1887.

NEW ZEALAND.

GOLDFIELDS, ROADS, WATER-RACES, AND OTHER WORKS IN CONNECTION WITH MINING

(REPORT ON).

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

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(REPORT ON).

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

Mr. H. A. GORDON, F.G.S., Inspecting Engineer, to the Hon. W. J. M. LARNACH, C.M.G., Minister of Mines.

SIR,— Mines Department, Wellington, 5th May, 1887.

I have the honour to submit my annual report on works constructed and in progress during the year ending the 31st March, 1887, which have been either undertaken or executed under authority from the Mines Department, and also on the state of mining generally on the various fields I have visited during the past year, together with a report on the treatment of gold- and silver-ores both in this colony and in America, and on hydraulic mining.

The subjects are classified under the heads of "Subsidized Roads and Tracks on Goldfields," "Drainage- and Sludge-channels," "Aids to Deep-level Tunnels," "Aids to Prospecting," "Roads wholly constructed by the Mines Department;" "Water-races;" "Report on the Gold- and Silver-mines, Copper-mines, and Antimony-mines," in the colony; "Ores and their Formation," "Treatment of Gold- and Silver-ores," and "Hydraulic Mining;" with statistical tables showing the expenditure.

SUBSIDIZED ROADS AND TRACKS.

COROMANDEL COUNTY, AUCKLAND.

Track from Vizard's Claim towards Maribel.—This is the continuation of the road from the Matawai Battery to Vizard's claim, to join the road coming up from Fraser's Mill to the Tiki mines. The distance of track required to join these two roads is about two miles, which is estimated to cost £200, of which amount a subsidy of £133 6s. 8d. was authorized. Of this subsidy £70 has been paid.

Extending and widening Waitiai Road.—This is a track leading from Mercury Bay to Waitiai, where prospecting is being carried on. Gold was obtained several years ago in Waitiai Creek, but nothing of any importance was found until recently, when gold of a payable character has again been discovered. There are several quartz reefs in the ranges at the head of the creek, where prospecting is being carried on; but, with the exception of the new find at the head of the creek, no auriferous quartz has been found which would pay for working. The distance from Mercury Bay to Waitiai is twelve miles. There is a fair road for most of the distance, but in some places it is very steep, and in others the track is not formed. I estimate the cost of forming these portions of track and making deviations to avoid the steep places would be £400. A subsidy has been transferred from the Success track to this work, amounting to £66 13s. 4d.; but this will not complete the track on the usual subsidy principle.

Tracks, Old Saw-Mill to Awakanae and Makarau to Waiau.—These tracks form really one—namely, between Eccleston's Clearing, on the Waiau River, to Makarau Flat, on the Mercury Bay side of the range. Six miles of the track is constructed—namely, four miles on the Coromandel side of the saddle, and two miles on the Mercury Bay side. There is another contract let for the continuation of the track down the Makarau side of the range, but a considerable distance more will be required to be constructed before the communication is complete to Mercury Bay. The portions constructed and in progress are estimated to cost £1,400. Of this amount subsidies were authorized to the extent of £933 6s. 8d., of which £800 has been paid. It will cost about £600 more to complete this track through to join the Mercury Bay Road.

Track, Paul's Creek to Cabbage Bay.—This is a track to allow communication to the miners who are at work at the head of Paul's Creek. The estimated cost of the track is £200. As it was urgently required, the balance of subsidies on roads from Lynch's paddock to Matawai Battery, and from Vaughan's to Vizard's claims, amounting to £133 6s. 8d. was transferred to this work, of which £80 has been paid.

THAMES COUNTY, AUCKLAND.

Road from Sea-beach to Waiomo.—This is a dray-road from the head of Paroquet Creek to the sea-beach at the mouth of the Waiomo River. Payable auriferous-quartz reefs were discovered in June last at the head of Paroquet Creek, but, as there is neither road nor track in the locality, this road is required to allow the quartz to be conveyed to the crushing-batteries either at the Thames or Tapu. There is a road partially formed from the sea-beach up the side of the Waiomo River, to the junction of Paroquet Creek, which will require to be metalled in places and in some instances widened. From the junction of Paroquet Creek up to the quartz reefs a dray-road will have to be constructed for a distance of about a mile and a half. The work is estimated to cost £750, of which amount a subsidy has been authorized to the extent of £375.

