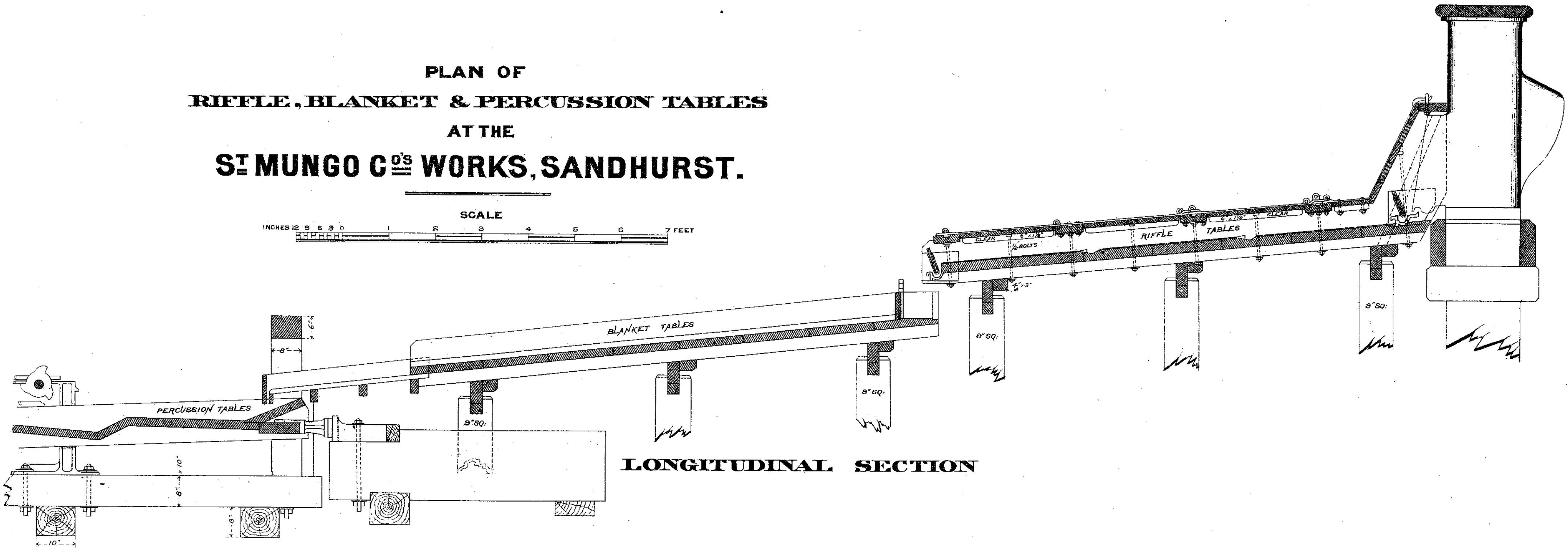
St. MUNGO Coy., SANDHURST.

G. P. WILSON DELT.

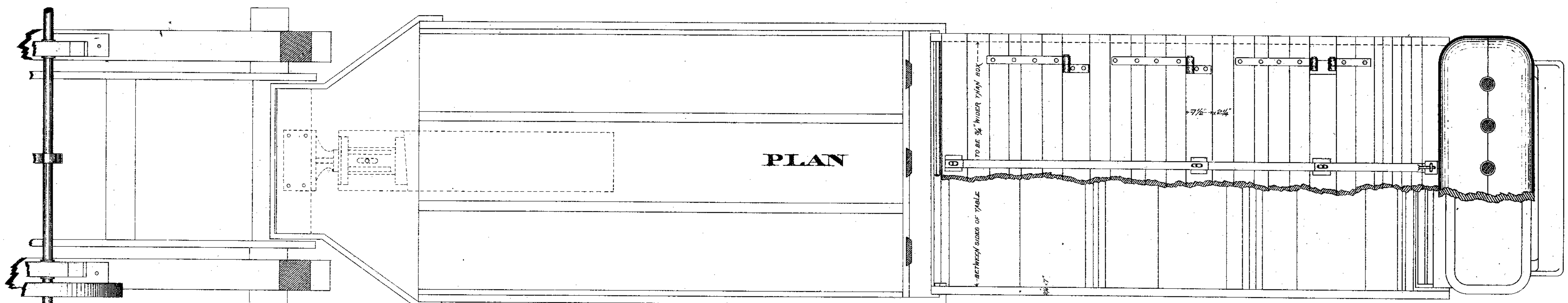
Photolithographed at the General Survey Office, Wellington N.Z. July 1885.

PLAN OF
RIFFLE, BLANKET & PERCUSSION TABLES
AT THE
St. MUNGO Co's WORKS, SANDHURST.

DRAWING No. 9

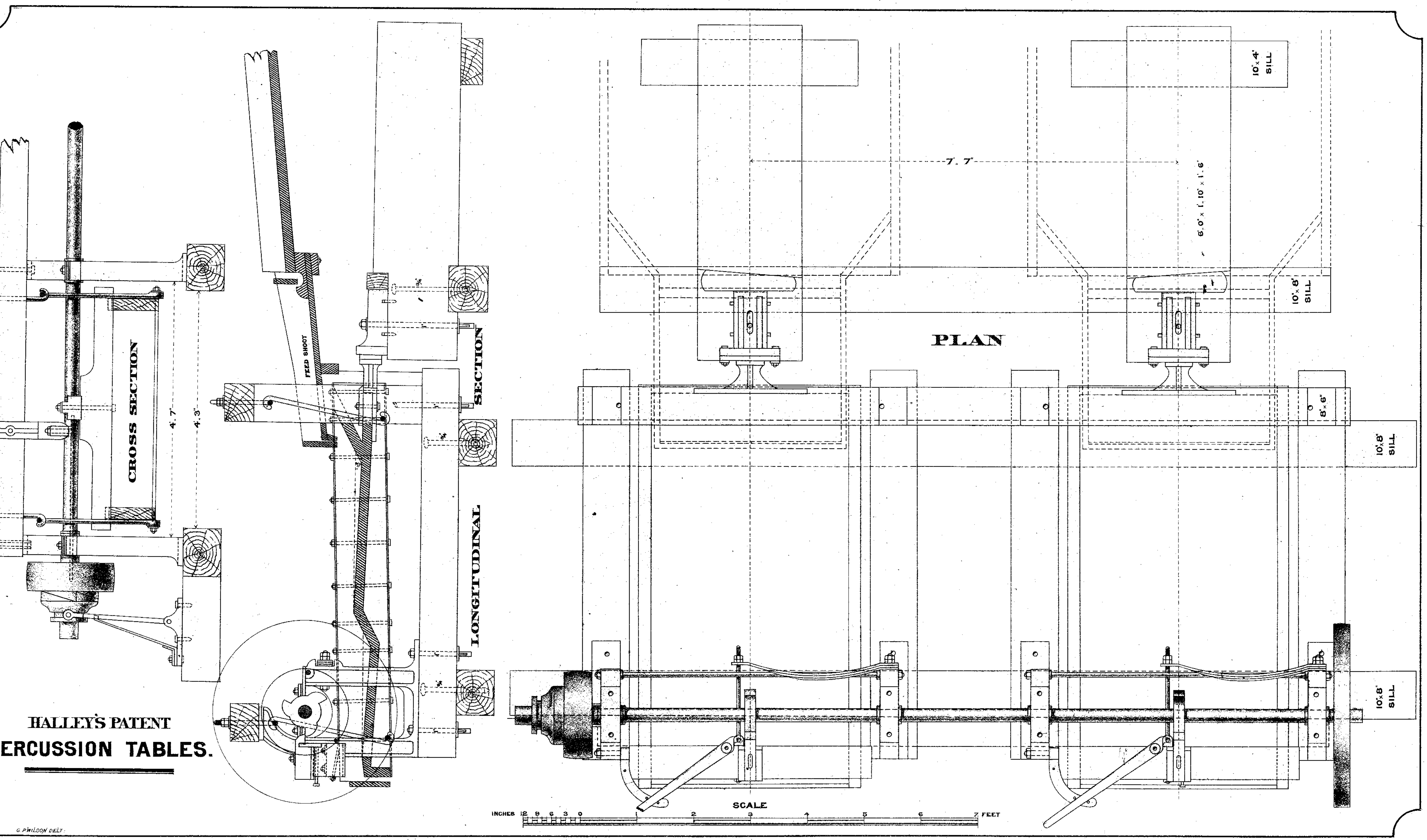


LONGITUDINAL SECTION



PLAN

G.P. WILSON DELT.



HALLEY'S PATENT
ERCUSSION TABLES.
CROSS SECTION
LONGITUDINAL SECTION
FEED SHOOT
PLAN
4'. 7"
4'. 3"
7'. 7"
6'. 0" x 1'. 10" x 1'. 6"
10" x 4" SILL
10" x 8" SILL
8" x 6"
SCALE
INCHES 12 9 6 3 0 1 2 3 4 5 6 7 FEET
G. P. WILSON DELT.

with reference to the complaints of some of the witnesses as to the deleterious effects of the fumes on shrubs and trees, some of the leaves of which were exhibited, that he had noticed precisely the same appearances on the leaves of plants in gardens in the vicinity of Melbourne, which are far removed from any pyrites-treating works. There is no doubt that, if sufficient precautions be taken, little or no injury is done.

"The method of condensation which recommends itself most strongly to the notice of the Board is the introduction of water- or spray-chambers into the flues. The water should be made to play in a series of chambers, the fumes that escape the first being conveyed to the second, and so on, the effect being the gradual purification of the fumes, so that by the time they reach the open air at the mouth of the flue they are rendered comparatively harmless.

"There is some difficulty in dealing with the water after use in the condensing-chambers, as it then carries with it certain proportions of arsenious acid. In one case a suggestion is made that it be got rid of by evaporation, the arsenic remaining being saved; in another, that it be passed through filter-beds of red oxide of iron (the waste from roasted pyrites), which would purify it; in a third, that it be run off into abandoned shafts. The Board cannot make a recommendation, as future experiment only can thoroughly and satisfactorily determine the best method of purification; but so much depends on the local circumstances of each case that it may be advisable to adopt one of the plans suggested in one case where it would be impracticable in another. Care should, however, be taken to prevent such water from being allowed to flow into any source of domestic supply.

"*Summary of Recommendations.*

"We may briefly summarize the result of our inquiries as follows:—

"(1.) That it is decidedly better to crush quartz containing pyrites raw.

"(2.) That the method of concentration which has given the most satisfaction in this colony is the use of Borlase's buddles, with Munday's patent scrapers.

"(3.) That it is absolutely necessary to roast pyrites previous to amalgamation, and for this purpose reverberatory furnaces with inclined hearths are the best at present in use in the colony; that the introduction of combustible substances with the charge is not advisable; and that attention should be given to the regular supply of fuel and to the proper regulation of the draught.

"(4.) That for the purpose of amalgamation Wheeler's pans and Chilian mills are both very efficient; but, owing to the inability of the Board to obtain analysis of the waste from each description of machine, the comparative saving values cannot be determined

"(5.) That the evil effect of the noxious fumes on health and vegetation are not at all great, and can be easily and wholly avoided by the use of water-condensers in conjunction with suitable flues and high chimney-stacks; and that the water used in condensing be disposed of in the most effectual manner that the local features in each case admit.

'(6.) That it would be very advantageous if large central works were erected for the thorough treatment of pyrites and the whole of the waste products thereof; and that encouragement should be given by the Government, either by the way of bonus or suitable site, to the person or company first establishing such works.

"*Concluding Remarks.*

"The importance of dealing with the waste product of pyrites cannot be too highly estimated. Tens of thousands of pounds are annually lost to the country by the non-existence of such establishments as are advocated; but we unhesitatingly recommend, rather than this annual loss should be borne, Government assistance be given to any person or company first establishing central and efficient works for the proper treatment of the whole of the commercial products of pyrites on a large scale. Such assistance should be given subject to such conditions as may be deemed necessary to secure a permanent establishment of the works advocated. In connection with this matter, it is regretted that the Government do not see their way clear at the present time to comply with the request made by the Board for a sum of money for making an analysis of samples, as already set forth in the sixth paragraph of this report; as by this means the actual value of samples of waste from all the gold-fields where pyrites are treated could have been in some degree determined, and the commercial value of the product so obtained would have formed a reliable basis for estimating the cost of and profit on operations if conducted on a large scale. From Mr. Newbery's evidence it will be seen that a sample of antimonial ore from Costerfield was found to contain no less than twelve different metals, some of which could be easily utilized at a small cost. We regret we are not in a position to deal with this portion of the subject so fully as its importance deserves, as we confidently believe that new industries would be established and many valuable articles of commerce ultimately produced from this source; and we venture to express a hope that the Government will not lose sight of the desirability of carrying out our suggestions in this matter."

The following account, given with reference to the extraction of gold and silver from copper pyrites, is from Fred. Claudet, *Annales de Chimie*, Quatrième Série, November, 1872, T. XXVII., p. 407:—

"English manufacturers draw the greatest part of the pyrites they employ in making sulphuric acid from Spain and Portugal. As they all contain more or less copper, the residues, after the extraction of the sulphur, are sold to the copper-smelters, who, on account of the large quantity of oxide of iron they contain, employ them as a flux for siliceous copper ores. In the operation they recover the copper from the pyrites, but all the iron passes into the slags. The extraction of copper from minerals by the humid method, first practised by Longmaid, and since applied by W. Henderson to the treatment of pyritous residues, does not give rise to this loss of the iron of the pyrites. This mode of treatment is now much used, in consequence of the increasing importation of these pyrites, which has risen from four hundred thousand to five hundred thousand tons annually, and continues to increase. The pyrites are sold according to the amount of sulphur and copper they contain. The manufacturers, who only buy them for the sulphur they contain, sell the roasted mineral to works at which the copper is extracted. Such an establishment has been founded by F. Claudet and J. A. Philips, at Widness, near Liverpool.

"Spanish and Portuguese pyrites vary little in their composition. The following is a fair average from the mines of San Domingo, which furnish about half the pyrites used:—

"Sulphur ...	49·00
Arsenic ...	0·47
Iron ...	43·55
Copper ...	3·20
Zinc ...	0·35
Lead ...	0·93
Lime ...	0·10
Water ...	0·70
Quartz residue ...	0·63
Oxygen and loss ...	1·07
	100·00

"In the last item (1·07) are comprised traces of a great number of metals.

"These pyrites, after being roasted in the manufacture of sulphuric acid, form the material treated for the extraction of copper. They contain, with slight variations—

"Sulphur ...	3·76
Arsenic ...	0·25
Iron ...	58·25
Copper ...	4·14
Zinc ...	0·37
Cobalt ...	Traces
Silver ...	Traces
Lead ...	1·14
Lime ...	0·25
Insoluble residue ...	1·06
Water ...	3·85
Oxygen and loss ...	26·93
	100·00

"The traces of silver amount to from 20 to 28 grammes per ton, according to assay, and can be extracted with profit by the process now to be described.

"The pyritous residues are first pounded and sifted, and are then roasted in a reverberatory furnace, at a very low temperature, with chloride of sodium. The oxidation of the metallic sulphides and the decomposition of the chloride of sodium which follows give rise to the formation of sulphate of soda and soluble chloride of copper. When it is found by assay that the mineral has been sufficiently roasted, and has become cool enough, it is placed in a large wooden tub with a double bottom, forming a filter, and is several times washed with water slightly acidulated with H. Cl. until the copper is removed. The insoluble residue remaining in the tub consists almost entirely of oxide of iron, and has about the following constituents, according to analysis:—

"Sesquioxide iron ...	96·20*
Sulphate of lead ...	0·86
Copper ...	0·18
Cobalt ...	Traces
Alumina ...	0·45
Lime ...	0·46
Soda ...	0·10
Phosphoric acid ...	0·00
Arsenic acid ...	Traces
Sulphuric acid ...	0·49
Sulphur ...	0·16
Chlorine ...	0·03
Silica ...	1·22
	100·15

"This oxide of iron, on account of the uniformity of its composition, is sold to the ironworkers, where it is used with advantage to line the puddling furnaces. The washings from which the copper has to be recovered are poured into other tubs previously supplied with pieces of iron. Chloride of iron is thus formed, and metallic copper precipitated, taking with it the small quantity of silver contained in the liquid. The precipitated copper is then melted and refined, to bring it to the state of merchant copper. The liquid from which the copper has been separated still contains salts of iron and the alkalies, which are lost; but, in the subsequent operations adopted in our works, we obtain on the one hand sulphate of soda nearly absolutely pure; and, on the other, oxide of iron in a state of very fine division, suitable for polishing glass. The liquor, before the precipitation of the copper by the iron, contains, as stated, silver dissolved in the state of chloride. This cannot be extracted by precipitation with metallic copper, for, the silver being soluble in a mixture of chloride of sodium and bichloride of copper, the precipitation cannot take place until all the bichloride is reduced to the state of protochloride by the metallic copper added. Then the most minute quantity of silver is wholly precipitated by the excess of copper, but also with some protochloride of copper,

* = iron, 67·35.

which the chloride of sodium is no longer able to hold in solution. It is necessary, therefore, to have recource to a further separation, the cost of which more than absorbs the value of the silver. This process is of no economic value. There is another method of separating the silver from the copper, which consists in converting the precipitate into sulphate of copper, but, as the market for this is limited, this method is only applicable to a limited extent.

"After much research, I have arrived at the following mode of separation. It is founded on the fact that iodide of silver is nearly insoluble in solution of chloride of sodium at ordinary temperatures.

"The mineral roasted with common salt undergoes, as has been before stated, several successive washings, but only the first three waters contain a notable quantity of silver.