Road, Karaka Creek to Auckland Claim, Lucky Hit.—There is a road up Karaka Creek, but a great portion of it has never been metalled, and in some places it requires to be widened. In wet weather, with dray-traffic, it becomes impassable, being simply a quagmire. A new discovery of a payable quartz reef has lately been made up Lucky Hit Creek by the Auckland Company; and this road is required to allow them to get their quartz conveyed from their mine to the crushing-battery at Grahamstown. The estimated cost of the work is £600: of this amount a subsidy of £300 has been authorized.

Track, Waiotahi towards Mercury Bay.—This is the continuation of a track leading from the head of Waiotahi Creek to Punga Flat, which has been constructed for about seven miles, but beyond this there are no tracks of any description. The track in course of construction is from Punga Flat to Gum Town, the latter place being at the head of Mercury Bay—a distance of about ten miles. A track has been surveyed, and portion of it is under construction. To complete the track for the whole of the distance would cost about £1,500; but in order to get a portion of it completed, which will open up a country which is believed to contain auriferous-quartz deposits, a transfer of balance of subsidies which was formerly authorized for road from Hape Creek to Otanui, amounting to £210 15s. 4d., has been applied to this work.

Track, Upper Karaka Creek.—This is a district where a large number of miners are employed, and it is believed that were the track extended new ground would be opened. A survey of the extension of this track has been made, and a transfer of a balance of a subsidy formerly authorized for metalling Kauaeranga Valley Road, amounting to £119 15s. 4d., has been applied towards constructing this work.

Track up Mangakirikiri Creek.—This track was in course of construction last year, and is now completed. It is one of those tracks which allow the miners to get further back into the country on foot, but is of very little use for anything else. The cost of the track has been £91 14s. 4d., of which amount a subsidy of £61 2s. 11d. has been paid.

Widening Road from Bridge over Hape Creek to Otanui Mines.—This work was commenced last year, when the mines at Otanui looked more promising than they do at present. The widening, however, of this road would have been of very little service, as it is constructed with steep grades, and the distance from Otanui to Grahamstown is too great to convey low-grade quartz to the crushing-batteries. Besides, there is a crushing-battery adjacent to the mines, at the junction of the Otanui and Mangakirikiri Creeks, with a good dray-road leading from the mines to the battery. The county widened the road for a certain distance from Hape Creek Bridge, which cost £183 17s. Of this amount a subsidy of £122 11s. 4d. was paid; and the balance of the subsidy formerly authorized, amounting to £210 15s. 4d., has been transferred towards constructing track towards Mercury Bay.

OHINEMURI COUNTY, AUCKLAND.

Waitekauri to Goldfields, Parakawai.—This is for a prospecting-track, and to enable the miners who have discovered auriferous-quartz reefs at Parakawai to get supplies brought on the ground. The estimated distance is ten miles, and the cost to clear a track is estimated to be about £400. Of this amount a subsidy has been authorized to the extent of £200.

Track to connect Tui Creek with Tramway, Waiorongomai.—This is partially a prospecting-track and partially a track to get the quartz from the Tui Creek reefs taken to the crushing-batteries at Waiorongomai. The estimated distance is about two miles, and the cost to the Piako County boundary is estimated to be £320, of which amount a subsidy has been authorized to the extent of £213 6s. 8d.

Track, Tui Creek.—This is a horse-track up to the reefs at Tui Creek from the Thames Valley side of the range. The track has been laid off in a haphazard manner, with grades far too steep to allow the track to be of any real service. It is about two miles in length, and has cost £306, of which amount the Government has paid one-half.

Extension of Karangahake Track towards Te Aroha.—This track was partially constructed by the Thames County before the Ohinemuri County was in existence. The balance of subsidy, £366 6s., has been transferred to the Ohinemuri County on the same conditions as those authorized to the Thames County—namely, £2 to £1, which will make £549 9s. to be expended on its continuation. This track will go through an auriferous country for the whole of the distance, and will do a great deal towards opening up the field.

Tramway from Karangahake Track to Railey's Battery.—There has been a new battery erected in the gorge of Waitawheta Creek, about a mile and a half above the junction of this creek and the Ohinemuri River, for the treatment of gold- and silver-ores. From the parcels of ores which have been treated it has given very satisfactory results. The side of the range from the Karangahake Track is very steep down to the creek where the battery is erected. A dray-road could only be constructed at a great expense, and the character of the country is more suitable for the construction of a self-acting inclined tramway, which is estimated to cost £400. Of this amount the Government has authorized a subsidy of £200.

Road from Gold- and Silver-mines to Battery Tramway, Waihi.—There is a crushing-battery belonging to the Martha Company, erected on the side of the Ohinemuri River at Waihi, being the only crushing-battery in the district. It is connected with the Martha Mine by a tramway, and it is from this tramway that a dray-road is required to be constructed to allow the quartz from the Union, Rosemount, Silverton, and other mines to be conveyed to the battery. It is estimated to cost £300: of this amount a subsidy has been authorized to the extent of £150.

Prospecting-track, Waitekauri.—This track is constructed from Waitekauri for some distance into the ranges, to give the miners facility for prospecting and getting their supplies. The total cost of the track is estimated at £250: of this amount a subsidy has been authorized to the extent of £166 13s. 4d.

PIAKO COUNTY, AUCKLAND.

Track from Waiorongomai to County Boundary in the Direction of the Tui Creek Reefs.—This track is to join the track that the Ohinemuri County is constructing from the Tui Creek reefs to Waiorongomai, the track being partially in Piako County and partially in Ohinemuri County. The portion in the Piako County is estimated to cost £60, of which amount a subsidy has been authorized to the extent of £30.

Track to Claims, Buck Reef.—This is a horse-track that has been constructed along the range to the Buck Reef, at a cost of £55 5s. 6d., of which amount the Government has paid a subsidy of £36 17s.

Track from Fern Spur to Butler's Spur.—This is for deviations and improvements on the original track, which was far too steep for horse-traffic. It has been constructed at a cost of £231 17s. 9d.; of which amount Government has paid £154 11s. 10d.

Track up Stoney Creek.—This is a prospecting-track up Stoney Creek, to enable the miners to get into the country in this locality. The balance of subsidies on track from Fern Spur to Butler's Spur, amounting to £108 11s. 2d., has been transferred: the total cost is estimated at £162 16s. 9d., of which amount the Governmment has paid on this subsidy £36.

HUTT COUNTY, WELLINGTON.

Track, Makara Junction to Terawhiti.—This is a horse-track from Makara Junction to the Maori gardens at the foot of the Terawhiti Range, to afford a shorter and better means of communication between Wellington and the quartz reefs at Terawhiti. The distance of track constructed is about nine miles, which has cost £337 10s. Of this amount, a subsidy of £225 has been paid.

MARLBOROUGH COUNTY, NELSON.

Track, Deep Creek to Dead Horse Creek.—This is for improving the track from Deep Creek to Dead Horse Creek, to allow machinery to be taken up to one of the river-claims near the junction of Dead Horse Creek and the Whakamarina River. The cost of this work was £68, of which amount a subsidy has been paid to the extent of £45 6s. 8d.

COLLINGWOOD COUNTY, NELSON.

Bridge over the Aorere River.—This is a horse-bridge over the gorge of the Aorere River at Salisbury's Crossing. This bridge is much needed, as the fords in the river near this point are dangerous when there is a fresh in the river. It is by this route that goods and foot-passengers get to the Quartz Ranges, where there are several mining-claims. The estimated cost of the bridge is £220. Of this amount a subsidy has been authorized to the extent of £146 13s. 4d., of which £70 has been paid.

WAIMEA COUNTY, NELSON.

Road to open Table-land Diggings.—This is a track from the valley to the top of the table-land, to enable the miners to get supplies. Gold has been found here from time to time, but nothing of any consequence has yet been got. This track, however, will tend to open up the country so that it can be thoroughly prospected. It is estimated to cost £260. Of this amount a subsidy of £130 has been authorized.

BULLER COUNTY, NELSON.

Road up the Nile Valley.—This is a dray-road of 30 chains in length, for the purpose of allowing the miners to get sawn and other timber from the bush. The estimated cost is £75, of which amount a subsidy was authorized to the extent of £37 10s.

Track, Denniston Extension.—This is a horse-track from the Township of Denniston to Mount William, where gold-workings were some time ago discovered. The total distance of track required is six miles, of which two miles have been completed and two miles are under construction. The total cost is £700; of which amount a subsidy was authorized to the extent of £400, of which sum £99 16s. has been paid.