"We have found by experience that the two first waters contain about 80 per cent., and the three first 95 per cent., of the total quantity of silver dissolved. According to analysis of one of these waters, marking 1·24 on the areomètre, a cubic metre of this liquor contains:—

	Grammes.
"Sulphate of soda	144·171
Chloride of sodium	63·914
Chlorine (in combination with other metals)	66·143
Copper	52·855
Zinc	6·857
Lead	0·571
Iron	0·457
Lime	0·743
Silver	0·0437
	335·7547

"Minute quantities of arsenic, bismuth, and other are omitted in this analysis. The above is only given as an example, for the silver here given as 43·7 grammes varies in our operations from 25 to 75 grammes to the cubic metre, according to the richness of the mineral and the degree of concentration of the liquors. We only employ the first three washings. These are poured into a wooden cistern, and allowed to remain till the solid matters in suspension settle; and, in order to employ the quantity of iodide absolutely necessary, we commence by determining the quantity of silver contained in the liquor. To effect this, a given quantity is taken and diluted with water; a little hydrochloric acid is added, to retain the copper in solution; then a weak solution of iodide of potassium is added drop by drop, which converts the soluble chloride of silver into insoluble iodide; at the same time, by the addition of a solution of acetate of lead, we throw down a heavy plumbic precipitate, which entangles all the silver. This precipitate is dried and melted with a flux, with addition of metallic iron. The resulting lead button is cupelled, and the quantity of silver held in the liquor thus determined. The clear assayed liquor is then run into another vessel, where the quantity of iodide of potassium shown by the assay to be required is added, diluted with a quantity of water equal to about one-tenth of the cupreous liquor. The whole is then agitated, and afterwards allowed to settle for forty-eight hours. The supernatant liquor is then clear. This is drawn off, and the vessel again filled for a fresh operation, and so on (the iodide of silver not being quite insoluble, about 5 grammes to the cubic metre remain in solution and pass into the copper). After every fiftieth charge, the accumulated deposit is collected. It consists principally of sulphate of lead, iodide of silver, and salts of copper: the latter are easily separated by a washing with weak hydrochloric acid. The deposit, thus freed from copper, is decomposed by metallic zinc, which, in presence of water, rapidly and completely reduces the silver, with the formation of soluble iodide of zinc. The following are the products:—

"(1.) Soluble iodide of zinc, which is filtered off, and, after 'tritration,' is used instead of iodide of potassium in the subsequent operations to precipitate fresh quantities of silver.

"(2.) A deposit, rich in silver, composed in great part of lead in the state of metal and of sulphate of lead, besides several other substances. The following assay of a dried sample will give an example:—

"Silver	5·95
Gold	0·06
Lead	62·28
Copper	0·60
Oxide of zinc	15·46
Oxide of iron	1·50
Lime	1·10
Sulphuric acid	7·68
Insoluble residue	1·75
Oxygen and loss	3·62

"This analysis shows that all the iodine of the iodide of silver has combined with the zinc and become soluble, since the deposit does not contain any, or only traces. The gold appears here for the first time. It must have existed in the mineral, and it would appear that, in the operation of roasting, chloride of gold is formed, which, rendered more stable by the presence of chloride of sodium, is not reduced at the low temperature of this roasting. This chloride therefore enters into solution with the silver, and is precipitated with it by the iodine. It is now easy to separate from these products the precious metals by the ordinary processes of fusion for matters containing gold and silver.

"During 1871 we operated on 16,300 tons of roasted pyrites, from which we extracted—gold, 3,172 grammes; silver, 333,242 grammes—being a little more than 20 grammes of the precious metals to the ton, which produced 80,800 francs, after deducting cost of melting and refining. The special expense of separation of the precious metals is about 10,400 francs; in this is included 137 kilogrammes of iodine, representing the loss of this substance, and 1,900 kilogrammes of zinc. It is remarkable that the gold, which is not present in the mineral in weighable quantity, should be sufficient, nevertheless, to cover all the cost of the operation. The cost of the iodine, always high, has become much more considerable by the abnormal increase of the cost of this substance. This has called my attention to the use direct of the washings of the 'vareech'-ash instead of iodide of potassium, and recent experiments in this direction have answered our expectations. Not only are we able by this means to utilize all the iodine contained in this varech, of which a great part, as is well known, is usually lost; but, also, these trials have suggested the idea of an inverse operation, on which I am engaged, for manufacturing iodine, which consists in precipitating this metalloid from the washing of the varech-ash by means of a salt of silver. This separation of 20 grammes of precious metals to the ton of burnt pyrites is doubtless small; but when we reflect that in England alone the operation can be applied to 340,000 tons of mineral, and produce thus, with a proportionally increased profit, 7,200 kilogrammes of precious metals, of a value of 1,700,000 francs, we shall see that such an annual result should not be neglected. The above process can also be employed for various cupreous minerals capable of treatment by the wet method, and we are beginning to apply it to the copper ores of Cornwall, which contain generally more silver than Spanish pyrites, and which at present are only worked by the dry method, and for the extraction of their copper only."

"To the directors of the Port Phillip and Colonial Gold-mining Company.

"GENTLEMEN,— Metallurgical Laboratory, School of Mines, London, 23rd June, 1862.

"In accordance with your instructions, I have carefully considered the question, how to diminish as far as practicable the amount of gold which escapes in the tailings. I have made numerous experiments upon this subject, and I have now the pleasure of communicating to you such of the results as seem to justify a positive conclusion.

"From the letter of Mr. Bland, of (no date), it appears that the chief difficulty with which he has to contend is the treatment by amalgamation of the matter of which you have sent me a sample, under the name of 'Pyrites and iron from blankets;' and he then writes, 'The remainder of the gold (about 10oz.) is caught upon the blankets with the pyrites and a portion of the sand; and it is this fine gold, associated with the tailings, that Dr. Percy wants to experiment with chemically, the separation from which is our present difficulty.' I have accordingly devoted my attention to the examination of this matter (which I will call blanket-stuff) with a view to the removal of this difficulty.

"*Nature of Blanket-stuff.*—It consists essentially of finely-divided metallic iron derived from the stamp-heads, iron pyrites, and arsenical pyrites, together with a small proportion of siliceous sand.

"(*a.*) *Metallic Iron.*—This may be readily and completely separated by a magnet. Three experiments were made to determine the amount of iron which might be thus extracted, and the results are as follow:—

"No. 1.	... ...	Iron separated, 45·72 per cent. of the blanket-stuff
No. 2.	... ...	Iron separated, 45·72 per cent. of the blanket-stuff
No. 3.	... ...	Iron separated, 49·20 per cent. of the blanket-stuff
Mean	... ...	46·90 per cent. of the blanket-stuff

It might be supposed that some gold would adhere to this finely-divided iron, and this supposition was confirmed by experiment. One ton of iron retained 1oz. 8dwt. 18gr. of native* gold. This proportion is doubtless very small in relation to the total amount of gold in the original crushed; but in the reports which I have received from you there are no data from which this relation can be readily completed.

"*Iron Pyrites.*—The residue, after the separation of the metallic iron by the magnet, consists almost entirely of iron pyrites and arsenical pyrites, which contained 0·083 per cent. of native gold —that is, 27oz. 2dwt. 12gr. to the ton.

"Experiments were now made to determine whether the gold might not be completely extracted by amalgamation from the pyrites of the blanket-stuff after the separation of the metallic iron by the magnet. The results are as follow:—

"*On the Extraction of the Gold from the Raw or Unroasted Pyrites.*—The stuff was mixed with water to the consistency of thick mud, so that the mercury might be uniformly distributed in fine globules through the mass. After the addition of the mercury the whole was saturated from time to time during about twenty-four hours. The mud was afterwards diluted with water, and again triturated at repeated intervals. It will be perceived that the most favourable conditions were presented for the action of the mercury.

"First experiment. — Gold separated, 8oz. 14dwt. 17gr. per ton of iron pyrites. Second experiment.—Gold separated, 8oz. 10dwt. per ton of iron pyrites. Thus only about one-third of the gold was extracted by the mercury.

"*On the Extraction of the Gold by Amalgamation from the Roasted Pyrites.*—The roasting was carried on until sulphurous acid ceased to be evolved. The amalgamation was conducted with the precautions above described.

	Oz.	dwt.	gr.	
"First experiment. — Gold extracted by amalgamation	24	16	13	per ton of iron pyrites
Second experiment. — Gold extracted by amalgamation	25	1	3	per ton of iron pyrites
Mean	24	18	20	

The residue after amalgamation retained of gold 16dwt. 8gr. per ton of iron pyrites.

* Gold containing silver, as it occurs in nature in an auriferous quartz

"The preceding results demonstrate—First, that, even when the process of amalgamation is conducted under the most favourable conditions not more than about one-third of the gold can be extracted from the raw blanket-stuff previously freed from the metallic iron by the magnet; second, that when the process of amalgamation is conducted under similarly favourable conditions, nearly the whole of the gold can be extracted from the completely-roasted blanket-stuff.

"Experiments were made to determine whether, after rendering the pyrites magnetic by partial roasting, and then separating the magnetic portions by the magnet, any and what portion of gold would be removed along with the magnetic portion from the partially-roasted pyrites. The roasting was conducted so as to render nearly the whole of the stuff magnetic, and in small experiments there is no difficulty in securing this result:—

"First experiment.—The pyrites, rendered magnetic and separated by the magnet, contained of native gold 10oz. 16dwt. 21gr. per ton of iron pyrites. The residual sand contained of native gold 17oz. 18dwt. 16gr. per ton of iron pyrites. Total native gold, 28oz. 15dwt. 13gr. per ton of iron pyrites.

"Second experiment.—The residual sand, after separation by the magnet of the portion rendered magnetic, contained of native gold 20oz. 7dwt. 1gr. per ton of iron pyrites.

"Third experiment.—The residual sand, after separation, &c., contained of native gold 20oz. 12dwt. 6gr. per ton of iron pyrites.

"Fourth experiment.—The stuff was reduced to a finer state of division. The pyrites, after separation, &c., contained of native gold 14oz. 12dwt. 1gr. per ton of iron pyrites. The residual sand contained of native gold 15oz. 18dwt. 19gr. per ton of iron pyrites. Total gold, 30oz. 10dwt. 20gr. per ton of iron pyrites.

"No experiments have been made on the blanket-stuff containing the metallic iron. I do not, however, apprehend that the presence of this iron would be injurious; but, if it should, there would not, I think, be any practical difficulty in economically effecting its removal by means of an electro-magnetic arrangement under the blankets. It would be easy to contrive a simple, effective, and inexpensive apparatus to accomplish this object in every respect satisfactorily. Our electro-magnetic arrangement, it is stated, has been adopted with success in Italy for the separation of magnetic oxide of iron from certain ores.†

"It occurred to me as possible that by rendering the pyrites as far as practicable magnetic by roasting, and then separating the magnetic portion, the gold might be left in the residue; but the preceding experiments show that this is not the case.

"I do not think it necessary to communicate the results of numerous and varied experiments which I have made concerning the extraction of gold by liquid reagents. So long ago as 1848 I presented to the British Association a paper on the subject, which was subsequently published in the *Philosophical Magazine* for 1850. I have recently experimented on the Australian quartz-tailings, with a view to the application of liquid reagents for the separation of the gold; and the conclusion at which I have arrived, and which is strengthened by the opinion of Mr. Bland, is that, however applicable processes founded on this principle might be in England, they would be difficult of application at present in Australia, and would probably be unremunerative.

"I would observe that the results of the experiment on the application of liquid reagents to the extraction of gold from its ores, which I communicated to Mr. MacDonnell some time ago, are the identical results of Mr. Daintree to which Mr. Bland refers. They were obtained in the metallurgical laboratory of the School of Mines by Mr. Daintree, under my direction. As far as I am able to form a judgment from experiments on a small scale, I should say that the best thing to be done is simply to roast the blanket-stuff completely, and subject it afterwards to careful amalgamation. This would involve no change of system and no expensive outlay, and the roasting might, I think, be conducted with a very small consumption of fuel, as the stuff itself contains much combustible matter. You may, perhaps, be disposed to regard this suggestion as so simple as to be superfluous; but I would beg to remark that in practical metallurgy many very important results have flowed from apparently the most trivial changes. I do not pretend that there is any novelty of principle in this suggestion. I have simply to express my opinion that it is the best thing to be done under the circumstances.

"I should, however, wish to speak with a certain amount of reservation. My experience of metallurgical operations on the great scale has brought me to be cautious in proposing alterations or innovations founded merely on experiments on the small scale. But you have in Mr. Bland a manager who evidently well understands his subject, and I should be disposed to rely with confidence on his judgment as to the value of any schemes which may be proposed for your adoption. He has great experience, and knows all the possible conditions of the country, of which I must be comparatively ignorant. "I have, &c.,

"JOHN PERCY."

JOINT REPORT BY MESSRS. ULRICH AND NEWBERY.

Effect of Fumes on Vegetation.

"There can be no doubt that sulphurous, sulphuric, and arsenious acid vapours given off from roasting pyrites will destroy vegetation. The country adjacent to all the great metallurgical works of Europe is destitute of vegetation, though of late years the damage has been diminished, owing to attempts being made to condense the fumes. The chief cause of damage is the sulphurous and sulphuric acid. These acid vapours are condensed on the surface of leaves, causing spots and stains, ultimately destroying them and in time killing the plant.

"In the neighbourhood of pyrites works all damage to vegetation will of course be credited to the fumes and not to other causes. The dark stains and mildew-like coating are quite as prevalent in districts where no sulphurous acid fumes exist as they are in some of the mining towns where

† I have received a pamphlet on this subject from Signor Gabau, Italian Commissioner at the International Exhibition.

there are furnaces in constant work. Even by careful examination it is often very difficult to determine whether the spots are due to the action of acid vapours or parasites. Leaves from plants near the Castlemaine works showed spots of a dark-brown, almost black, colour, with and without an encircling parasitic growth; and leaves from plants growing in the suburbs of Melbourne were found in exactly the same condition. Spots made on leaves by applying dilute acid were without any encircling parasitic growth, though allowed to remain on the growing plant for several weeks.

"Some experiments made since this inquiry began show that in a moist warm atmosphere sulphurous acid has comparatively very slight effect on the leaves of plants. When the atmosphere is cooled the moisture condenses on the leaves in drops, each to a certain degree charged with sulphurous acid, which then begins to act on the plant, chiefly, it seems, by the sulphurous acid being gradually converted into sulphuric acid, which, being concentrated by the evaporation of the moisture, destroys the portion of the leaf on which it rests.

"*The Action of Fumes on Iron Roofs.*

"The fumes from roasting pyrites attack the zinc on moistened galvanised iron, forming sulphate of zinc. Dry zinc is not attacked by the fumes.

"Several samples of water from the galvanized iron roofs of houses near pyrites works have been tested in the Technological Museum laboratory, all of which have been found to contain sulphate of zinc in quantity, but only very minute traces of arsenic. The first water from these roofs, after periods of heavy dews, should be allowed to run to waste, and not stored for domestic purposes.

"*Poisonous Waters from Condensers.*

"Numerous methods may be suggested to remove the acids dissolved in the water flowing from the condensers; but their adoption will depend on local circumstances.

"1. Where motive power can be cheaply applied a pump might be arranged so as to continually use the same water in the condensers. The arsenious acid would gradually deposit from the water as the solution became concentrated, or it could be wholly removed by sulphuretted hydrogen, generated by the action of the acid waters on sulphide of iron in a covered tank; a pipe from the tank to the furnace would convey the excess of gas away so that it might be burnt and cause no nuisance.

"2. By filtering through hydrous oxide of iron and lime in layers.

"3. By running the water into abandoned workings.

"4. By converting the sulphurous acid into sulphuric in lead chambers, and removing the arsenic from the sulphuric acid by sulphuretted hydrogen, as in 1. Owing to the inferior quality of the acid produced it is doubtful whether the manufacture of acid for commercial purposes would be profitable; but were large works established for treating pyrites the acid formed would be required for the economical treatment of the ore.

"*Loss of Mercury, &c.*

"In a series of laboratory experiments, we find that partially-decomposed iron pyrites causes more 'flouring' of mercury and consequent loss than undecomposed pyrites, arsenical pyrites more than iron pyrites, and sulphide of antimony more than arsenical pyrites.

"We have failed to unite the globules of mercury, divided by sulphide of antimony, by the use of sodium amalgam or other specific, but found the globules more readily collected on an amalgamated zinc surface in the presence of weak acid than in any other way. A large number of specifics have been suggested to assist amalgamation and prevent loss of mercury and amalgam, among which maybe mentioned—

"1. *Sodium Amalgam.*—Found to be useful in keeping the surface of the mercury bright and quick, causing it to adhere easily to copper plates, and in collecting floured mercury and preventing its 'flouring.' When the method of using sodium amalgam is more thoroughly understood, it will probably come into greater use: at present many find fault with it for collecting base metals, and for causing a loss of mercury; this latter is probably owing to their allowing the sodium to be all converted into soda.

"2. *Solution of Soda.*—The surfaces of the particles of gold sometimes resist the action of mercury, and appear to be greasy, through what cause cannot be explained; but if they are rubbed with mercury in a solution of soda they are soon amalgamated. It is sometimes used in Chilian mills and in pans: it keeps the mercury-surface clear.

"3. *Solution of Potash,* same as soda.

"4. *Lime* has somewhat the same effect as soda and potash. The amalgamator collects better in an alkaline solution, which keeps the surface of the particles clear.

"5. *Cyanide of Potassium* keeps the mercury bright and clear; prevents flouring.

"6. *Sulphate of Copper.*—Laboratory experiments show no advantage from amalgamating in the presence of this salt.

"7. *Sulphate of Iron,* same as sulphate of copper.

"8. *Common Salt,* same as sulphate of copper.

"9. *Nitre,* same as sulphate of copper.

"10. *Sulphuric Acid* tends to keep the mercury bright, and to collect floured mercury. In this respect it appears to act better than either nitric or hydrochlorine acids.

"With the exception of sodium amalgam, none of the so-called specifics can be applied except in amalgamators, such as the Chilian mill, Wheeler's pan, or arastra.

"*Burning Pyritous Quartz.*

"As regards the burning of the pyritous quartz previous to crushing, we consider it very disadvantageous, for the following reasons:—

"1. Supposing the stone only to contain true pyrites (species free of galena), the burning, however carefully conducted, would not effect a thorough roasting of the pyrites, but produce, as it were—and as can be observed on examination of kiln-burnt mineral—three different stages. One part of it, in the centre of the larger quartz-fragments, is generally but little affected; another par s converted into a lower or mono-sulphide, which, in contact with clayey and siliceous dust, producest hard, glassy slag-coatings on the outside of the stone. The third part, that on the surface of fragments freely exposed to the access of air during burning, is well roasted—*i.e.*, converted into powdery sesquioxide of iron, with its originally-contained gold disseminated through it in microscopical particles. Now, on subsequent crushing and amalgamation of the burnt mineral, the gold of the slightly-affected pyrites cannot, or but very imperfectly, be extracted by the common amalgamating appliances (deep quicksilver troughs, amalgamated copper plates, &c.), whilst that distributed through the monosulphide of iron, the hard slag-coatings, and the iron sesquioxide is to a great extent lost—that of the first body through being too much enveloped, and the monosulphide itself being besides liable to sicken the mercury; that of the hard slag-coating through being glazed over, and is generally with very great difficulty liberated; and, finally, that of the well-roasted mass, on account of its finely-divided state, which renders it liable to be carried off by the stream of water without its having even come into contact with the mercury.