Track, Promised Land towards Motueka.—This is the continuation of the road up the south side of the Karamea River, from the Promised Land Settlement towards Motueka. There are several miners working up the river and along the route where the track is to be constructed. The country is covered with dense bush, which renders prospecting and getting supplies a very difficult task. A 3ft. horse-track is going to be constructed for two miles from the end of the present road, which is estimated to cost £380. Of this amount a subsidy was authorized to the extent of £190. When the track is completed there will be a good track from the Karamea wharf to a point near the gorge of the Karamea River, a distance of five miles.

Track over Gentle Annie Terrace.—This is a track over Gentle Annie bluff, on the beach-road to Karamea, about one mile north of the Mokihinui River. The length of the track is 66 chains, and it is estimated to cost £200. Of this amount a subsidy was authorized to the extent of £100.

Track, North Terrace to Poverty Terrace.—This is a horse-track from the North Terrace, near Westport, to Poverty Terrace, where gold was discovered many years ago, but was considered at the time not to be of a payable character. Recently it has been prospected and a portion of it taken up again. The distance of this track is about 50 chains, which is estimated to cost £100. Of this amount a subsidy has been authorized to the extent of £50.

Track South of Brighton.—This is a horse-track south of the mouth of Fox's River, to give communication to the miners who are working on the ocean-beach. The estimated cost of the work is £140, of which amount a subsidy to the extent of £70 has been authorized.

Road to Deadman's.—This is a road along the North Beach towards Deadman's, about two miles from Westport. The estimated cost of portion under construction, which is one mile, is £200. Of this amount a subsidy was authorized to the extent of £100.

Track to Low-level Tunnel, Lyell.—This is a track 21 chains in length, along the bank of Lyell Creek, to allow horse-traffic up to the mouth of the tunnel, which is about two miles and a half up Lyell Creek from the township. The estimated cost of the work is £120. Of this amount a subsidy has been authorized to the extent of £60.

Track, Lyell Bluff to Victor Emmanuel Claim.—This track was in course of construction last year and is now completed, giving a good means of communication with the quartz claim up the valley of New Creek. It has cost £650, of which amount a subsidy of £433 6s. 8d. has been paid.

Road to Cape Foulwind.—This road was in course of construction last year, and is now completed. The cost has been £450. Of this amount a subsidy of £300 has been paid.

Track over Bluff near Little Wanganui.—This is a track over a very steep bluff, about three miles south of the Wanganui River, to avoid going over a very steep and high range. The cost of this work has been £150, of which amount £100 has been paid as subsidy.

Inangahua County, Nelson.

Track, Crushington to Globe Company's Claim.—This is a track from the Inangahua River, near Crushington, over the range to the Globe Company's mine, a distance of 2 miles 4 chains. The estimated cost is £365, of which amount a subsidy has been authorized to the extent of £182 10s., on condition that the plans and specifications were approved. The plans come to hand cannot, however, be approved, as the present surveyed line has grades for a great portion of the distance of from 1 in 5 to 1 in 7. Tracks with grades of this description can never be widened for dray-traffic, and are even of very little service for horse-traffic.

Track up Snowy Creek.—This is a track from the Grey Valley Road up the valley of Snowy Creek to a few chains above Mossy Creek. The distance is 71 chains, and the estimated cost £85 15s. Of this amount a subsidy has been authorized to the extent of £42 17s. 6d.

Track, Glenroy Terrace to Horse Terrace.—This is a track to enable the miners who are at work in this district to get their supplies brought on the ground. The distance is nearly two miles, and the estimated cost is £247, of which amount a subsidy has been authorized to the extent of £123 10s.

Track, Reefton to Big River.—This track has been in course of construction for over two years. It is now completed to the Big River, where a number of quartz claims are situated. The last portion of this road authorized was from Merrijigs to Big River. This has cost £1,754 15s., of which amount a subsidy has been paid to the extent of £1,169 16s. 8d.

Track to connect Lone Star Claim with Capleston.—This track was constructed for the purpose of getting access to the Lone Star claim, which being isolated from other claims, the proprietors had no means of getting supplies and materials. The cost of the track has been £75, of which amount a subsidy of £50 has been paid.

Track, Larry's Creek to Lyell Road, near Dee River.—A survey has been made of a track leading through the country to the Lyell Road, near the Dee River, from the end of the track from Capleston to Caledonian claim, Larry's Creek; but steps have not yet been taken to construct it. The estimated cost of this track is £1,500. Of this amount a subsidy of £750 has been authorized.

Grey County, Nelson.