"2. Should the stone contain galena in association with pyrites, not only would the loss of gold be considerably increased, but quicksilver would be lost in notable quantities; the cause of this being the partial reduction or conversion of the galena in contact with the burning fuel into lead, a metal which, as is well known, strongly sickens the mercury. Of course all depends upon the quantity of pyrites and galena contained in the quartz. If this amounted to less than 1 per cent., rendering concentration not profitable, the burning of the quartz previous to crushing would, like that of stone containing no pyrites at all, be advantageous on account of the much easier reduction of the burnt stone, and consequent diminished wear and tear of the crushing machinery. It must, however, be remarked that with any ferruginous quartz there would also be a likelihood of the formation of the above-noted hard slag-coatings over the surface of the fragments, consequently liability to loss of enveloped fine gold particles during crushing.

"*Metals found in Pyritous Quartz.*

"Besides gold and silver, the sulphides or 'pyrites' found in the auriferous-quartz veins contain other metals, some of which might be economically saved as by-products in a large establishment. At Maldon the pyrites of many of the reefs contains a very considerable quantity of copper, some assays reaching as high as 19 per cent. Others in the same district contain bismuth as sulphide, native metal, and as a native alloy with gold. The other districts are much the same. Nearly all samples of massive pyrites have been found to contain a notable amount of copper, and in many an amount of silver not in alloy with gold. The grey antimony ore of Costerfield was found to contain no less than twelve metals besides antimony—namely, gold, silver, copper, lead, arsenic, bismuth, cadmium, zinc, manganese, chromium, cobalt, and iron. At Dunolly, Burke's Flat, and St. Arnaud the pyrites contain a large quantity of argentiferous galena.

"*Methods of Treatment.*

"Where the mineral to be treated is chiefly a mixture of iron, arsenical, and copper pyrites, the simple addition of salt (chloride of sodium) in the reverberatory furnace will be found to render the copper and silver soluble in water. Particulars of the methods of treatment of the solution will be found in most of the recent metallurgical works. One ingenious method by which salt is saved is to roast the pyrites to about 5 per cent. of sulphur, and then add to it 4 per cent. of salt, and continue the roasting for a few hours. The copper and silver are rendered soluble in water, from which solution they are precipitated as sulphides by sulphuretted hydrogen. The first fifth of the precipitate contains all the silver; this is separated, and the precipitation of the copper continued. The sodium compounds (sulphate of sodium) contained in the solution is converted into sulphide by evaporating it to dryness and igniting with coal-dust in a closed furnace, and the sulphide then serves to supply sulphuretted hydrogen to precipitate a fresh quantity of copper and silver, while it is converted into carbonate of soda by a stream of carbonic acid gas from a lime-kiln.

"*Oxidation by Atmospheric Action.*

"In South America the Indians decompose the pyrites by exposing them to atmospheric action. The pyrites are decomposed into basic sulphate of iron, and the gold is liberated so that it may be amalgamated; but by this process several years are required to fully decompose each heap. It is, however, worth considering whether this process of oxidation could not be hastened, so as to make it applicable to our requirements, and enable miners in outlying districts to get the gold from the pyrites not allowed to run to waste with the quartz-tailings. A few inexpensive experiments might be conducted, either by constructing a heap with brushwood so as to allow a free circulation of air, or by making a heap on the principle of a "nitre plantation," with nitrogenous matter. The latter would seem to have all the necessary conditions—heat, moisture, with air and nitrates to carry on the oxidation.

"*Smelting.*

"Smelting pyrites containing galena presents no metallurgical difficulties. Where there is much lead it would probably be the best method, collecting the gold and silver in a lead button; but where lead is absent the process of roasting, extraction of the copper and silver, and amalgamation for the gold, is undoubtedly the most advantageous, as it would allow a number of processes being carried on in one establishment, producing several profitable products.

"Where antimony is present in large quantity, smelting is also necessary, and a process is patented by us, in connection with Mr. H. Y. L. Brown, for the extraction of gold from auriferous antimony ores. The process consists in passing the same quantity of metallic antimony through successive charges of molten sulphide or other ore, and extracting the gold from the metallic antimony when it has been sufficiently enriched.

"*Chlorination.*

"The process of chlorination, though working admirably on a small scale, we do not believe to be adapted for the treatment of the great quantity of pyritous material with which we have to deal.

"*Roasting-furnaces.*

"So far as we know the furnaces in use in Victoria for roasting pyrites are—

"1. Reverberatory furnace with inclined hearth: the dimensions being—Length, 30ft. to 35ft.; width, 5ft.; inclination, 1 in 7; height, from hearth to arch, 16in. to 18in. This furnace was first erected at Port Phillip Works, Clunes, by Messrs. G. J. Latta and H. A. Thomson.

"2. Ordinary flat-hearth reverberatory furnace.

"3. Flat-hearth reverberatory, with hearth about 6ft. by 6ft. 6in., with flue over fire, like a baker's oven.

"4. Stetefieldt's shaft-furnace, especially designed for the chlorination of silver ores. Its dimensions are about 30ft. high, 4ft. to 5ft. square. The ore enters the furnace through a sieve at the top of the shaft, and falls through the ascending current of heated gases from the fire. One of these furnaces has been erected at St. Arnaud. In America it is said to be extensively used for the treatment of pyritous silver ores. It could, no doubt, be applied to auriferous ores. It is claimed for it that with eight men twenty to twenty-five tons may be treated in twenty-four hours.

"Amongst those which have been recommended in other countries, but have not been introduced here, we may mention—

"5. Oxland and Hocking's revolving cylindrical furnace.

"6. White's rotating furnace, closely resembling Oxland and Hocking's. Its dimensions are—24ft. long, 30in. diameter, inclination 1 in 12. The outer shell is cast iron, in lengths 3ft. long, lined with fire-brick. (See *Scientific Press*, No. 17, Vol. XXIII.)

"7. Kerpely's step-furnace.—A shaft-furnace with inclined steps, over which the pyrites runs in a thin stream.

"8. Gestenhocfer's shaft-furnace.—A narrow shaft with triangular rests, over which the pyrites falls, resting on each a short time. It is fed by a self-acting hopper. Approximate dimensions—15ft. to 18ft. high; 1ft. to 1ft. 6in. wide; and 10ft. to 12ft. long.

"9. Whepley and Storer's furnace.

"10. McClew's furnace.—An inclined hearth, behind which are three fires with blasts. The flues open through the hearth, over which the ore passes.

"11. Küstel's furnace.—An inclined hearth, broken twice at right angles, so that the highest and lowest points are on one side; the working openings are at the angles, so that the mass of ore is easily shifted. The ore is introduced at the upper end, and distributed on the first hearth, where it is roasted for an hour. It then passes to the second hearth, and finally to the third. The heat is obtained by fires at the angles. It is claimed that no stirring is required. Fifteen to twenty tons are treated in twenty-four hours, with two shifts of three men each. (See *New York Engineering and Mining Journal*, 25th November, 1873.)

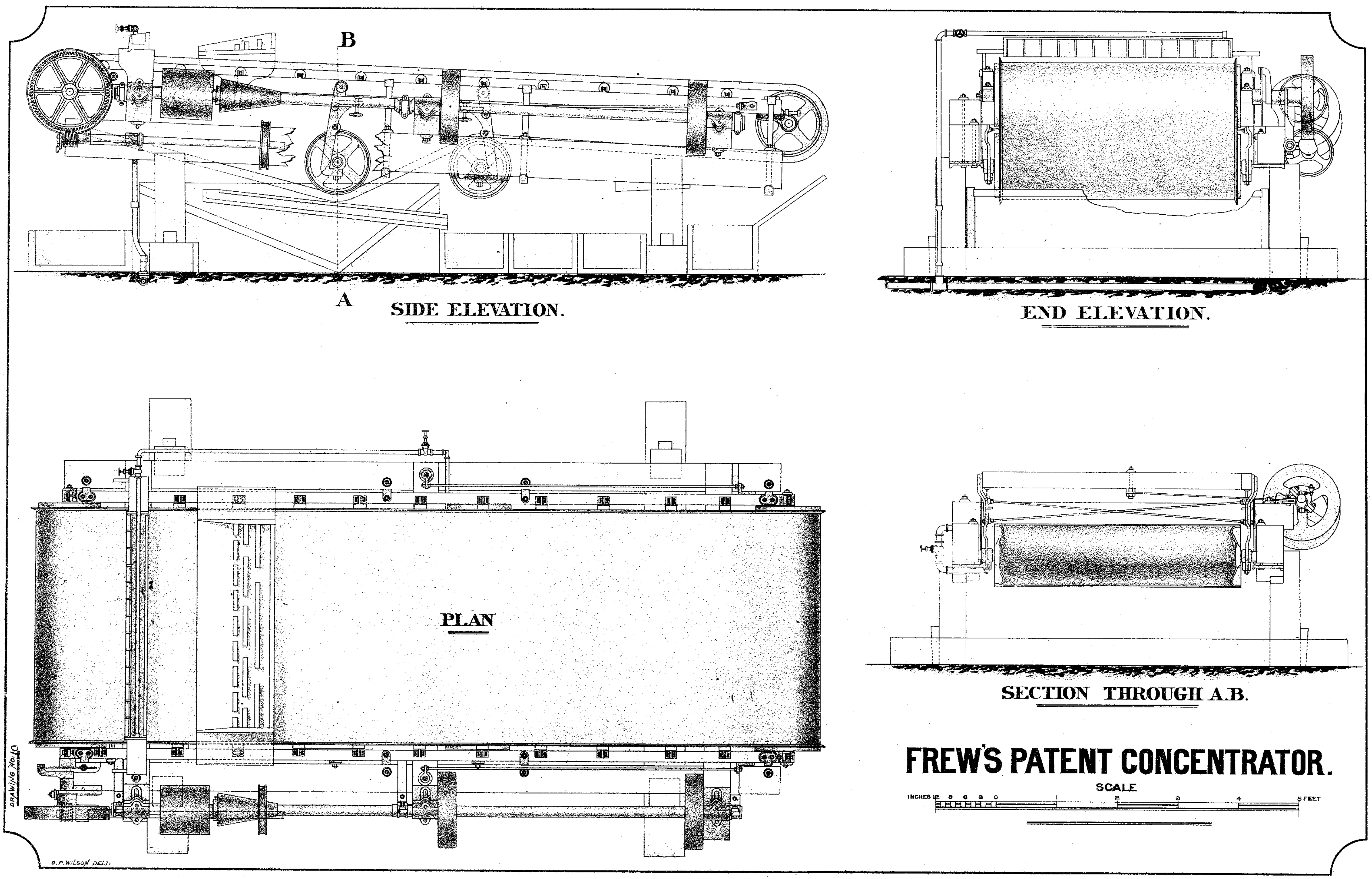
"12. Aiken's furnace.—A modification of Stetefieldt's. Said to be less costly.

"With respect to the value of classification according to size of grain of the crushed material previous to concentration, the value of the self-acting jigging machine as a concentrator, and that of the Tyrolese mill for the saving of mercury and amalgam, we have to make the following observations:—

"All methods of the mechanical concentration of ores by means of water are, as is well known, based upon the feature that the ore is specifically heavier than the gangue; and the best method can therefore only be that which uses that excess in weight to the best advantage. Both equal size and form of the grains are hereby the principal conditions. As regards the form, we have no control whatever during the process of crushing, and must therefore leave it entirely to chance; but for the procuring of equal size of grain, at least within certain limits—viz., for a systematic classification of the crushed material previous to concentration—a number of contrivances have been invented, and are in successful use in the ore-dressing establishments of European and American mining localities. They are there considered necessary for the concentration of even such heavy ores as galena, tin ore, &c. In the case of our auriferous pyrites, which is much nearer in specific weight to the quartz than those ores are to their gangue, which is more brittle and softer than quartz, and therefore generally crushed to a finer grain than the latter, its small excess in specific weight is liable to be rendered void by the larger size of the quartz-grains; for as both are acted upon by the same stream of water, finer pyrites grains may be, and no doubt are, carried along by the stream, whilst coarser ones of quartz settle down. For these reasons classification must evidently be of considerable advantage.

"The most exact classifiers for finely-crushed material are inclined rotating sieve-drums, into which the material is introduced at the higher end, passing finer and coarser sieves in succession. These machines require, however, a great deal of attention, and for a country where labour is as expensive as here, and where in comparison far larger quantities of material are required to be treated in a certain time than in European establishments, any advantage in using them would be rather doubtful. There are two simple contrivances, however, which, though they do not classify as exactly according to size as the drums, are nevertheless of very great value in the after-concentration of ore from fine sands and slimes, and to which we desire to draw particular attention. These are Rittinger's 'Spitzkästen' and 'Spitzlutten' (pyramidal boxes and triangular double troughs).*

"* See description in 'Observations on the Mode of Treatment of Auriferous Lead and Silver Ores at Schemnitz, Upper Hungary,' published by the Mining Department. Also models in Technological Museum.



B
A
SIDE ELEVATION.
END ELEVATION.
PLAN
SECTION THROUGH A.B.
FREW'S PATENT CONCENTRATOR.
SCALE
INCHES 12 9 6 3 0 1 2 3 4 5 FEET
DRAWING No. 10
G.P. WILSON DELT:

They need only casual supervision, but require a steady, unchanging influx of water and material. That the introduction of these machines into our pyrites-saving establishments would be found highly advantageous we have not the slightest doubt. Borlase's buddle, with Munday's patent scrapers, is, if properly worked, an excellent machine, and perhaps the best that could be used for the saving of pyrites from unclassified material; but it must be evident that even these machines would work better if the stuff to be treated by them was previously classified. For instance, if classification produced three sizes of grain—viz., coarser sand, fine sand, and slime—and three buddles were employed, one for each of these sizes, this would be a better arrangement than if the three buddles worked the material with the sands and slime intermixed.

"With regard to the self-acting jigging machine (one of the most important inventions in ore-dressing in recent times, which has produced quite a revolution in European ore-dressing establishments), we apprehend that the comparative failures of the trials which have been made with it on our goldfields must have been owing partly to want of previous classification of the material, partly perhaps to unacquaintance with some of the main points governing its successful working on certain sizes of grain—viz., length and velocity of stroke of piston and influx of water. One of the writers has seen numbers of these machines at work in the ore-dressing establishments of the Hartz and Saxony, and was greatly surprised at the excellent results achieved with them, even on ores very difficult to concentrate. They produce very pure ore with inconsiderable loss, require little supervision and small motive power, and—what is a great advantage—need not be stopped working in order to be cleared, as the ore collects in receptacles outside the machine.

"In summing up our observations on this subject, and taking into account the price of labour in this colony, we come to the conclusion that if the crushed pyritous material, after passing the usual amalgamating appliances (quicksilver troughs, copper plates, &c.), was, by one triangular double trough and two pyramidal boxes, classified into three sizes of grain—viz., coarser sand, fine sand, and slime—and the first treated by self-acting jigging machines, the other two by Borlase's buddle, it would prove a more satisfactory process for the saving of the pyrites than any at present in use.

"The construction and mode of working of the Tyrolese mills are also described in the pamphlet previously quoted. These mills are excellent amalgamators, easily managed, and require a very small motive power. Messrs. Thomson and Rosales, the renowned managers of the two principal mining companies on Cohen's Reef, Walhalla, use them, as reported, with marked success for the saving of finely-divided mercury and amalgam in roasting the amalgamated roasted pyrites.

"George H. F. Ulrich.
"J. Cosmo Newbery."

Memorandum Descriptive of Plan of Condensing Apparatus for Pyrites Furnaces.

"1. Every furnace should be provided with vertical spray-pipes, erected over separate water-tanks, as shown on plan; and should also have, wherever sufficient ground is available, a brick ground-flue, with spray-tanks and baffle-walls at intervals along its course, each tank having three cross spray-pipes and three baffle-walls, and baffle-walls being also constructed in the flues alternately on each side, in the spaces between the tanks. There should be two condensing-tanks in each 100ft. of ground-flue.

"2. The number of vertical spray-pipes, and the length of the ground-flue from these to the chimney-stack, will, of course, depend on the extent of the operations carried on, and also on other circumstances, such as the surface contour and the area of available ground; but in all cases vertical pipes and a ground-flue should be provided in at least the following proportion, viz.: For a furnace the area of the floor of which is 150 square feet, or which is capable of treating, say, 15cwt. at each charge, or about 3 tons of material in twenty-four hours, there should be not less than three vertical spray-pipes and tanks, and 200ft. in length of ground-flue, with baffle-walls and four intercepting spray-tanks. Should, however, circumstances prevent the construction of a flue more than 100ft. in length, then three more vertical spray-pipes and tanks should be provided for a furnace of the capacity above mentioned. However many vertical pipes may be provided, in no case should there be less than 100ft. of ground-flue, with the baffle-walls and the two intercepting spray-tanks already described.

"3. If in any case it be found that noxious matter is, from any cause, still discharged with the fumes from the chimney, the number of vertical pipes, or the length of the ground-flue, or both, must be increased until this is entirely prevented.

"4. The vertical pipes should be constructed so as to be easily cleaned; and the brick ground-flue should be large enough to allow of the easy entry of a man for the like purpose.

"5. All the spray water-jets should be kept continually in use and in thorough efficiency whenever the furnace is in operation.

"6. The fumes should be finally conducted into a chimney not less than 50ft. in height, or not less than 70ft. if closely surrounded by dwelling-houses.

"7. The chimney should, wherever practicable, be placed at, or as near as possible to, the top of any hill or other neighbouring eminence.

"8. The chimney should be provided with some appliance (such, for instance, as a plate fixed on its summit, which can be easily lowered for inspection) by means of which it can at any time be readily ascertained if any noxious matter is deposited by the discharged fumes.