Track, Red Jack's to Nelson Creek.—The length of this track is 5 miles 8 chains. Commencing at Blackwater Creek, near its junction with Red Jack's Creek, it goes across the country and joins on to the end of the metalled track from Hatter's Terrace to Kangaroo. This work was completed in June last, and cost £796 15s. Of this amount a subsidy was authorized to the extent of £500, of which sum £401 5s. has been paid.

Track, Barrytown to Brighton.—This is a portion of the main road between Greymouth and Westport. The track, newly constructed, commences at Clarke's Creek, about 1 mile 20 chains north of Barrytown, it goes along the foot of the range to Razorback, a distance of seven miles, giving communication to the diggings at Parnell, Von Moltke, Blacksand, Tipperary, Meagher's, Scotchman's and Trainor's Terraces. The cost of this work has been £2,240. Of this amount a subsidy was authorized to the extent of £1,493 6s. 8d., of which the sum of £1,212 has been paid. The county is at present erecting a foot-bridge over Canoe Creek on this road.

Grey County, Westland.

Extension of Limestone Track.—This is a continuation of the track that was made by the county several years ago from the main road between Greymouth and Marsden to the Limestone Diggings. It is now being extended to the Township of Dunganville, or Maori Creek, *via* Meehan's Flat. The total distance is 5 miles 23 chains, of which 3 miles 23 chains are completed, and the remaining two miles are in course of construction. The estimated cost of this track is £800. Of this amount £533 6s. 8d. was authorized as a subsidy, of which £239 6s. 8d. has been paid.

Track, Irishman's to Lake Brunner.—This track commences at Irishman's Diggings, about two miles from Marsden, and follows the range, cutting the heads of Cock-eye, Cock-a-bulla, Mosquito, Eight-mile, and Blackwater Creek (also Niagara and Granite Creeks, which are tributaries of the Big Hohonu River), and terminates at Lake Brunner, about one mile north of the mouth of the Big Hohonu River. The survey is completed for the whole distance. Five miles of metalled track, 3ft. in width, is completed, and two miles is in course of construction. The estimated cost of this work is £2,400. Of this amount a subsidy was authorized to the extent of £1,200, of which £750 has been paid.

WESTLAND COUNTY, WESTLAND.

Track, Arahura to Browning's Pass.—This track goes up the valley of the Arahura River, and is now formed to a point twenty-four miles from Humphrey's Gully and a mile and a half from the Styx Saddle. Along the flat, where the surface is generally good, the work consists of clearing, about 12ft. wide, and rough levelling; but along sidlings the track is cut out and formed to a width of 5ft. On the upper four miles of track there has been a considerable amount of rock-cutting. A subsidy of £2,000 was authorized, on the £2 to £1 principle, for the construction of this track, of which £1,484 2s. 8d. has been paid. The total expenditure on this work up to date has been £2,959.

Track, Gentle Annie Terrace.—This is the extension of the track formerly constructed to Gentle Annie Terrace. It has recently been extended from Coal Creek to the right branch of the Kanieri River in the direction of Kokatahi Flat, a distance of three-quarters of a mile. The track is estimated to cost £220, of which amount a subsidy of £146 13s. 4d. has been authorized. Of this subsidy £83 13s. 4d. has been paid.

Track, Okarito Forks to Teal Creek.—This track commences near the bridge over the main branch of the Okarito River at the forks, and goes across the country to Teal Creek, a distance of 4 miles 30 chains. The track is 3ft. wide on top of the metal, and the clearing is 12ft. wide. Two miles of it is constructed, and 2 miles 30 chains is in course of construction. The value of contracts entered into for this work amounts to £783 5s. A subsidy was originally authorized to the extent of £400, but none of this has yet been paid.

Track, Mapourika to McDonald's Creek.—This is a 3ft. metalled track extending from the Main South Road, Mapourika Township, in a southerly direction to McDonald's Creek, a distance of 129 chains. A contract was let for this work in October last for £202, but no subsidy has yet been paid.

Track, Bullock Creek to Abbey Rocks.—This is for a prospecting-track from Bullock Creek, where payable auriferous washdirt was worked some years ago. Rich patches of gold have also been found near Abbey Rocks; and this track is to open up the country between those points, being an estimated distance of ten miles. The estimated cost of track is £1,080. Of this amount a subsidy has been authorized to the extent of £540, but nothing has yet been done towards the construction of the work.