"As the water when finally discharged from the condensing tanks will still contain some proportion of arsenic, it should be passed through a filtering medium, composed of the refuse material from which the gold has been extracted, mixed, where practicable, with ordinary quartz-tailings, the filtering-bed being made of considerable thickness. (The refuse material referred to consists largely of oxide of iron, which, by exposure to the atmosphere and the weather, becomes hydrated peroxide of iron; and experiments made with the material in the latter state shows that from water containing as much as 3½gr. of arsenic to the gallon all the arsenic was removed on passing the water through a bed of six inches of the material in question.) As the arsenic-absorbing power of the iron is of course limited, the material of the filtering-bed will require to be occasionally renewed in order to keep it effective, and experiments should from time to time be made with the filtered water, in order to ascertain when such renewal is necessary.

"Central Board of Health, Melbourne, 17th July, 1873."

Concentrating Machinery.

In addition to the appliances already described for concentrating, there is another in general use in California, which is known as "Frue's Ore-Concentrator," a plan of which is hereto annexed drawing No. 3.

A description of this is given by G. Thureau in his report on mining in California and Nevada in 1879. The same gentleman also gives a description of a "drop"-furnace in use there which is superior to the ordinary reverberatory furnace for calcining pyrites. The following are extracts from Mr. Thureau's report:—

"*Frue's Ore-Concentrator.*—This machine is simply an improvement, in many respects, upon the well-known endless blanket, first brought under notice by Mr. Thomas Carpenter, M.E. Its Californian prototype is on the same principle as a revolving and endless blanket, only the materials used are of greater durability, and show some additional improvements in working, and have aided in the perfection of the machine. Two principal rollers at each end of the machine carry the belt or endless blanket. These rollers are made of galvanized sheet-iron, riveted together, 13in. in diameter and 51in. in length; and a larger roller, 24in. in diameter, is placed midways and a few inches below the line of the lower periphery of the two end rollers, so that the belt 'bands' on the top of the end and beneath the intermediate roller. A fourth roller is provided, made of hardwood, which is geared to a movable plummer-block by a screw. This screw is also used to take up the slack on the belt caused by the weight of the stuff and water, thus preventing the bagging of the belt. This belt is 4ft. wide by 27ft. 6in. long, and it travels on a number of intermediate rollers so as to keep an even surface. It is made of vulcanized rubber and A1 three-ply navy canvas; and it has two rims at the sides raised to 1½in., thus forming an even narrow channel. The sand (crushed or otherwise) is run through a distributor upon this revolving belt in this way, that the belt travels towards the feed; and at the same time an additional supply of water, arranged in irregular drops or jets, is thrown in so as to prevent the sand from forming ridges or grooves. When working, not less than half an inch of sand should cover the belt. And, in order to improve the action of the belt as a concentrator still further, three flat springs are provided, which are worked by cranks off the roller. These springs communicate a quick, lateral motion, about 190 per minute, to the belt, thus inducing a kind of wavy motion, which results in bringing the lighter sand on the belt to the surface, to be washed away. As the belt travels along, carrying the sand, the result is as follows: The concentration takes place just beneath the feed, where the metalliferous and concentrated parts of same are carried in the opposite direction of the feed, whereas the waste remains on the belt until it falls into a launder at the opposite end. The concentrated pyrites on the belt are immersed in the vessel, provided below, in order to be collected. These machines work very easily—one lad can attend to more than half a dozen of them; the only thing that wants regulation being the additional supply of pure water during the process. They may be placed immediately beneath the tailing-shoots, where they can treat from six to ten tons per day. Some kindred concentrators require an inordinate amount of motive-power—in some cases up to three or more horse-power each; but in this instance from a quarter to half a horse power is ample for the purpose. The results of samples of raw sands washed in my presence in San Francisco for concentration, were most satisfactory. Both tailings and black sand, as thrown up by the Pacific Ocean, were tested with equally convincing results as to the capabilities of this concentrator. The black sand, which was mixed with titaniferous ironsand, and was more difficult to separate than fine gold and pyrites from tailings, gave, on systematic tests by assay, an average value of $8·27 per ton of unconcentrated sand, as found *in situ* at the coast. This sand, after treatment in Frue's concentrator, had been enriched to $1,035·43 per ton, with but a slight trace of gold in the tailings. This machine is eminently suited for reworking old tailings."

According to the account that Mr. Thureau gives, this machine is not only a good concentrator for quartz-tailings, but it might be employed to treat the black sand which is found in many places along the ocean-beach on the west coast of the Middle Island.

"*Drop-Furnaces.*—The concentrated sulphurets are roasted dead in these furnaces, which have for a charge one ton of sulphurets at a time. They have an average of 130 square feet, the dome or cover rising but 24in. in the centre above the brick of the floor of the hearth. The sulphurets are delivered through a cast-iron funnel at the top of the first hearth from trucks, cars, &c.; and, when they are fine, a 'dust-chamber' will save as high as 5 per cent. of the ore calcined. With these drop-furnaces from five to six tons of sulphurets can be calcined at the expense of but two cords of soft firewood, in three shifts, or twenty-four hours—a considerable improvement on our reverberatory furnaces capabilities, assuming that in both cases the pyrites are delivered in as dry a state as possible. These drop-furnaces may be worked in distinctly different ways—namely, for producing sulphuric acid as a by-product, and for oxidation and chloridizing calcination. When for the latter, the furnace consists of two hearths, constructed at different levels, or one about 12ft. above the other, and placed end for end. They are connected with each other by means of a vertical flue of the same width as the hearths; and this flue, 12in. deep, is constructed so as to lead to the lower hearth zig-zag fashion, or over a series of terraces built in the flue right down to the bottom hearth. The fireplace, common to both hearths, having been built in front of the lower hearth, the flame therefrom primarily affects the pyrites as separated only from the lower hearth by a low bridge in that hearth; then these flames, &c., ascend through the flue or drop to the upper hearth, subjecting the pyrites there in like manner, finally passing out through the damper into the stack and open air.

As soon as the charge has been fed into the upper hearth the hopper is closed, the usual burning and raking takes place for a specific period, and then the partly-calcined pyrites are raked into the drop-flue, where they descend like a thin sheet into the ascending flames, which latter subject any particles of these sulphurets to severe calcination. At the bottom of the drop-flue is what is termed the 'back-hearth,' whence the roasted ore can be withdrawn for outside treatment by means of a trap-door. If, however, the ore is to be calcined further in the lower hearth it is raked into the latter, and the final roasting takes place, including the addition of coarse salt after three hours' work. By means of this salt the gold is freed from the oxides, and is besides rendered easier for chlorination by removing lead or other sulphates obnoxious to the final process; consequently the quantity of salt to be added depends on the greater or lesser percentage of lead in the ore."

It will be seen, therefore, that in the Australian colonies, America, and Europe attention has been specially directed to extracting all the various minerals from gold-bearing lodes, and that the proper treatment of pyrites has resulted in giving large profits to the shareholders who have undertaken the manipulation. I have dwelt at considerable length on this subject, as it is a process that will be the means of making many of our quartz-mines, now lying idle or worked without paying any interest on the capital invested, give fair returns.

Amalgamation.

I have not seen any appliance for amalgamation at work on a large scale which may be said to be complete. The great object in amalgamation is to mix the mercury with the ground or crushed material as much as possible, and to prevent it from becoming floured, or, at least, to be able to collect the floured mercury again before it leaves the amalgamator to run away with the tailings.

The best principle of an amalgamator that I saw was that of "Barker's Patent Electro Amalgamator," which was discovered, or, rather, perfected, by Mr. Richard Barker, F.G.S., of London, in the beginning of 1883, and is now being introduced into the Australian Colonies. This amalgamator has been tested by a number of scientific gentlemen and mining managers, who all agree that it is one of the best processes yet found out for preventing the mercury getting sickened by coming in contact with the base metals, and likewise from getting in a floured condition. The following is a translation from an extract from the *Pesther Lloyd (Times* of Hungary) of the 6th October, 1883:—

"We have had a series of very interesting trials of Barker's discovery, under the superintendence of Mr. Henry Tapp, representative of the Electro Amalgamator Company, London, which system permits of direct amalgamation by means of electricity, so that gold, silver, and copper may be recovered from very inferior ore in a most simple way, and at a minimum expense of 5s. per ton, while the 'Designole system' hitherto applied in our establishments has proved as tedious as it is costly and imperfect. . . . . When Nature provides gold, silver, or copper ores in metallic condition, they seem to be predestined for this method; but with us the metals are found in combination with sulphur, arsenic, and antimony, and this combination is indissoluble by mercury. To apply the 'Designole system' to ores containing this combination, it is necessary in the first place to reduce the metal into such a state as to admit of the iron combining with the chloride of mercury. This can only be brought about (and that not satisfactorily) through calcination or chlorination, which renders the 'Designole system,' that ought to be very cheap, a costly one, the treatment of inferior ore being in consequence altogether impracticable. 'Barker's' invention renders all this feasible in the simplest possible manner. It consists in the discovery that mercury will amalgamate direct under the influence of electricity. The process is as follows: The ore, reduced to a powder, is carried over an inclined plane, where it must pass over several stages, consisting of a copper plate and a layer of mercury. If these plates are connected with the positive pole of a battery and the mercury with the negative pole, the mercury receives at once all the precious metals, which collect at the negative pole, while sulphur, arsenic, and antimony adhere to the copper, the tailings being forced down by water. If the mercury be sufficiently saturated with precious metals, which can be easily ascertained, the superfluous mercury, which has become amalgam, is drawn off in a simple way, the amalgamation continuing without interruption. The trials to-day in the presence of Government Councillor Belhazy and Mining Captain Reitzner, also of Director Meechwort and other scientific authorities in chemistry, mining, and electricity, were all most successful.

"They commenced with the poorest ore, both raw and calcined, which had been reduced to powder by Ganz's crushing machine. The result was very striking, even with the Kapnik sulphur pyrites. Such of the pyrites as had passed over the surface contained barely 2 per cent. of the original metal. All the rest was perfectly amalgamated. . . . .

"Thus the problem is solved of bringing all those hundreds of thousands of tons of inferior ore within the reach of profitable treatment, that up to now, owing to the poorness of quality and cost of manipulation, have been all but lost to our industry; and this seems to open up a new and more cheering prospect for our mining. The well-known geologist, Dr. Robertson, who a few weeks ago visited Hungary in order to study our mineralogy, has expressed his opinion that Hungary, through this (Barker's) process, may become the California of Europe."

The London *Times* of 8th February, 1883, likewise states that trials were made with this appliance at the company's works, near London Bridge, in the presence of a number of gentlemen interested in gold-mining, who assembled to witness a demonstration of the invention, and were highly satisfied with the results obtained. The *Engineer* of the 9th February, 1883, in an article describing this process, states: "We have seen quartz heavily charged with sulphur and arsenic from sulphur pyrites. One shovelful of this stuff sufficed to sicken all the mercury in the riffle, and the mercury was brought back to condition in less than a minute after the current was turned on. With the current flowing, the mercury could not be made sick. One experiment which we witnessed showed in a startling way the effect produced by the passage of the current. Four or five pounds of clean mercury being put into a china bowl, some oil was added, and the whole beaten up with a stick to a species of ointment—a process which occupied five or six minutes. A sovereign dropped into this mixture of oil and mercury came out untouched by the mercury. For all purposes of amalgamation the mercury was useless, and must remain so until retorted. The bowl was now nearly filled with water, and the end of a negative wire from a battery was plunged into the mercury and oil, while the positive wire was just dropped into the water, which stood 2in. or 3in. deep. The moment the contact was made with the water the oil began to rise in streams from the mercury, which could be seen collecting itself into little drops, two or three of which would coalesce. In about three minutes the whole of the oil had come to the surface of the water, and the mercury lay, pure and bright, at the bottom of the bowl."

I witnessed a trial made with this appliance by the agent for the company at Melbourne, which surprised me at the effect produced on the quicksilver by a current of electricity; and I am convinced that this appliance will be the means of more gold being saved than hitherto. It consists of a common riffle-table, such as would ordinarily be placed next a battery of five head of stamps, the length and width being about the same as the tables now in use. The table has riffles, and is covered with electro-plated copper plates such as those now used on the ordinary riffle-tables. Across each riffle is a bar or band of carbon, which comes down to within a quarter of an inch or so of the surface of the quicksilver in the riffle. There are likewise sliding carbon bars which, by a mechanical motion, are made to move up and down directly above the surface of the copper plates that are between each riffle, so as to touch the water that flows over the tables, but not to touch the surface of the plates. The negative wires from the battery are placed in the quicksilver and to the copper plate, while the wires from the positive pole are attached to the carbon bar or bands that are placed across the box, thus sending the current through the water into the quicksilver. I mixed up some mercury with grease in a dish to test the effect that the electricity had upon it, and, although the mercury was so sickened with the grease that it was perfectly useless for amalgamation, in a few minutes after the current was turned on the effect produced was almost magical: the grease and impurities came boiling out of the mercury, and left it in a pure and bright condition.

Mr. J. Naylor, of Stawell, imformed me that a company with which he was connected had made arrangements to erect a plant of these amalgamators to treat the heaps of quartz-tailings then on the ground, and he promised to send me a full description, with the result of its manipulations.

Winding Machinery.

The winding machinery in Victoria is far superior to that in use in New Zealand, every winding plant being fitted with powerful brakes on the winding-drums, and fly-wheels of the engine, so that it can be stopped at once on a signal being given. The winding-ropes have all safety-hooks coupling them with the cages, which detach the rope automatically in the event of over-winding; and the cages are all fitted with approved safety appliances to prevent the cage falling down the shaft should the winding-rope break. The majority of the companies in the Sandhurst District have likewise safety-braces, about ten feet above the main brace, as an extra safety-guard should the cage be taken up to the poppet-heads and the hook or safety appliances on the cage fail to act. These precautions are essentially necessary in working deep mines. In the Sandhurst District they have been the means of saving a number of lives, either through accidents to the winding appliances, or through the carelessness of the engine-drivers. This is a subject which deserves the attention of mine-proprietors and mine-managers in New Zealand, and more so in future than what has been the case in the past, as our mines are getting deeper every year, and some of them are at present a considerable depth. For instance, the Big Pump shaft and the Queen of Beauty shaft at the Thames, the Golden Fleece shaft at Reefton, and the shaft at the Greymouth Coal-mine, belonging to the Westport Coal Company, are all considerably over 600 feet in depth, while the Golden Fleece and Queen of Beauty shafts are over 700 feet in depth. Yet none of these companies have proper safety appliances for winding. It is not only the companies named that these remarks apply to, but likewise every company working its mine from a shaft by which the workmen go up and down.

The Inspection of Mines Act in Victoria makes it compulsory on the owners of every mine using winding-machinery to have approved safety appliances, and the Inspectors of Mines for the various districts inspect and test them periodically. Mr. Grainger, the Inspector of Mines for the Sandhurst District, which is the largest field where mining operations are carried on in Victoria, states that he experiences very little trouble in getting companies to comply with the Act in this respect, as they find it to their own advantage to do so.

Compressed-Air Rock-boring Machine.

Air-Compressors.—These machines are in use by almost every mining company in Victoria, and they are coming into use in New South Wales. Compressed air is not only used for rock-drills, but also as a motive-power for working underground winding-winches, and its use generally tends to assist the ventilation of the mines. The compressors differ greatly in construction. Some are known as the "wet" and others as the "dry." It is unnecessary to enter into the merits of each compressor, for which several patents are held. Those generally in use in the Sandhurst District are the "National" and "Ford's," while in the Stawell Districts "Wayman and Kay's" and the "National" are generally in use. The most compact and simple compressor that I saw was the "National," which may be termed a "dry compressor," having hollow ends on the air-compressing cylinder, so that a current of cold water can be circulated to keep it cool: the compression of air in the cylinder causes an evolution of heat, which it is necessary to keep below a certain temperature, or else the air would lose much of its expansive power as a motor. The only objection that I could see in the "National" was that the cylinder of the steam-engine was rather small for the cylinder of the compressor, as it required the steam to be at high pressure to do the work, whereas if the cylinder of the steam-engine was a little larger than the cylinder of the compressor, it would not require so high a pressure of steam to work it. "Wayman and Kay's" is what is termed a "wet compressor," and is highly spoken of by those companies that use it; but it requires much more room, and is not nearly so compact as the "National." At the same time it does its work satisfactorily. Plans of this compressor are attached (*See* Drawing No. 7). These compressors force the air into a receiver, which is generally in the shape of an egg-end boiler, and from this the air is led, in gas-pipes of from 2in. to 3in. in diameter, into the mine on the various levels where it is required. When rock-drills are used in stoping out, the air is taken from the main service-pipe in flexible tubing made of vulcanized rubber. This flexible tubing is likewise used for connecting the main- and branch-pipes with the different machines that are at work. The power required to supply air for an ordinary rock-borer is equal to about from two to three horse power. A 12in.-cylinder steam-engine would be amply sufficient to drive a compressor capable of supplying air to work four drills.

Compressed-Air Rock-Drills.

The managers and those interested in all the mines that I visited were unanimous in their opinion with regard to the use of these drills, and stated that they not only cheapen the cost of working the mine, but likewise, by their use the large amount of air required to work them, they assist materially in ventilation. In sinking shafts, winzes, and in driving tunnels, levels, &c., their use enables the work to be done for nearly one-half of the cost of ordinary hand-labour; but in stoping out the lode the actual cost of breaking down the stone, in some instances, is as much as by hand-labour. But even in this case their use enables the lode to be worked out at a greater rapidity, thereby effecting a saving in the surface expenditure. The rock-drills mostly in use are the "National," "Ingersoll's," "Eclipse," "Mitchell's," "Naylor and Thornton's," and "Wayman and Kay's." Plans of the two last are annexed (*See* Drawings Nos. 5 and 6).

From what I have seen of the working of these drills, the two last named seem to give great satisfaction. These drills are mostly used at Stawell, where the rock is harder than in any other district in Victoria; and one of the chief advantages of the Naylor and Thornton drill is that it is lighter than any of the others, at the same time combining strength and simplicity of construction, whilst its equilibrium valve renders the friction very little and allows the whole of the power to be concentrated on the main piston, which works the drill. Several of these drills are used in the Inangahua district, and every one of them has given great satisfaction. But, at the same time, while I think highly of this drill, I do not wish to depreciate the value of any of the others, which may be equally effective in doing their work.

As stated previously in the case of the "Wayman and Kay's" drill, which was worked under similar conditions with those of the "National" and "Eclipse" drills, it proved to be superior, inasmuch as the cost of repairs was considerably less, as also the amount of air consumed in working it. This drill is only about 4lb. heavier than the "Naylor and Thornton" and costs about £25 less in the first instance.

Diamond Drills.

These drills have been greatly used in Victoria and New South Wales, and their use has been marked with great success in boring through sandstone, shale, and basaltic rocks for coal and alluvial gold deposits. But in boring through metamorphic-schist formations for gold in quartz-reefs they have not been successful. The district where they have been chiefly employed in prospecting for quartz-lodes is Stawell, in Victoria, where thirty-one bores have been put in, equalling 12,080ft. 8in. The managers of companies, and others interested in mining in this locality, do not consider their use of any particular advantage, and look upon them as misleading with regard to the thickness of the lodes bored through, inasmuch as, in boring through silurian rocks, the alternate hard and soft veins in the strata cause them to run away from the initial direction of the bore, especially if it is following nearly in the direction of the strata. They have, in some instances, in this district, cut the lode-veins at such an angle that the bore almost followed along them, thereby representing a much greater thickness of lode than actually existed. As, for instance, one of the bores in the Oriental Company's mine showed a deviation from the initial direction (at 400ft.) to be about 50ft., and also showed the quartz-leader which was cut containing gold to be two or three times thicker than it really was. This was the means of inducing the company to sink their shaft and put in levels to work the supposed lode, which when found was not of sufficient thickness to pay.

The following table will show the results obtained by underground diamond drill in prospecting or gold in quartz-reefs in Victoria from the 27th April, 1880, to the 24th November, 1884:—

Name of Company.	District.	Number of Bore.	Depth bored.	Total Depth bored.	Employed in actual Boring.	Depth bored per Day.	Remarks.
			Ft. in.	Ft. in.	Days.	Ft. in.	
Gt. Northern Crown	Stawell	1	506 8	..	44	11 6	No gold.
" "	"	2	136 0	..	20	6 9½	Horizontal bore from No. 3 level.
				642 8			
Scotchman's United	"	1	519 8	..	91	5 8½	Vertical bore from bottom of shaft; 1dwt. 18gr. from 7lb. of core at 361ft. 10in.
" "	"	2	505 2	..	116	4 4	Depth from surface, 343ft; angle from perpendicular, 1 in 5; quartz 4in. thick at 54ft., in which gold was seen.
" "	"	3	120 6	..	32	3 8½	Put in from 756-ft. level, horizontal.
				1,145 4			
West Scotchman's	"	1	500 0	..	73	6 10	Horizontal bore, dipping 1 in 6 from 853-ft. level; gold from core at 350ft. averaged at the rate of 23dwt. per ton.
				500 0			
Magdala	"	1	521 0	..	72	7 3	Vertical bore from bottom of shaft, 2,409ft; no gold.
"	"	2	502 0	..	58	8 8	Put in at 728-ft., level, 5° from horizontal.
"	"	3	298 5	..	48	6 2½	Vertical bore at 728ft. from surface; gold in core taken from reef at 284ft.
"	"	4	498 3	..	87	5 9	Vertical bore at 1,200ft. from surface.
"	"	5	499 7	..	72	6 11	1,200ft. from surface; angle of bore, 65°; gold in core from reef at 307ft.
"	"	6	399 1	..	46	8 8	1,200ft. from surface; angle of bore, 53° from vertical; gold in core, 355ft.
"	"	7	304 0	..	39	7 9½	1,400ft. from surface; angle of bore, 8ft. in 10ft.; gold in core, 190ft.
"	"	8	39 4	..	4	9 10	1,500ft. from surface; angle of bore, 50° from horizontal.
				3,061 8			
Oriental	"	1	506 6	..	61	8 3½	1,080ft. from surface, vertical bore.
"	"	2	530 5	..	60	8 10	1,505ft. from surface, vertical bore.
"	"	3	166 9	..	11	15 1	1,700ft. from surface, horizontal bore.
"	"	4	136 1	..	11	12 4	1,700ft. from surface; angle of bore, 45°.
"	"	5	500 4	..	74	6 6	1,030ft. from surface; angle, 1 in 5 from vertical.
"	"	6	301 9	..	33	9 2	1,500ft. from surface, horizontal bore.
"	"	7	515 1	..	57	9 0½	Vertical bore at 520-ft. level.
				2,656 11			
Crown Cross Reef United	"	1	500 0	..	71	7 0½	1,318ft. from surface; angle, 1 in 4 from vertical; splendid prospects of gold at 473ft.
Ditto	"	2	309 1	..	59	5 1	1,800ft. from surface; angle, 1 in 10.
				809 1			
Carolina	"	1	500 4	..	39	12 10	782ft. from surface; angle, 30° from vertical.
				500 4			
North Scotchman's	"	1	500 0	..	46	10 10½	400ft. from surface, 9° from vertical.
				500 0			
Great Southern ..	"	1	78 4	..	8	9 9	Vertical bore from bottom of shaft.
				78 4			
Prince Alfred ..	"	1	499 11	..	46	10 10½	No remarks.
"	"	2	499 4	..	45	11 1	1,780ft. from surface, vertical bore.
				999 3			
New Albion ..	"	1	325 7	..	30	10 10	537ft. from surface, 33° from vertical.
				325 7			
Big Hill	"	1	346 0	..	90	3 10	450ft. from surface; angle, 45°.
				346 0			
Pleasant Creek Cross Reef	"	1	515 6	..	67	7 8½	700ft. from surface, vertical bore; gold seen in core at 505ft.
				515 6			
				12,080 8	1,610		
Alfred Tribute ..	Sandhurst	1	281 6	..	60	4 8	400ft. from surface, horizontal bore; gold in core at 251ft.
"	Ditto	2	483 7	..	68	7 1½	350ft. from surface, horizontal bore.
				765 1			
Koch's Pioneer ..	"	1	397 2	..	64	6 2	400ft. from surface, horizontal bore.
				397 2			
				1,162 3	192		
Eaglehawk Union	Maldon	1	440 9	..	74	5 11½	700ft. from surface, horizontal bore.
" "	"	2	308 8	..	43	7 5	1,000ft. from surface, horizontal bore.
" "	"	3	242 0	..	33	7 4	1,000ft. from surface, horizontal bore.
				991 5			
					150		
				14,234 4	1,952	..	Total distance bored with underground diamond drills.

Total distance bored, 14,234ft. 4in. in 1,952 days, averaging 7ft. 3½in. per day, which equals 2 miles 55 chains 67 links lineal measure. Deducting Sundays, it took 6 years 12 weeks and 2 days to bore this distance. Altogether, there were 37 bore-holes put down.

It must be borne in mind that this table only gives the number of days that the drills were actually at work; but, on examining the tables published in the Victorian report, I find that, in addition to boring, the time occupied in shifting and fixing the drills in position ready for work was as follows: No. 1 drill bored 13 holes and took 131 days to shift and fix in position; No. 2 drill bored 3 holes and took 22 days shifting and fixing; No. 3 drill bored 7 holes and took 61 days shifting and fixing; No. 4 drill bored 3 holes and took 33 days shifting and fixing; No. 5 drill bored 11 holes and took 76 days shifting and fixing: total, 37 holes, 323 days.

This, added to the time actually employed in boring, gives the result of 1,952+323=2,275 days to get the average distance bored per day, as the shifting and fixing in position must be included in the cost of boring, thus reducing the average work done to about 6ft. 3in. per day, and showing that the shifting and fixing in position is equal to boring about 1ft. ½in. per day. Taking the results obtained from prospecting with these drills, gold was obtained from nine bore-holes, of which good prospects were found in four, the other five holes having only a trace of gold. The cost of working these drills, as shown in Mr. Langtree's report, is about 18s. per foot, exclusive of superintendence and clerical work connected with the management, which may amount to 2s. per foot more: say, in round numbers, that everything connected with the boring costs £1 per foot, it would show that £14,234 had been spent in prospecting with these drills in four years; and of this amount £12,081 has been spent in the Stawell District. It may be said that £1 is in excess of the actual cost per foot; but when their working is further analyzed, the wages and everything taken into consideration, it must, I think, be admitted that £1 will be about the minimum cost of boring in silurian rocks, three shifts of men being employed at the following wages per day:—

	£	s.	d.
Engineer in charge of drill (£4 per week)	0	13	4
Two foremen, at 10s.	1	0	0
Six assistants, at 8s.	2	8	0
Estimated expense of repairs and loss of diamonds (£10 per week) (this is taken from estimate in late Victorian regulations and present regulations of New South Wales)	1	13	4
Fuel and oil, &c., say	1	0	0
Total	£6	14	8

Deducting the cost of fuel and oil from the number of days employed in shifting—namely, 323—being about 2s. 10d. per day, the daily cost of working is reduced to £6 11s. 10d.; and, taking the average work done per day at 6ft. 3in., it makes the cost to be £1 1s. per foot.

The working of diamond drills in prospecting for gold in quartz in Victoria has not hitherto been marked with great success, and it is questionable if they can be employed in prospecting quartz-lodes in New Zealand with any better results, on account of the broken nature of the reefs, which are far more in bunches and detached blocks, and do not run so regularly as they do in Victoria.

Surface diamond drills have been very little used in prospecting quartz-lodes. Only seven bores have been put down: out of these the rods broke in three of the bores and were not recovered.

The following table shows the results of surface diamond drills in prospecting for gold in quartz-reefs in Victoria:—

Name of Company.	District.	Number of Bores.	Depth bored.	Time Employed in Actual Boring.	Average Depth bored per Day.	Remarks.
			Ft. in.	Days.	Ft. in.	
Garden Gully ..	Sandhurst	1	440 4	86	5 1½	
G. G. Consolidated	"	1	825 6	153	5 5	Gold seen in pieces of core. Work stopped on account of rods breaking and not being removed.
Moonta	"	1	706 6	122	5 9	No gold seen.
Cumberland Reef ..	Castlemaine	1	424 0	43	9 10	The bore was stopped on account of rods breaking and not being recovered.
Cymbeline Prospecting	Malmsbury	1	427 2	44	9 8½	Got colour of gold on crushing and washing small piece of core. Bore abandoned owing to tubing having parted and dfficulty in getting rods down.
Ditto	"	2	355 6	59	6 0	Got colour of gold by crushing and washing small piece of core. Bore abandoned owing to rods breaking and not being recovered.
"	"	3	302 11	70	4 4	Bore not bottomed.
			3,481 11	577		

This would average about 6ft. 1in. per day during the time that the drill was actually at work; but if the shifting and fixing in position were taken into account it would reduce the amount of work done per day more than that shown by the shifting of the underground drills.

These drills have been very successful in going through basaltic rock, sandstone, and shale, or through any rock of a uniform character: the harder the rock the better suited they are for boring. They have been the means of proving the existence of alluvial leads of gold under the basaltic rock in the Creswick District in Victoria, which is now being worked, and proved to be the best for alluvial mines in that colony at the present time. The Madam Berry Mine was first tested with a diamond drill: several bores were put down which gave satisfactory results. A shaft was bottomed in

September, 1880, from which was washed 28oz. of gold. Since then 93,426oz. of gold have been obtained, £209,700 paid in dividends, and £29,000 in royalty to the proprietors of the freehold where the mine is situated; and since this discovery numerous mines have been opened in that district, all giving handsome returns. These drills have likewise been very successful in finding coal in New South Wales; but they do not seem to have been greatly employed in that colony in boring through metamorphic-schist formations, or if so, I could not get returns to base any data upon.

With respect to their use in New Zealand, the surface-drills could be utilized to advantage in testing the coal measures, and likewise they might be advantageously employed in searching for marble, good building-stone, &c.; but, as far as testing the quartz-reefs is concerned, the rough and broken nature of the country, where no roads exist, is in itself a sufficient bar to their being used to any profitable advantage. In the Australian Colonies they can be comparatively easily transported to any part; but in New Zealand the quartz-reefs are so broken, and the country generally where they are found so precipitous, that prospecting can be carried on equally as advantageously by hand-labour, and especially with the use of compressed-air rock-drills.

The underground drills, being light, might in some instances be employed to advantage; but even this is open to question, as the general feeling in districts where they have been used is that it is better to prospect with compressed-air rock-drills. Notwithstanding this, where there is a large body of water to contend with, such as that found in the deep levels at the Thames, they could be employed to advantage, the formation there being an igneous rock, better suited for their use. In the Australian Colonies there is very little water to contend with in comparison to what there is in the deep quartz-mines at the Thames, and accordingly the cost of prospecting is considerably less.

The Victorian Government have ten surface diamond drills, five of which were manufactured in the colony at a cost of £1,250 each, including boiler; and five underground drills, four of which were also made in the colony at a cost of £1,100 each, including air-compressor: but it must be borne in mind that this price does not provide for any duplicate parts, and only 200ft. of rods, which is the recognized length supplied with drills in America and in the Australian Colonies. Anything over that length is considered extra, and charged for accordingly.

The regulations issued by the Department of Mines and Water Supply, dated Melbourne, the 1st August, 1884, for the use in Victoria of these drills are as follows:—

"1. Every application for the use of a drill shall show for what purpose the machinery is required, and shall contain an undertaking on the part of the applicants to make good all losses for diamonds, to keep the machinery and appliances while under their charge in good order and condition, and, whenever required by the Minister, to return them to the Department of Mines in a perfect state of repair; and, further, to give such other guarantee as the Minister may consider necessary for the fulfilment of the conditions.

"2. On the approval of an application, the drill and appliances shall be handed over to the applicants, who shall undertake such removal of the machinery as may be necessary, and also the careful supervision of the boring operations.

"3. No diamond drill shall be worked except under the direct charge and supervision of an authorized foreman; and all such foremen in charge of the working of the machinery shall be appointed by and be under the control of the Minister of Mines; and every such foreman shall be subject to removal or dismissal by the Minister if he shall be considered to have worked the drill under too great pressure, or to have caused undue destruction of diamonds, or to have been guilty of any misconduct in the performance of his duties, or if his services shall no longer be required.

"4. The rates of payment of all employés in connection with drills shall be subject to the approval of the Minister.

"5. Any company working a drill shall defray the cost of all necessary renewals and repairs, and of the working and removal of the machinery.

"6. All fittings needed for the drills shall be obtained either from the stock in the Department of Mines, or from some person or company who may contract with the Government to supply such fittings, so as to insure that all the renewed parts of the machinery shall be in accordance with the regulation pattern and sizes.

"7. The Department of Mines will allow the use of the drills and appliances free of all rent-charges, and will subsidize such companies employing the same for gold-mining purposes to the extent of one-half, and for coal-mining to the extent of two-thirds of necessary expenses incurred in removals, repairs, and working of the machinery, if such companies shall be engaged in prospecting operations, and shall not be working their mines profitably; but the cost of all necessary tubing shall be borne entirely by the company employing the drill.

"8. The amount of subsidy shall be based on approved vouchers of expenditure, and any claim for such expenditure may be amended, or it may be rejected if it appear to the Minister to be excessive and inadmissible.

"9. The payment of subsidy up to the amount of £100 shall be deferred, and the money shall be retained until the drill and appliances shall be handed over to the Department of Mines, and any portion of the whole amount of the subsidy so retained shall, on the order of the Minister, be applied to making good any apparent deficiency in the machinery or appliances, or in defraying any necessary cost incurred by the department through any breaches of the conditions on the part of the company.

"10. The Department of Mines will also from time to time allow the use of diamond drills and appliances to companies who may be working their mines at a profit; and the use of such drills and appliances shall be subject to these conditions, except that no money subsidy shall be allowed in part payment of the working and other expenses of the machinery.

"11. The machinery shall at all times be subject to the inspection and supervision of the Superintendent of Drills or any other officer authorized by the Minister, and mining operations shall be suspended or absolutely discontinued, and the machinery shall be removed from the control of the company, at any time on the order of the Minister.

"*Note.*—Not more than three drills shall be used at any one time in boring for coal."

The New South Wales Government have eleven diamond drills, besides five Tiffin augurs, which have been employed very successfully in boring for coal and water. Nine of these were purchased from the Australian Diamond Drill Company, and were manufactured by the Mort's Dock Company in Sydney; the other two were purchased from America. The two latter machines are constructed on quite a new principle, and are adapted for both surface and underground work. The engines that work these drills are compound, having feed-gear that can be altered as the boring is going on. The rods are coupled so that by half a turn of the wrench they can be disconnected, and a register is connected with the thrust, so that the pressure on the diamonds can be indicated on the surface. Mr. W. B. Henderson, the Superintendent of Drills in New South Wales, in a long conversation I had with him on the subject, while speaking highly of the colonial-manufactured drills, states that the American drills are superior in many respects; and in his report to the Government on the improvements of these drills, with regard to the self-registering apparatus he says: "This is an improvement of the greatest importance in work, and cannot fail to decrease the cost of boring, as by means of this register it is believed that the loss of diamonds will be much reduced. I anticipate that these improvements will enable boring to be carried out in the underground workings of the inland mines at such reduced rates as to cause a keen demand for the use of these machines."

The cost of boring per foot in New South Wales, which has been principally through sandstone, conglomerate, chert, and shale, has been a little under 13s. per foot, including all expenses connected with shifting the drills and boring. This corresponds with the cost in Victoria whilst the drills were employed in boring through similar strata, the cost given in Mr. Langtree's report being 10s. per foot for sandstone and 14s. per foot for basaltic rock. The American drills were manufactured by Mr. C. Bullock, 31 and 33 South Canal Street, Chicago, Illinois, and cost about the same as those manufactured in the colony. In visiting Mort's Dock Company's Works, to see the drills they were manufacturing and likewise the La Monte smelting-furnace, Mr. Mort, the managing director of the company, kindly supplied me, at Mr. Kahlo's request, with plans of the smelting-furnace, and likewise gave me the prices that those drills could be supplied in Sydney for, which are as follows:—

	£	s.	d.
A machine capable of boring a $2\frac{1}{2}$in. hole 2,000ft. to 2,500ft. ...	850	0	0
A similar machine boring 1,500ft.	800	0	0
One boring 1,000ft.	712	0	0
Boiler mounted on carriage complete (plan attached)	340	0	0

This would make the total of price of a machine to bore 2,000ft. £1,190; but it must be borne in mind that this price only includes 200ft. of rods. The items included in this sum are 200ft. of rods, 3 blank diamond bits, 1 core-lifter, 1 core-barrel 10ft. long, 1 water-joint hose, 1 safety clamp, 1 lifting-shackle, donkey-pump and drill with boiler mounted on carriage (but exclusive of carbons). Rods with couplings will be charged extra at the rate of 5s. per foot for $2\frac{3}{8}$in. and 4s. per foot for $1\frac{7}{8}$in. rods.