Track, Upper Dam, Kawhaka, towards Wainihinihi Creek.—This track is 2 miles 66 chains in length, extending from the Government dam, Kawhaka Creek, to the top of the saddle, where it joins another track, which has lately been surveyed from the Arahura River to the Christchurch Road near the Wainihinihi Creek. The work, which consists of a 3ft. metalled track, with clearing 16ft. wide, was completed in January last, the cost being £623. A subsidy of £300 was authorized for this work, none of which has yet been paid.

TUAPEKA COUNTY, OTAGO.

Road to open up Quarry for Stone, Waitahuna Bridge.—A new bridge has been constructed over the Waitahuna River, and a road was constructed to a quarry to get stone for building the piers and abutments. The estimated cost of this work is £200. Of this amount, a subsidy formerly authorized for the construction of a road from Lawrence to antimony mines, amounting to £200, has been transferred for this road; and £106 19s. 11d. of the subsidy has been paid.

Track, Clutha River Valley to Campbell's and Pomahaka.—This is a track from the main road up Clutha Valley, over the Old Man Range, to Campbell's and the head of the Pomahaka River. It also includes the erection of snow-poles across the range to indicate the direction of the track when the ground is covered with snow, which is generally the case during five months of the year. The estimated cost of the work is £450. Of this amount a subsidy was authorized to the extent of £300, of which £50 19s. 4d. has been paid.

Road, Waitahuna to Copper-mine.—This is a portion of the road between Waitahuna and Waipori, commencing at the point where the road leaves the Waitahuna Valley to take on to the terrace. The old road was extremely steep, it never having been formed. The estimated cost of constructing this portion of road is £200. Of this amount a subsidy was authorized to the extent of £133 6s. 8d., all of which has been paid.

Road, Waipori viâ *Bungtown.*—This is a continuation of the road between Waitahuna and Waipori, and when completed will form portion of the main road between Lawrence and Waipori. The present road goes over a very high range, which is covered with snow during the winter months. This proposed road will not only be over tolerably low ground, but will also be considerably shorter than the old road. The estimated cost of the work is £750. Of this amount a subsidy has been authorized to the extent of £375, of which £50 has been paid.

TAIERI COUNTY, OTAGO.

Road, Mullocky Gully to Silver Peak.—This road has been in course of construction for the last three years, the estimated cost being £600. Of this amount a subsidy was authorized to the extent of £400, of which £333 3s. 4d. has been paid.

MANIOTOTO COUNTY, OTAGO.

Track to connect the Kyeburn Peninsula with Main Road.—This is a road from the main road between Palmerston and Naseby to the Kyeburn Peninsula, to afford means of communication to the mining population that are situate in this locality. The estimated cost is £100, of which amount a subsidy has been authorized to the extent of £50.

Road, Shepherd's Hut to Vinegar Hill.—This is a road for the purpose of affording a better means of communication with the sluicing-claims at Vinegar Hill. The estimated cost of the work is £100. Of this amount, a subsidy was authorized last year to the extent of £66 13s. 4d., none of which has yet been paid.

Road, Pig and Whistle to Clark's Diggings.—This is a road that has been constructed to Clark's Diggings, which are situated on very high land, and the old line of road formerly used was very steep, and of little service to get supplies and material on the ground. The cost of the work has been £200. Of this amount a subsidy of £133 6s. 8d. has been paid.

LAKE COUNTY, OTAGO.

Road, Rees Valley.—This road is a continuation of a road constructed from the head of Lake Wakatipu up Rees Valley by the Lands Department, to open up lands for sale. These lands have been sold and fenced in, so that the former road up the side of the river was closed. The road has now been constructed on the road-reserve at a cost of £450. Of this amount a subsidy was authorized to the extent of £200; and the Lands Department also authorized a subsidy of £100, all of which has been paid.

Road, Rees River to Company's Workings.—This is a road to connect the quartz and tailings company's workings with the road constructed up Rees Valley. The estimated cost of the same is £122 15s. Of this amount a subsidy was authorized to the extent of £61 17s. 6d., of which £30 13s. 9d. has been paid.

Road up Left Branch, Skipper's.—This is a road up the left branch of Skipper's to the bush, for the purpose of getting timber for mining purposes to supply the quartz claims up the right branch of Skipper's Creek. The estimated cost of the road is £80. Of this amount a subsidy has been authorized to the extent of £40.

SOUTHLAND COUNTY, OTAGO.