The New South Wales Government do not grant any subsidy for the working of the diamond drills, but simply lend them out to any one requiring them, charging the actual cost of working expenses, whereas the Victorian Government pay one-half of the cost of working whilst employed in prospecting for gold, and two-thirds the cost in prospecting for coal.

The following are the regulations in force in New South Wales for the use of diamond drills, issued 30th November, 1883:—

"1. Applications for the use of diamond drills must be in writing, addressed to the Under-Secretary for mines, accompanied by a deposit of £2 2s. towards the cost of inspection. If an application be refused without inspection having been made, the deposit will be refunded.

"2. Each applicant must state the mineral to be bored for, the probable depth to be bored, and whether the work is to be confined to one or more holdings owned or occupied by the applicant, or to be spread over a tract of country for prospecting purposes; and in either case a plan or sketch, or description, defining the holding or tract of country to be operated upon must accompany the application. Upon receipt of any such application and deposit, the Minister for Mines may direct an inspection and report to be made, or he may refuse the application without inspection or report.

"3. Applications approved of will be dealt with in the order of priority.

"4. Before commencing operations the Minister may require the applicant to deposit a sum of money as security that the conditions will be observed and the payments duly made.

"5. The person to whom the use of the drill is granted must (*a*) defray the cost of removing the drill and all necessary appliances from the place where standing to the site of operations, and placing it in position thereon; (*b*) supply or defray the cost of all necessary fuel and water for working the drill; (*c*) pay the cost of any tubes that may be damaged or destroyed, or cannot be withdrawn from the bore; (*d*) pay £10 per week to cover the cost of diamonds, and wear and tear of machinery; (*e*) pay the actual wages of the foreman and labourers working the drill.

"6. Payments shall be made on demand or within fourteen days thereafter, and upon failure to do so the drill may be withdrawn, and the money deposited applied to payment of amount due.

"7. Persons preferring to pay for the work by the foot instead of the foregoing rates may, on application, state that fact, and the Minister may, if the site be considered suitable, cause a price per foot to be fixed for various depths, such price to include the cost of all labour, diamonds, wear and tear of machinery and all material except tubing, and shall be inclusive or exclusive of cost of fuel and water according to agreement."

Coal-mining.

The only coal-mines that I have seen in New Zealand resembling in character and nature of the coal in the Newcastle district are the mines on the west coast of the Middle Island; but even these are different in some respects. The dip or inclination at which the seams or beds of coal lie is considerably greater than in New South Wales, and there are likewise a far greater number of faults and rolls to contend with in New Zealand, which will always make our coal-mines more expensive to work. The great inclination that our seams or beds of coal have requires larger pillars left in cutting up the the blocks in the first instance, so as to guard against a "creep" taking place. However, this is no disadvantage, as it will allow the coal to be easier taken out of the pillars when they come to be worked. The faults and rolls which occur in all manner of forms prevent our mines being worked in as regular a manner as those in New South Wales. But, at the same time, if sufficient care and forethought is taken, even with these difficulties our mines can be opened out in such a way that the whole, or nearly so, of the coal will ultimately be won. This is a subject which should receive the special attention of the Government, not only because these mines are the property of the Crown, but also because they are the most important bituminous coal-measures of New Zealand.

Underground Haulage.

The system adopted in New South Wales is known as the "tail-rope," but it is a question whether this plan of haulage is superior to the endless-chain system adopted in the Westport Coal Company's mine at Waimangaroa. Each of these systems has its advantages and defects.

The tail-rope can be used more advantageously than the endless chain where there are sharp bends and curves in the road, or where there are several branches of the main tunnel; and, although the expense of machinery to work it is more than that required to work an endless chain, this is compensated for by the cost of construction of the main tunnel, which only requires a single line of rails. The first cost of a rope, from $\frac{7}{8}$in. to 1in. in diameter, made of steel wire, is much cheaper than the cost of a $\frac{3}{4}$in. chain. The length of the tail-rope must be one and a half times more than the length of an endless chain, as the tail end of the rope has to be twice the length of the hauling part. The rails for the tail-rope system likewise require to be well laid and made as solid as possible, as the velocity at which the rope travels is about ten miles per hour. The wear and tear on the tail-rope, rails, and pulleys is likewise much greater than on the endless-chain system, as well as the consumption of fuel to work the machinery. Yet, with all these disadvantages I think the tail-rope system could be employed with more success in our mines than that of the endless chain, which requires straight roads, or nearly so.

The endless-chain haulage will not work well if there are bends in the roads, unless the curves have a great radius, and even then a man is required to be alongside these curves, as the chain is always liable to come out of the forks, which grip and haul the skips by its weight resting on the bottom of the fork on each end of the skip.

The following statement shows the approximate cost of each system for one mile of haulage, exclusive of the fixing in position and cost of pulleys:—

Tail-rope System.

	£	s.	d.
Say, 16,000ft. of round steel-wire rope, 1in. in diameter, or $3\frac{1}{4}$in. in circumference = $9\frac{1}{2}$ tons, at £40	380	0	0
Two miles rails, 24lb. per yard = say 38 tons, at £10	380	0	0
Sleepers, say 2,640, at 2s.	264	0	0
Fastenings, &c., for rails, say	80	0	0
Total	£1,104	0	0

Endless-chain System.

	£	s.	d.
Say, 11,000ft. of $\frac{3}{4}$in. chain, about 26 tons, at £20	520	0	0
Four miles rails, 24lb. per yard, say 76 tons, at £10	760	0	0
Sleepers, say 1,560 double length, at 4s.	312	0	0
Fastenings, &c., say	160	0	0
Total	£1,752	0	0

The cost of the endless-chain haulage is more in the first instance; but this would be reduced by the cost of the engine, which need not be so large as that required for working the tail-rope system.

The quantity of coal that could be hauled for 1 mile per day of 8 hours by the tail-rope, allowing for stoppages and for fixing the trains, would be about 500 tons; while by the endless-chain system the quantity would depend in a measure on the elevations and depressions in the road, and the power required to do the haulage. However, the tail-rope system need not be confined to a single line of rails: the same engine could be used for four winding-drums, and thus work double lines, thereby increasing the output to 1,000 tons per day.

"Callon, on Mining," gives the cost of working these systems as follows:—

Cost per Mile per Ton in Pence.

	Tail-Rope.	Endless Chain.
Wear and tear of ropes and chains	0·276	0·083
Maintenance of way and rolling-stock	0·462	0·468
Coal	0·558	0·256
Labour	0·583	0·572
	1·879	1·379

This allows for each system hauling about the same amount per day.

Ventilation.

The ventilation in the mines I visited was everywhere good. Particular attention seems to have been paid to the subject. The air-courses are in the openings formerly made in working out the coal, and where necessary they are built securely up with brick and mortar; but, where openings have to be left to enable the workings of the mine to be carried on, they are all fitted with doors which when closed are almost air-tight.

There are several things to be considered in ventilating a mine, one of the most prominent being the amount of carbonic-acid and carburetted-hydrogen gas that may be generated in a mine; but, in order to produce a free circulation of air, "Callon, on Mining," has laid down the following fundamental principles to be observed:—

First: "To compel a current of air to follow a given course." This is generally done by placing stoppings at the entrance of each of the central galleries which cross those forming the given circuit. These stoppings sometimes consist of thin partitions of brick placed on edge, with mortar joints; sometimes of more or less thick walls of ordinary masonry, or even of dry walls. Wherever there might be a danger of these walls being destroyed by an explosion of fire-damp, they should be made tolerably thick. An ordinary wall of stowing, two or three yards thick, will resist an explosion better than a thin wall of the best masonry, because of the instantaneous shock of the explosion. A true shock is produced, which generates an effort the intensity of which cannot be calculated, but which is greater and more instantaneous in proportion as the obstruction is more unyielding. If this obstacle is quite rigid, it will most certainly be broken; but the inertia of a large and less incompressible mass cannot be overcome in a short interval of time, and this mass does not move much, nor does it acquire an appreciable momentum. If it is necessary, the barrier in the side gallery can be opened at pleasure, and a trap-door placed instead of the stopping. A single door can be made use of, if it can be opened temporarily without interrupting the ventilation; but double or even triple doors must be employed in the contrary case. The interval between any two consecutive doors should be sufficient to hold the longest train of wagons which traverse the galleries. The doors should always open in the direction in which the full wagons are travelling. They should shut of their own accord, and this is effected by placing the hinges in an inclined position. The edges of the doors which fall against the frame, and the edges of the frame against which the doors strike, ought to be lined with strips of cloth if they are required to be very air-tight. The space between the frame and the sides of the gallery should also be fiilled up, so as to prevent loss of air. The principal doors should be under the control of a "trapper," who should open and shut them as required. The doors which are opened only occasionally (like the doors leading to the furnace) should be under lock and key, and the key should be kept by the person whose business it is to look after the stoker. Lastly, it is sometimes the case that hanging-doors, or safety-doors, are placed at very important points of the workings. They are attached to hinges placed horizontally, and are supported in a suitable excavation in the roof, where they present no impediment to the passage of the air. If an explosion occurs which carries away the ordinary doors, it leaves the safety-doors uninjured; because the violent but instantaneous currents of air like those produced in an explosion are very destructive in the line of their movement, but produce no sensible effect sideways. The safety-doors can therefore be shut as soon as they are reached, after an explosion, in order to restore the air-current to its proper course. They may even be made so that they are shut by the explosion itself, if the support which holds them up is placed in such a position that the blast of the explosion drives it out. By means of these doors it becomes possible to restore the main features of the distribution of air soon after an explosion. It has also been claimed for them that they might be used for insulating faces in the workings into which the men could retreat and escape the deleterious effects of after-damp and thick clouds of dust after an explosion.

Second: "To force air into an advanced gallery which is not in the direct course of the air-current." This question corresponds to a case of very common occurrence in practice. It includes the ventilation of a sinking shaft; that of a cross-measure drift; and, lastly, that of all the galleries which are pushed forward for purposes of exploration. The general solution consists in the establishment of two distinct air-ways in the cul-de-sac which constitutes the working-place, one serving the purpose of conducting the air-current (or part of it) to the face, the other serving to bring it back to the main air-way again. For this purpose an air-compartment is formed, either by means of boards placed horizontally or vertically, or a thin brick brattice is built, or a brick arch; or, if the place is large enough, a mass of stone is built along the middle; or, lastly, if there is plenty of air and no necessity for husbanding it, loose cloth may be hung from the roof to the floor along the line of the galleries. Again, if the gallery is narrow, air-boxes made of wood, or pipes made of sheet-iron or zinc, may be substituted for the brattice. These are joined end to end, and either lie on the floor or are suspended in the angle of the timbering by means of two small pieces of boards. Lastly, one of the methods very often resorted to, more especially in exploring-galleries in coal-seams, is to drive two parallel drifts, having a barrier of several yards in thickness between them, and to make a cross-cut through the pillar every now and then, as it is required. The last cross-cut serves to introduce the air from one drift into the other, and the previous cross-cut is stopped up or stowed up as soon as the new one is completed. All these methods are commonly used in mines. They can always be employed in such a way as to bring a current of air as close to a given point as may be desired. One method or the other can be adopted, according to the degree of difficulty or danger which a particular place may present. In order to produce a current of air in galleries divided in the manner described, the point at which the air enters them requires to be separated from the point at which the air leaves them again on its return back from the face. This is effected by either completely or partially closing the passage which the air would naturally take, and so forcing it to take the way that has been prepared for it. This may be done in some cases by means of a single or double trap-door, or by a fixed brattice, or by a simple cloth stretched across the gallery.

Third: "To cause two or more currents to circulate in the same gallery, and travel either in the same direction or in opposite directions, without allowing them to mix with each other." The solution of this question (of which the preceding one was only a particular case) is obtained by simply dividing the gallery into as many compartments as there are separate air-currents.

Fourth: "To cause one current of air to cross another one without mixing with it." The general method consists in taking down the roof of one of these galleries for a certain distance on each side of the point of crossing, and at that point to make an artificial roof by means of an arch of masonry or a timber platform at the height of the original roof, and, lastly, to cause the air-current to cross over in the empty space existing above the arch or the planks. The insulation of the current is completed by setting up two stoppings, or by two single or double doors under the part in which the roof has been taken down, according as it is necessary to stop the air or allow it to continue travelling through the gallery.

Fifth: "To preserve a passage for air amongst old workings." It may often be necessary to preserve a passage for air through the old workings, for the sake of shortening the distance which the air has to travel. For instance, if the method of working is one by which falls of roof are liable to occur, the gallery so preserved will require to be maintained by strong timbering, and it should be low and trapezoidal or rectangular in section. It should be surrounded on the sides and top with a certain thickness of stowing taken from the adjoining waste; and when the heavy falls of roof take place ultimately this stowing will resist the impact of even large masses of roof, and the gallery will be able to be kept open for a considerable time. If the method is with stowing, the air-way will be simply a gallery left in the midst of this stowing. If the air-way which has to be preserved is of little importance it can be made by means of wooden boxes or iron pipes, around which stowing is carefully packed; and this will prevent the pressure causing them to collapse when the body of the stowing is subject to the weight of the roof.

Sixth: "To compel a current of air to divide itself between two galleries in a given proportion." When an air current arrives at a point where two galleries branch off and constitute separate passages until the "upcast" shaft is reached, it rarely happens that these two air-ways are identical in every respect. They may differ as regards their length, or their section, or their temperature, which they impart to the air in passing through them. The result is that one of the air-ways offers less resistance to the air than the other. The air takes the easier way, and is therefore more or less withdrawn from the more difficult passage, which may be the very one requiring the larger supply. Where the difference of resistance is very considerable, so is the difference in the proportion of air which traverses each of the galleries.

For example, if a direct passage were opened between the downcast and the upcast shafts, the whole of the air would travel through it, and the distant working-places would be ventilated by diffusion only. The same result might follow if a door was not sufficiently air-tight; because the resistance offered by the door to the passage of the air might not be so great as that encountered in a long air-way. It is evident, therefore, that the air ought to be divided at a point where the two air-ways branch off, according to their individual requirements. This is done by leaving the more difficult passage entirely open, and placing the door (having a regulator in it) in the other one, varying the regulator as required. It often happens that an ordinary door is sufficient, either on account of leakages, or on account of the quantity of air which passes through it when it is opened for the requirements of traffic.

Mining Surveys.

VICTORIA.

The mining surveys in Victoria are all done by officers of the Mines Department, and plans and record of every survey are in the head office in Melbourne. The system on which mining surveys are conducted is as follows:—

There is a Mining Surveyor appointed for every mining district, who holds a certificate of competency; but these surveyors do not receive stated salaries—they are paid by fees fixed by regulation, as follows:—

Mining Leases or Claims.

	£	s.	d.
Surveying boundaries of any block under twenty acres	3	3	0
Twenty acres and under forty acres	4	4	0
Forty acres and upwards, at per mile of boundaries	3	10	0
Interior lines, to fix the position of objects within the block, at per mile	2	10	0
Connection to nearest fixed point, at per mile	2	10	0
Travelling expenses to the block to be surveyed, for any distance after the first three miles from the Mining Surveyor's office, at per mile one way	0	4	0

Water-right Licenses Regulations.

	£	s.	d.
Survey of water-races or channels not exceeding half a mile in length	2	0	0
Exceeding half a mile in length, at per mile	3	0	0

These are the fees paid for mining surveys in all districts with the exception of Gippsland, where the fees are about double the above rates, and the travelling expenses 5s. per mile one way after the first three miles from the Mining Surveyor's office. These fees include in all cases the making and furnishing of plans and reports.

When Mining Surveyors are required to do any work outside mining leases, &c., they are paid £2 per day, and 15s. per day is allowed for travelling expenses when away from home, in addition to the cost of locomotion; they are likewise paid for any necessary labour that they may employ, and assistance to prosecute the work.

The mining surveys are all made with a theodolite, but on magnetic meridians; and the surveyor, in sending in his plan, has to show the variation between this and the true meridian. He has likewise to send in the calculation of the area of the block, deduced from the meridian and perpendicular distances.

In making inquiries as to why the surveys could not be done by the Survey Department, Mr. Langtree informed me that in many instances where these surveys had to be made the officers of the Survey Department were engaged at other work, and left the mining surveys to stand over for such a length of time that before the ground was surveyed the applicants were put to a deal of inconvenience, and had in some instances left the district. This led the Mines Department to have officers of their own for this special work.

NEW SOUTH WALES.

The mining surveys here are partly done by the Mines Department and partly by surveyors authorized by the Survey Department; but, as the latter are paid by fees, and the mining surveys are frequently in widely-dispersed localities, which will not pay the authorized surveyors, they are, as a rule, executed by salaried surveyors of the Mines Department. These are divided into two classes—namely, first class and second class. The first-class surveyors receive a fixed salary of £300 per annum, with an equipment allowance of £100 and travelling allowance of £300, and all fees, together with railway fares for self and one man. Surveyors of this class are employed in making isolated surveys, and have to travel over large areas of the colony. Second-class surveyors receive a stated salary of £300 per annum; equipment allowance, £100; travelling allowance, £100, and all fees, together with railway fares for self and one man; but surveyors of this class have not so much travelling as those of the first class.

In each of these cases the plans are drawn by the department; but the surveyors pay their own men. Each Mining Surveyor before being gazetted must pass the Surveyor-General's examination.

The fees to surveyors are as follows:—

Gold-mining Leases.