Road, Waikaka to Switzer's, and Road, New Township, Switzer's.—These roads are mentioned as separate roads; but in reality are one and the same road. The work done has cost £300, of which £200 has been paid as subsidy.

WALLACE COUNTY, OTAGO.

Road, Round Hill to Colac Bay and Orepuki.—This is a road from railway at Colac Bay to Round Hill. The old track is scarcely passable for horses. In some places it is very steep, and, being corduroyed for the whole of the distance, it became dangerous in frosty weather for horse-traffic. This work is estimated to cost £1,125. Of this amount subsidies have been authorized to the extent of £650, of which £450 has been paid.

FIORD COUNTY, OTAGO.

Track, Dusky Sound.—This is a prospecting-track from the sea-beach back into the ranges, to open up the country, which is said to contain copper, zinc, graphite, and other minerals. The cost of the work has been £300. Of this amount £200 has been paid as subsidy.

SUBSIDIZED DRAINAGE- AND SLUDGE-CHANNELS.

St. Bathan's Sludge-channel, St. Bathan's, Otago.—This is, properly speaking, a tail-race for the discharge of tailings from the whole of the mining-claims at St. Bathan's. The ground has been worked to as low a level as the old tail-races would admit. The gold-washdrift has been proved to a considerable depth below the level that has been worked; and the whole of the claim-holders combined to form a company to construct a new channel or tail-race, which will allow the ground to be worked to an extra depth of about 70ft. When this company was formed the estimated cost of the work was £2,700; and this capital was subscribed *pro ratâ* among the claim-holders in proportion to the interest each held in the ground to be worked. The undertaking, however, proved far more extensive than was at first anticipated. It was commenced in 1882, and will yet take a considerable time to complete it. A subsidy of £1,000 was authorized towards the completion of this channel, which will be 1 mile 20 chains in length, 10ft. wide in the bottom; with a grade of 1 in 60 for about 35 chains, and the remainder on a grade of 1 in 100. At the point where the grade of 1 in 60 terminates there has been a large flushing-race constructed from Dunstan Creek, which is capable of conveying upwards of sixty sluice-heads of water. With this auxiliary, it is considered that the grade of 1 in 100 will be sufficient for the lower end, which empties into Dunstan Creek. A subsidy of £711 3s. 10d. has been paid on this work.

Muddy Creek Channel, St. Bathan's, Otago.—This is a large tail-race or channel that has been in course of construction for the last thirteen years, and has cost up to the present time over £13,000. When completed it will be over three miles in length. The same description of auriferous wash-drift—namely, old quartz-drift deposit—occurs in a long line of country following the terrace-land at the foot of the high ranges from Tinker's to Maerewhenua. The ground has been sluiced away along the sides and bed of Muddy Creek, at as low a level as it was possible to be worked; and this new channel, which is almost completed, will allow the ground to be worked to an extra depth of from 60ft. to 70ft. A subsidy of £1,000 was authorized for the completion of this work, all of which has been paid.

Drainage Tail-race, Ophir, Otago.—This is the continuation of the drainage-channel which was

constructed many years ago to work Black's Flat. The old channel has been deepened up from the Manuherikia River to its terminating-point to as low a level as drainage would permit, and the new channel has been constructed further up the flat. The large amount of water in this ground could not be overcome with any ordinary appliances the miners had, and therefore could not be prospected. A lead of highly-auriferous washdrift was traced into the deep ground, and several attempts have been made to trace it higher up the flat without any success, owing to the large quantity of water met with in sinking. This channel will drain the whole of the ground, so that it can be easily prospected and worked. It is estimated to cost £2,300. Of this amount a subsidy of £1,150 was authorized, of which £1,099 8s. 6d. has been paid.

Pipeclay Sludge-channel, Bannockburn, Otago.—This is a tail-race from the Kawarau River to the top of Pipeclay Gully, where there is a considerable area of payable auriferous ground that could not be sluiced for want of proper fall. This channel was commenced about eight years ago, and has lately been completed. A subsidy of £773 19s. has been paid towards the construction of this work.

Long Gully Channel, Maerewhenua, Otago.—This is a tail-race to carry away the tailings from the sluicing-claims. It is 54½ chains in length, 2ft. 6in. wide at the bottom, and 5ft. at the top, having a depth of 3ft. The bottom is all paved with stones, and the sides are partially lined with stones and partially with scrub. The cost of this work has been £150 : of this amount a subsidy of £100 has been paid.