	£	s.	d.
Less than 1 acre	1	0	0
Exceeding 1 acre and less than 5 acres	1	10	0
Exceeding 5 acres and less than 10 acres	2	0	0
Exceeding 10 acres and less than 20 acres	3	0	0
Exceeding 20 acres up to 25 acres	3	10	0

Mineral Leases.

					£	s.	d.		£	s.	d.
20	acres and less than	40	acres,	if isolated,	4	0	0;	when conterminous,	3	0	0
40	"	80		"	5	0	0	"	3	15	0
80	"	160		"	6	0	0	"	4	10	0
160	"	320		"	7	0	0	"	5	5	0
320	"	640		"	8	0	0	"	6	0	0

Lineal measurements are paid at the rate of £1 10s. per mile.

The same system prevails in New South Wales as in Victoria—namely, that all surveys have to be made with a theodolite on magnetic bearings; but the surveyor has to show the variation between this and the true meridian. When isolated surveys are made they are connected to some permanent object, as a rock, &c., as there are no trigonometrical stations in the interior to connect them with; but where a number of surveys are made in one locality they are connected one on to another.

The instructions sent to Mining Surveyors from the Chief Mining Surveyor of the colony are, "That they are to make connections to some fixed points on a previous survey made under the Crown Lands Amendment Act, or to some survey known by the surveyor to have been so connected. If there are no surveyed lands within a reasonable distance some conspicuous object of a permanent nature may be used. This system is not all satisfactory, as the variation shown between the magnetic and true meridian differs with each instrument employed: there are scarcely two instruments that will show the same difference. These compass surveys will inevitably lead to future litigation, as we have experienced in former years in New Zealand in the case of Blue Spur, Otago, where thousands of pounds were expended in settling a dispute on boundaries through magnetic surveys. The trigonometrical system of survey now in operation in New Zealand is the only effective means of definitely defining areas so as to prevent any doubt or confusion in the future as to boundaries.

The systems adopted in both New South Wales and Victoria are, to say the least of them, very loose, and they bear no comparison with regard to efficiency to the New Zealand system. There is no doubt the surveys in those colonies are conducted on a cheaper scale than in New Zealand; but the nature of the country, which is comparatively level, with open bush and large plains, would admit of this in any case, even if they adopted our system: whereas our mining country is in most instances very rough and broken, and in parts densely timbered, with thick under-scrub. Although the surveys in the Australian Colonies I visited are cheaper in the first instance, they will ultimately have to adopt a system similar to ours; in fact, their officers admit this, and state distinctly that our system is the most perfect in any of the colonies. The longer they continue on the present course the greater the complications will become as the country gets settled. Our survey system is beyond doubt far superior to that in practice in the colonies I have recently visited; and, as all our mining districts are now triangulated, surveys can be accurately and promptly executed.

Organization of Mines Departments.

In Victoria the Secretary for Mines and Water Supply is also Chief Mining Surveyor and Chief Inspector of Mines, having under him Geological and Mining Surveyors, Inspectors of Mines and Water Supply, Mining Registrars, and a Superintendent of Drills. At every Mining Surveyor's office there is a book in which is entered every survey made, with the date that he first received instructions, the date of survey made, as well as all the dates at each stage the survey goes through, until the plans are made and copies forwarded to the head-office in Melbourne.

In the head-office there is a chief clerk, an accountant, with several assistants and draftsmen. Complete records are kept here of everything that transpires relating to the Mines Department.

When the Crown Lands Department desires to dispose of lands for sale within goldfields boundaries, it sends notice of its intention to the Secretary for Mines and Water Supply, with plan showing the lands proposed to be sold; and if he, after making inquiries, finds that the sale of such lands would be prejudicial to the interests of the mining community, the land is not offered for sale.

The Government assist in making roads on goldfields, something in the same manner as in New Zealand. They sometimes give grants, but in most cases subsidize Shire Councils, on approved works, from one-half to two-thirds the cost. The work in almost all cases is done by the Shire Councils, who employ certificated engineers, and the Government pay the money as the work progresses on the certificates of those engineers, the Government having officers of its own who occasionally visit the localities to see that the works are properly carried out.

The Diamond Drill Branch incurs a considerable expenditure every year, inasmuch that it subsidizes boring to prospect for gold to the extent of one-half the cost, and in prospecting for coal to the extent of two-thirds the cost, as they employ a number of those drills. It has always on hand a large supply of tubing, duplicate parts of drills, with all necessary appliances to work them; and it likewise keeps a considerable stock always on hand of boarts and carbons.

In New South Wales the official head of the Mines Department is the Under-Secretary, who has under his control the Geological Survey Branch, Mining Surveyors, the Examiner of Coalfields, who occupies the position of Chief Inspector of Mines, Inspectors of Mines, Mining Registrars, and a Superintendent of Drills.

In the head-office in Sydney there is a chief clerk, an accountant, with assistants, Chief Mining Surveyor, Geological Surveyor in Charge, and draughtsman. The Chief Mining Surveyor issues all instructions with regard to mining surveys, and has the field-notes of the Mining Surveyors all forwarded to him at the head-office, where all the plans are drawn: the Mining Surveyors only have to do the field-work, and each branch of the department keeps complete records of all plans and anything that transpires connected with its functions. The Diamond Drill Branch conducts the boring operations, and puts down bores in various places, approved by the Geological Surveyor in Charge, entirely at the Government expense; but if any company or person requires these drills to prospect with, or to bore for water, they have to pay the whole cost of working, repairs, and shifting. In cases where the drills are used in boring for water or for prospecting they are made self-supporting.

All roads and other works required throughout the country are constructed by Government. There is a Chief Engineer of Roads, another in charge of railways, and another in charge of harbours, water-works, and river improvements; and all the different works are carried on by the officers belonging to the branch which each class of work comes under. But, as far as roads are concerned, in the interior of the country they mean only the bush and scrub being cleared for one chain wide. There are very few macadamized roads. As an illustration, during the last three weeks I was in New South Wales I travelled about 1,200 miles in coaches, and through the whole of this distance the coach-horses had no shoes.

School of Mines.

This is a subject which deserves considerable attention. In New Zealand a variety of minerals is known to exist. Nature has so formed her that, whilst having valleys, plains, and low undulating country suitable for agricultural and pastoral pursuits, the mountain lands contain the mineral wealth, and are at present looked upon as of very little value. But these may in reality become the most valuable lands in the colony, as the minerals are only commencing to be developed.

Our mining has hitherto been confined almost exclusively to gold and coal. Of late years manganese, antimony, copper, silver, and scheelite have been found; but very little has yet been done to prove their extent. Apart from the rugged nature of the mining districts in New Zealand, the chief reason of the delay is, that the mining community is not sufficiently educated in metallurgy to be able to distinguish the minerals in the various forms in which they occur. For instance, in New South Wales, where rich lodes of silver ore have recently been found, no one unacquainted with ores would suspect the existence of silver in the lode. It would be well, therefore, that the means should be placed within the reach of our miners of attaining such a knowledge of ores, their appearance and tests, as would enable them to prospect intelligently.

The establishment of a school of mines at Ballarat, Victoria, was first suggested by Mr. Harrie Wood in 1869, and in 1870 a lease of the buildings formerly used as the Circuit Courthouse was obtained at a nominal rental for a term of fifteen years, and lecturers were appointed to impart information to students on the various subjects, which from time to time have since been augmented. Classes were held last year in elementary, inorganic, organic, and pharmaceutical chemistry, natural philosophy, metallurgy and assaying, mineralogy, geology, mining, land, and engineering surveying, mathematics, mechanical engineering, electricity and magnetism applied, telegraphy, materia medica, pharmacy and physiology, general botany, and astronomy. To suit the special requirements, an evening class has been established for training mining managers, miners, and others in the art of surveying mines and drawing mine-plans.

Fees (Payable in Advance).

	£	s.	d.
Trainees—			
Indentured for three years' professional course	105	5	0
Entrance, except on nomination by a Governor	1	1	0
Term—Applied electricity and magnetism	2	2	0
Each course of lectures in other single subject	1	1	0
Special course of lectures for pharmacists (three years)	12	12	0
Elementary course in chemistry (ten lectures)	0	5	0
Examination (pupils free)	0	2	6
Examination as captain of shift or engine-driver...	0	5	0
Examination as underground manager	0	10	6
Examination as engineer	1	0	0
Examination as pharmaceutical chemist	1	1	0
Certificate in any scientific subject	0	5	0
Certificate as mining engineer...	2	2	0
Certificate as mining surveyor...	1	11	6
Certificate as assayer	1	1	0
Certificate in inorganic chemistry	1	1	0
Certificate as captain of shift	0	10	6
Certificate as underground manager	0	10	0
Certificate as engineer	1	1	0
Certificate as engine-driver	0	10	6
Certificate in telegraphy	1	1	0
Certificate in pharmaceutical chemistry	1	11	6

The terms commence in the months of January, April, July, and October, and extend over periods of ten weeks. The institution is supported by grants from Government (about £2,000 per annum), subscriptions, fees, and donations.

A second school of mines was established at Sandhurst in 1873, which is conducted somewhat similarly to the one at Ballarat. The subjects taught are: spherical trigonometry and geodesy; geology, mining, mineralogy, chemistry, botany, and physiology; surveying, drawing-mine plans, &c.; mechanical, architectural, and freehand drawing; French, German, Italian, and Latin languages; and shorthand writing. The fees charged for imparting instruction in these subjects per quarter are as follows:—

	£	s.	d.
Mathematical class—			
Two attendances per week	0	10	6
Five attendances per week	1	1	0
Mechanics—			
Two attendances per week	0	10	6
Five attendances per week	1	1	0
Book-keeping—			
Two attendances per week	0	10	6
Five attendances per week	1	1	0
Surveying, two attendances per week	1	1	0
Mining managers class—			
Two attendances in the morning	1	1	0
Four attendances in the evening	1	1	0
Mechanical and architectural drawing, three attendances per week ...	0	10	6
Practical geometry, minor and senior, each	0	10	6
Chemistry lectures	0	10	6
Practical chemistry, including lectures with apparatus and materials provided	1	1	0
Metallurgy and assaying	1	1	0
Languages—			
French, twenty-six lessons	0	10	6
German and Italian, twenty-six lessons	1	1	0
Latin, twenty-six lessons	0	10	6

This institution receives a grant from Government to about the same extent as that given to the school of mines at Ballarat, and it is likewise supported by fees, subscriptions, and donations.

These schools of mines, especially the one at Ballarat, are well patronized, and have done a great deal of good in affording those who have attended them a sound technical education; but in dealing with this subject in New Zealand, what is most urgently required is a knowledge of metallurgy to such an extent as to enable miners to assay and make analyses of the various ores in order to ascertain their true value.

The establishment of a central school of mines here would be of very little value, as the class of students who could afford to attend it would be very small in comparison to the number who would avail themselves of instruction were it within their reach; and this could only be obtained by establishing evening classes in the principal mining centres. If these classes were established, miners would avail themselves of the opportunity of attending them, and they would not only be able to test the value of minerals other than gold, but likewise they would be able to test the value of the quartz-lodes containing gold by assay. In Victoria, and especially in New South Wales, the generality of mining companies have their own assayers, and where tin ore is purchased, as by the Glen Smelting Company, at Tent Hill, near Vegetable Creek, they make all their purchases by assay.

The instruction required in New Zealand need not be of so elaborate a character as that given in the schools of mines at Ballarat and Sandhurst. The simplest form whereby miners would be able to test the value of the various metalliferous lodes would be the means of opening up and profitably working minerals other than gold, and possibly do more towards developing our mineral resources with a less expenditure than any other means.

In New South Wales the only institution corresponding to a school of mines is the Technical College in Sydney, where Mr. S. H. Cox, F.C.S., F.G.S., who was formerly connected with the Mines Department here, is one of the lecturers. Mr. Cox travels about, visiting the different mining centres, and delivers lectures on geology, mineralogy, and metallurgy; but he does not hold any classes in up-country districts, his classes being entirely confined to the college in Sydney.

This is a subject which will repay a hundredfold any expenditure which may be incurred in establishing branch schools in the principal mining centres in New Zealand.

Summary.

In the foregoing remarks I have described the workings and different descriptions of mining and reducing plants that are employed in the various localities I visited, and I have also generally endeavoured to point out what may be of benefit to the mining community of New Zealand, namely,—

(1.) That the great depth of the quartz-workings in Victoria, and the different lodes that have been passed through in sinking, with the same indications still continuing, to a depth of 2,040ft. below the level of the surface (Lansell's 180 mine), encourages the hope that our quartz-mines are only yet in their infancy, requiring further prospecting to develop them.

(2.) The superiority of the processes adopted in Victoria for saving gold in concentrating and amalgamating, and likewise in the winding-machinery and safety appliances.

(3.) That the successful treatment of pyrites, and profits to be derived from its manipulation, showing that the whole of this product is allowed to run to waste in this colony, although some of the pyrites gives on assay over 11oz. of gold per ton.

(4.) The method adopted in Victoria for working alluvial leads of gold, and the system of going through drift-sand.

(5.) The price charged the miners for water, in Victoria, for sluicing purposes, being from £5 12s. 6d. to £6 per week, for a quantity equal to our sluice-head in the Beechworth District, and £2 5s. to £9 per week for a quantity equal to our sluice-head in the Castlemaine and Sandhurst Districts. The price charged in New Zealand is from £2 to £3 per head per week.

(6.) Tin-mining, and machinery employed in reducing the ore and extracting the tin, in the Vegetable Creek District, New South Wales.

(7.) Silver-mining, showing the various descriptions of ore as it is found, the formations where the lodes occur, the similarity of the formation to that of this colony, and the smelting and reduction plants for treating metalliferous ores containing silver and gold.

(8.) Copper-mining and reduction plants, showing how the ore is treated.

(9.) Coal-mining, showing method of haulage and ventilation of mines.

(10.) Hydraulic cranes, Newcastle, for loading vessels with coal; showing likewise that railway wagons for conveying coal from the mines to the port are superior to those used in New Zealand.

(11.) That air-compressors and rock-drills are everywhere advantageously used, both with regard to lessening the cost of working mines and assisting in ventilation.

(12. That diamond drills for prospecting in metamorphic schist for quartz-lodes have not been worked with great success, but that in boring for coal or through basaltic rock they have been worked very advantageously. Taking into consideration the nature and character of New Zealand, I do not think, unless in prospecting for coal, that their use would be of any great service.

(13.) The systems on which mining surveys are conducted in Victoria and New South Wales are not equal in efficiency to the New Zealand system.

(14.) The organization of the Mines Departments of Victoria and New South Wales.

(15.) The necessity of having schools of mines established in mining centres, but not on so extensive a scale as that on which they are conducted in Victoria, the instruction required being only of such a nature as will enable the miners to analyze the metalliferous ores that they find, so as to be able to test their value, and to have a knowledge of the various forms in which the different metals are found.

I have gone considerably into details of the different machinery and reduction plants that I have seen, plans of some of which are annexed, in order that any one interested in the subject may understand the principal details and have a general idea of their construction.

Conclusion.

From what I have seen in the Australian Colonies, especially in New South Wales, I am convinced that we have in New Zealand a country extremely rich in minerals other than gold; but, as our metalliferous lodes are generally in mountainous districts, which are very precipitous, having deep ravines between them, thus making it extremely difficult to prospect before roads are made, which from the nature of the country are very costly to construct and maintain, the development of our mines to any great extent cannot be proceeded with until the country becomes opened up.

Our mining community likewise has not a sufficient knowledge of metalliferous ores, and the various forms in which they occur; so, that taking the whole of these facts into consideration, it is apparent that the development of our mineral resources is bristling with difficulties, and consequently it must be a considerable time before our mining industries are so established as to attract capitalists to embark to any extent in mining as a commercial venture.

Our mining industry requires to be fostered to a greater extent than is the case in the colonies I have visited, inasmuch that the cost of prospecting here, on account of the insuperable difficulties there are to contend with, bears no comparison whatever with the cost of prospecting in either Victoria or New South Wales, where supplies can be brought almost to every place with drays and wagons. The inhospitable climate in the mountainous regions during the winter months also operates greatly against our high lands, being prospected; as, for instance, in the case of the rich finds that have recently been discovered at the Criffel diggings, although this field is in the vicinity of Cardrona, where there has been a considerable mining population for over twenty years, no one seemed to think it worth while to prospect on this high land (about 4,000ft. above sea-level). This is a low altitude in comparison to some of our mountain-ranges. Again, when the large quantities of gold that have been deposited on the ocean-beach between Okarito and Jackson's Bay (especially the Five-Mile Beach) are taken into consideration, which must have been washed down the rivers from the slips that have taken place from time to time in the mountain gorges, there can be little doubt that our high lands contain rich deposits; yet, in no instance has the gold been traced to its source.

It will take many years before our mineral resources are sufficiently developed to enable the value of the mountain-lands to be ascertained. That they will support a large mining population in years to come there can be but little doubt. The mining community will, as the alluvial gold-diggings begin to fall off, turn their attention to other classes of mining than for gold, and thus keep forcing their way back into the mountain-ranges to prospect.

Comparing our mineral resources with those in the colonies I visited, and taking the whole question into consideration, I believe this country to be equally as rich (if not more so) in proportion to its area as New South Wales, the latter colony being far richer than Victoria.

In travelling through Victoria and New South Wales I observed large engineering works of interest in connection with railways, waterworks, and harbour improvements; I likewise visited several large factories and mechanical engineering establishments; but, as these are foreign to the subject of mining, I will not refer to them further.

I have to thank the Hon. J. P. Abbot, Minister for Mines for New South Wales, and the officers of his department, for affording me every facility for collecting information in connection with my mission, and for supplying me with books and statistics connected with the colony. I have also to thank Mr. C. W. Langtree, Secretary for Mines and Water Supply for Victoria, and his officers, for affording me assistance while in that colony, and for supplying me with geological and other maps and forms, showing how the department was organized.

In both colonies I was afforded much valuable information by managers of mining companies and persons interested in mining; but where all were equally desirous of obliging me I find it difficult to select names for special mention. I would, however, particularly refer to Mr. W. C. Denovan, of Sandhurst; Mr. Alfred Cadell, of Emmaville; and Mr. Thomas G. Davey, Boorook; who were extremely anxious to afford me the fullest information in their power, and who put themselves to no small amount of trouble in doing so.

In not specially referring to the services of other persons, I trust my Australian friends will understand that I am unable to mention the name of each person to whom I am indebted for information and advice, as it would occupy too much space in this report, which, from the interesting nature of the various subjects dealt with, has, I fear, already exceeded the limits prescribed for ordinary official communications. I have, &c.,

HENRY A. GORDON,
Inspecting Engineer.

APPENDIX.

REPORT OF THE ACTING SECRETARY FOR MINES AND WATER SUPPLY, VICTORIA, ON DIAMOND DRILLS.

The ACTING SECRETARY, Mines and Water Supply, Victoria, to the Hon. J. F. LEVIEN, M.P., Minister of Mines for Victoria, &c.

SIR,— Department of Mines and Water Supply, Melbourne, 15th December, 1884.

I have the honour to submit for your information a few brief remarks concerning the introduction of diamond drills into Victoria, and the work done by them up to the 30th June last.

Imported Drills.

The first diamond drill was imported into this colony from America by the Government in the year 1878, and soon afterwards four others were obtained from the same source. Of these five drills, four were designed to work on the surface, by means of steam-power, and one was for underground work, the motive-power being compressed air. All these drills were manufactured under the patent of the Pennsylvania Diamond Drill Company, Pottsville, U.S.A. They were set to work in various parts of the colony, and so numerous and urgent were the applications received from mining companies for the use of them at that time that the Government decided to increase the number.

Colonial-made Drills.

With this view, tenders were called for the manufacture, in the colony, of ten additional drills—viz., six surface and four underground. The cost of each surface-drill, including boiler, amounted to £1,250; and for each underground-drill, including air-compressor, £1,100. The colonial-made machines, which are generally of the same design as the imported ones, are considered superior in many respects to the latter, on account of the improvements, suggested by experience, which have been added, and a summary of which is as follows :—

(1.) The bits imported as patterns from America were of brass, and the diamonds were wedged in them with copper. The first improvement was the manufacture of the bits from Lowmoor iron; but subsequently crucible steel was used, and the diamonds were imbedded in the metal, which was then hammered round each stone until the diamonds became so firmly fixed that nothing but the wearing-away of the steel could dislodge them unless they fractured. The American brass bits never bored more than 50ft., but those set in Lowmoor iron bored from 400ft. to 500ft., while the steel bits bored up to 1,312ft., without requiring to be re-set. It will therefore be readily seen that the improvement tended very much to reduce the cost of boring.

(2.) The next improvement was made in 1879, and consisted in the adoption of standard gauges for bits and all other drill appliances. Previous to this, bits and appliances of a special size had to be manufactured and kept in stock to fit each drill; but now every article made for one drill will fit every other drill of the same class to a nicety, the parts being perfectly interchangeable. The advantage of this is apparent.

(3.) The core-barrels imported with the American drills were of butt and lapwelded iron tubes, and they were continually breaking; but, on the recommendation of the Superintendent of Diamond Drills, the department obtained some weldless steel tubes, which have been found to answer remarkably well, causing no trouble.

(4.) Another improvement consists in the adoption of a method of working the valves of the drills so as to admit of using the steam expansively, thus effecting a saving of nearly one-third in the cost of fuel.

(5.) Previous to 1880 no known means existed for ascertaining the pressure which the diamonds were subjected to in boring. It was entirely a matter of guess-work on the part of the foremen of the drills, until Mr. Palmer, the Superintendent, succeeded in affixing to each machine an indicator, by the aid of which the pressure can be seen at a glance, and varied as desired. This improvement is highly valued by the foremen, as it enables them to avoid over-pressure, which is so destructive to diamonds.

(6.) Formerly great trouble was experienced in working the underground-drills, caused by short pieces of hard core breaking off in the bottom of the bore-hole and rolling under the diamond bits. Days were frequently wasted without the workmen being able to break the fragments of core or get them to the surface, until the Superintendent devised differently-shaped bits, which, instead of being in three parts, after the American pattern, were in one piece of less than half the length of the imported bits, and having the core-breaking ring close to the bottom. These new bits, which are now made from weldless steel tubes, rarely fail to bring up the whole of the core, and they cost only 11s. 3d. each, as compared with £3 6s., the price of the imported bits.

(7.) The Superintendent has also devised certain tools for recovering broken rods in a bore, and the appliances were found to suit admirably recently at Portarlington, where a drill had penetrated to a depth of 474ft. 10½in. in search of coal-seams. The rods had broken in the bore-hole and the ends had fallen into a cavity in the side, and baffled every attempt to remove them until the tools were constructed and used. The abandonment of the bore, which at first seemed inevitable, would have involved a very serious loss of time and money.

(8.) Another improvement, which, however, has as yet been applied to only one of the drills, is the substitution of an iron tubular derrick for a wooden one. This iron derrick has been in use for a long time, but is none the worse for wear; and it can be taken down and re-erected in one-third the time required for the wooden ones.

(9.) The latest improvement is the addition of an air-vessel to prevent the jumping of the rods, so destructive to diamonds. The foreman of the drill to which this appliance was first attached writes: "I have fitted the air-vessel on the hydraulic cylinders of the drill, and I find it to be of great advantage in rubbly and broken rock, as it greatly reduces the wear and tear on the machinery and diamonds."

(10.) The Victorian drills also differ from the American, in that the former are portable, being mounted on wheels with tires 7in. by 1in. Altogether they are stronger, more simple in construction, and considerably less costly than those imported.

Surface and Underground Drills.

The surface-drills are said to be capable of boring 2,000ft., but up to the present time the deepest bore put down by any of them for this department is 1,501ft. 2in. This was at Portarlington, where the drill was employed searching for coal-seams. The underground-drills are capable of boring either vertically, horizontally, or at any required angle. The longest bore put in by any of them for this department up to the present time is one for the Oriental Company, at Stawell, which was put in a depth of 530ft. 5in., commencing at a level in the company's shaft 1,505ft. from the surface.

Work done by Drills.

Up to the 30th June last the number of bores put down by all the diamond drills belonging to this department, in searching for gold, was 181, and the aggregate depth 61,201ft., or about eleven and three-quarter miles. The number of bores put down in search of coal-seams was sixteen and the aggregate depth 13,165ft. 4½in., or about two and a half miles. The drills have been used by forty-six gold-mining companies in various parts of the colony, and by seven coal-prospecting companies. Several of the drills have been idle for various periods at different times since their introduction into the colony, and some are at present unemployed. Full particulars of the bores put down by each drill, the locality in which it was employed, and the strata pierced in every case, will be found in Appendix A.

Size of Bits.

The size of the diamond bit used with the underground-drills is 1¾in. Each bit usually contains twelve diamonds, six on the crown, with three on the inside and three on the outside clearances. Boart diamonds are considered best for the clearances, and carbon for the crown. In boring from the surface, bits of 5in. diameter are first used, and as the bore becomes deeper it is often lined with thin iron tubes to prevent the sides falling in, and continued with bits of smaller diameter. A bore started with a 5-inch bit may be continued with bits decreasing in size to 4in., 3in., and 2in., owing to the necessity that frequently exists of introducing sets of tubing at different depths. The number of diamonds inserted in each of these last-mentioned bits is, as a rule, twenty, sixteen, twelve, and twelve respectively.

Work done by Bits.

Several of the bits used have bored over 500ft. in depth, and one, employed in coal-boring at Colac, bored as much as 1,450ft. with the loss of only two or three diamonds; while others have been destroyed after boring only a few feet. Much depends on the nature of the strata pierced, the quality of the diamonds, and the mode of setting them in the bits; and a good deal depends also on the skill and care of the operator in charge of the machine.

Diamonds.

With regard to diamonds used in boring, it may be mentioned that those which experience has shown to be most useful are, for underground-drills, Brazilian boarts as nearly globular in shape as possible, and Brazilian carbons as nearly cubical in shape and as smooth and free from sharp angles as they can be obtained. The carbons should weigh from ½ to 2 carats each, and should, when fractured, show a clear steel-grey colour, with very fine grain, and great hardness. For surface-drills the diamonds may be as large as 5 carats each for the 5-inch bits, down to 1 carat each for the 2-inch bits. Cape boarts, which are not one-fourth the price of Brazilian stones, have been tried by this department as an experiment; but, although they have answered fairly well in boring through mesozoic rocks (sandstones and shales) in search of coal, it is found that they are quite unfit for penetrating dense basalt in search of alluvial leads, or hard, broken schistose rocks in search of quartz-reefs.

Sites for Boring.

In selecting sites to put down bores the advantage of being adjacent to a good water supply should be borne in mind, as work cannot be done satisfactorily with less than from 500 to 1,200 gallons of water per day.

Cost of Boring.

When the drills were first introduced into this colony the prices of diamonds for drilling purposes were very much lower than at present, and of course the cost per foot of boring was comparatively less than it is now. Brazilian boarts were then obtainable at about £1 10s. per carat, and carbons as low as 17s. 6d.; but the prices at present ruling are about £4 4s. and £3 respectively, and diamonds (especially the best Brazilian boarts, known as ballas) are not always readily obtainable at even those rates. The estimated cost of boring per foot when drilling operations were first commenced was 7s. 6d. in sandstone, 8s. 6d. in basalt, and 12s. 6d. in metamorphic schist; but at the present time the cost is about 10s., 14s., and 18s. for the same descriptions of rock respectively down to depths of about 500ft.; and these rates would be exceeded at greater depths. The estimates mentioned include wages and the cost of diamonds, fuel, and water, also repairs to machinery; but not the cost of superintendence and of the clerical work connected with the management of the drills. The average number of diamonds lost and fractured per 100 feet of boring has been 2·89. The fractured diamonds are, as a rule, unsuitable for resetting, and they are sold as "splints" at about 12s. per carat.

Repairs.

The repairs and renewals required for the drills are executed under annual contracts. A copy of the contract at present in force (Appendix D) is attached to this memorandum. The cost of repairs and renewals (exclusive of diamonds) is estimated at £20 per month per drill, assuming the drill to be fully employed three shifts of eight hours each per day.

Conditions on which Drills are lent.

Prior to the 1st August last the companies using the drills were charged £10 per week for the wear and tear of machinery and loss of diamonds, and in addition they had to pay the wages of the men engaged by the department to work the machines. This was done under regulations, a copy of which will be found in Appendix B. With the view, however, of bringing the machines within the reach of poor and struggling companies and of parties of miners who might desire to prospect remote and untried localities, fresh regulations were framed. Under these latter (Appendix C) the drills are now lent to mining companies and individuals free of charge, and diamonds are supplied at current rates, half the working expenses being also borne by the Department of Mines in the case of companies searching for gold, and two-thirds of the expenses in the case of companies searching for coal. Mining companies are now also allowed to select their own men for working the drills (except the foremen), and to pay what wages they may determine upon, provided that the rates do not exceed those usually paid by the Government. The only condition imposed is, as mentioned hereunder, that the drills shall be kept in repair and be returned to the department in good order when boring operations are completed. In addition to the drills lent to mining companies, it has recently been decided to employ one drill in prospecting in each of the mining districts solely at the expense of the Government. A list of the sites already recommended for boring by the Geological Surveyor of the department is given in Appendix F.

Wages.

The wages paid by the department to drill employés are: Foreman in charge, £4 per week; second and third foremen (if two or three shifts are employed), 10s. per day; assistants, 8s. per day. A shift consists of a foreman and two assistants, working eight hours.

Deflection in Bore-holes.

It has been claimed for the diamond drill by the original manufacturers that the bore-hole made by it must of necessity be straight and true; but it is alleged by some of the companies who have used the machines that in many cases a considerable deflection takes place in the course of a deep bore: in fact it is stated that a bore put down at Stawell deviated 50ft. in 400ft. from its initial direction. The discovery of this circumstance has led to the invention of an ingenious contrivance by means of which the extent and direction of the deviation can, it is said, be determined. The contrivance is known as MacGeorge's Gelatine Test or Patent Clinograph, and it has been fully described in the newspapers of the colony, which are unanimous in the opinion that the instrument will prove useful in connection with drilling operations whenever a knowlege of the exact direction and position of the bore-hole is a matter of importance. It is also claimed for Mr. MacGeorge's invention that it is capable of affording a true indication of the strike and dip of the strata passed through by the bore. Should such prove to be the case, the fact alone would be sufficient to render the instrument valuable in the prospecting of deep ground.

The clinograph has not, however, as yet been used by this department in connection with any of the Government drills, the Superintendent being of opinion that a bore-hole started in a true perpendicular direction must continue in the same direction to the end. He accounts for the reported deviation at Stawell by assuming that the initial direction of the bore must have been slightly out of the perpendicular, the variation increasing with the depth attained. It is but justice, however, to the inventor of the contrivance to give his views regarding bore-hole deflections, and I therefore subjoin a short extract on the subject from a paper read by him before the Victorian Institute of Surveyors on the 1st September, 1883, as follows: "It is perfectly natural for those who work diamond drills and have the charge of them, who never see the course of the hole which they bore beyond the first few feet of straight, who look at each length of drill-rod in its 10ft., or 15ft., or 20ft. of sturdy stiffness as a thing which cannot bend—it is perfectly natural for such men—intelligent good workmen, proud of their instrument, which has always taken gratuitous credit for boring straight, and so rarely has its winding path opened to the light of day—to disbelieve *in toto* that drills hardly penetrate 20ft. into the strata of the earth before they begin, at first by fractions, then by inches, then by feet, and at last by fathoms, to stray off from the course they should pursue. But if such men, intelligent and observant as they are, once saw 500ft. of such drill-rods jointed end to end, and lying upon uneven ground—to which this great jointed wire will readily adapt itself, and sag and bend with ease, because of its great length and its poor inch-and-a-half of thickness—they would no longer accept the doctrine of its infallibility as preached by diamond-drill manufacturers."

General Results.

With regard to the work done by the drills generally it may be stated that the machines have been highly successful in boring in basaltic rocks for deep auriferous leads, and in mesozoic rocks in search of coal-seams; but in boring through Silurian rocks in search of quartz-reefs, great trouble has from time to time been experienced, as, owing to the rapid alternations from soft to hard rock, and the existence of small and large veins of quartz, diamonds are very liable to be broken. Furthermore, in boring down to the water-level those rocks are more or less decomposed; and it has frequently happened that the bores could not be extended without the introduction of tubing. In fact, tubing has to be used in all cases where the rocks are soft, to prevent the falling-in of the sides of the bore-holes under the influence of the water which is constantly forced down from the surface in the working of the drills. The successful issue of boring operations also depends greatly, as already stated, upon the skill and judgment exercised by the persons in charge of the machinery, in the manipulation of the valves regulating the speed and pressure, so as to avoid breakage of diamonds. Skill and judgment are also required in preserving the bore-holes from injury by the water used in the progress of boring. The working of the drills with undue haste or pressure, so as to obtain greater speed in boring, is certain to result in enhanced cost, as, apart from the injury likely to be caused to the more delicate portions of the machinery, the extra loss of diamonds alone entails expense far in excess of the benefits derived by the greater amount of work actually performed. The value of the diamonds contained in a single bit is often over £150, and it will be seen, therefore, that, irrespective of the difficulty of obtaining these stones in any considerable number, the careful use of the bits in boring so as to prevent the destruction of diamonds is a matter of the utmost importance in regard to the economical working of diamond drills.

Particular Results.

Concerning the actual results obtained by those to whom the drills have been lent, mining companies using them have been somewhat reticent; but it is known that their use has led to the discovery of gold both in alluvial and quartz, notably in the mines of the G.G. Consolidated, the Madam Berry, and the Magdala companies; and there is every reason to hope that important discoveries will be made through some of the drills now employed in searching for coal. On the whole, there can be no doubt that, under efficient management, these machines are a valuable aid to mining.

German Drill.

Another description of drilling machine has recently been brought under the notice of this department by Captain C. Wagemann of this city. It is known as the German or Fabian boring drill, and it is claimed for it that it saves $33\frac{1}{3}$ per cent. of the cost of boring with diamond drills.

It is ferther alleged that it is by far the quickest borer, and is capable of putting down a 7-inch bore-hole over 6,000ft. in eighteen months. This department communicated with the Agent-General in London to obtain full particulars respecting this kind of drill; but the answers obtained to inquiries made of commercial firms in different parts of Germany go to show that, whilst the German drill would be a useful machine for boring in alluviums for water or for deep leads of gold, where basaltic rock had not to be penetrated, it would not be suitable for such work as the diamond drills have hitherto done in Victoria.

Water-boring Machines.

In addition to the diamond drills the department employs two descriptions of water-boring machines namely, the Tiffin machines and those known as Wright and Edward's. A short synopsis of the work done by these machines will be found in Appendix E.

I have, &c.,
C. W. LANGTREE,
Acting Secretary for Mines and Water Supply.

The Hon. the Minister of Mines, Victoria.

SYNOPSIS of BORING done with the Diamond Drills up to 30th June, 1884.

	Total No. of Bores put down.	Aggregate Depth of Bores. Ft.	in.
Surface-Drill No. 1	32	8,920	9
Surface-Drill No. 2	43	14,105	0
Surface-Drill No. 3	31	11,596	8
Surface-Drill No. 4	8	2,793	8½
Surface-Drill No. 5	8	2,700	0
Surface-Drill No. 6	9	3,668	9¾
Surface-Drill No. 7	19	7,495	1
Surface-Drill No. 8	4	2,154	6
Surface-Drill No. 9	5	4,409	10
Surface-Drill No. 10	2	2,210	0½
Totals	161	60,054	4¾

	Total No. of Bores put in.	Aggregate Depth of Bores. Ft.	in.
Underground-Drill No. 1	13	5,593	4
Underground-Drill No. 2	3	1,111	1
Underground-Drill No. 3	6	1,938	5
Underground-Drill No. 4	3	1,221	8
Underground-Drill Nc. 5	11	4,447	9½
Totals	36	14,312	3½

	Ft.	in.		Miles.	yds.	ft.	in.
Surface-Drills bored	60,054	4¾,	or	11	658	0	4¾
Underground-Drills bored	14,312	4½,	or	2	1,250	2	3½
Total boring done	74,366	9¼,	or	14	148	2	8¼

NOTE.—The appendices and contracts referred to in Mr. Langtree's report are attached to the Victorian Report on Diamond Drills.

By Authority: GEORGE DIDSBURY, Government Printer, Wellington.—1885.