Repairs, Storm-water Channel, Ross, Westland.—This storm-water channel was constructed through Ross Flat in 1868 to prevent the water from Jones's Creek overflowing on to the Flat, as it did previous to its construction. In March, last year, during a heavy fall of rain, Jones's Creek became flooded to such an extent that the storm-water channel was not of sufficient capacity to convey the whole of the water. The ground being worked to a great depth close to the channel, as soon as the water overflowed, it washed away about 5 chains of the channel, besides tearing off portions of the lining of the channel lower down. The cost of effecting these repairs was £451 16s. 7d., of which amount a subsidy of £200 has been paid.

Grants towards the Construction of Drainage, Storm-water, and Sludge-channels, and Water-supply.

Storm-water Channel, Ross, Westland.—This is a storm-water channel constructed through Ross Flat to Donnelly's Creek, to prevent the water from Jones's Creek spreading over the flat amongst the workings. This is the same channel that a subsidy of £200 was given to repair the damage done by floods in March last year. The whole of the channel through the flat requires to be renewed, and the carrying-capacity made greater. An amount of £750 was authorized towards this work.

Sludge-channel, Ross, Westland.—This is a channel to carry off the water and sludge from the flat which is between the ocean-beach and Ross. There is a strip of land along the sea-beach that has been sold, and is now partially cultivated. The water and sludge from the claims between Ross and Donaghue's has been allowed to spread over the flat until the surface of the ground is considerably raised, causing the water to flow over the freehold land. The state of the case is simply this : the freeholders threaten to stop mining operations unless something is done to prevent the water and sludge damaging their property. £750 was authorized towards the construction of this work, of which £1,360 6s. 9d. has been paid on this and on the construction of the storm-water channel.

Drainage-channel, Lawrence, Otago.—This is a continuation of the channel that was constructed two years ago to prevent the tailings, sludge, and water from the workings at Wetherstone's and Gabriel's Gully getting into the township and the lower streets of Lawrence ; and also for constructing a short channel through a spur, to allow the sludge and water from the lower end of Gabriel's Gully to be conveyed into the main channel at such an angle that the water and tailings from Gabriel's will not impede the flow of water in the main channel so as to cause a blockage with the tailings which are conveyed into it. £1,000 was authorized for this work, and £956 14s. has been paid.

Water-supply, Maerewhenua, Otago.—This is to bring in a water-supply to the mining-claims in the Maerewhenua District ; and also for the purchase of land to allow an outlet for the tailings. £1,500 was authorized towards this work, of which £400 has been paid.

Aids to Deep-level Tunnels.

Tokatea Company, Coromandel.—This company constructed a low-level tunnel 800ft. below the crown of the range at the saddle for a distance of 3,000ft., for the purpose of cutting the reef they had worked in former years upon the upper levels. When the point was reached where the reef was supposed to be, a soft mullocky lode of schist was found between similar walls to that of the quartz lode on the upper level, but no defined quartz was found. A subsidy of pound for pound to the extent of £350 was authorized to prospect the ground in the low level ; but, after doing a considerable amount of work, and being unsuccessful in finding any quartz of a payable character, the balance of the subsidy was authorized to test the reef on the third level. The amount of the subsidy paid on this work to date is £246 17s. 9d.

Deep-level Tunnel, Manaia, Coromandel.—This is a district where gold was first discovered about two years ago ; but, being Native property, there has been some difficulty in getting a road completed to get the quartz taken to a crushing-battery to be properly tested. A subsidy was authorized to the extent of £250 on the pound-for-pound principle, to test the ground in this locality ; of which £148 16s. has been paid.

Deep-level Tunnel, Tapu, Auckland.—This tunnel is being constructed from the Tapu Creek, a short distance above Mr. Pepper's crushing-battery. It will, when completed, be about 1,500ft. in length, and about 150ft. below any of the present workings if taken to the point where the present-known reefs are being worked. A quartz leader was cut about 200ft. from the mouth of the tunnel,

which carried a little gold. Some quartz has been taken out from this leader, but I have not heard the result of the crushing. The tunnel is now constructed for 350ft. A subsidy was authorized for this work on the pound-for-pound principle to the extent of £750, of which amount £470 9s. 2d. has been paid.

Deep-level Tunnel, Owharoa, Auckland.—This tunnel was constructed several years ago for 350ft. into the hill, for the purpose of forming a main level to work some of the mines. At the end of this tunnel there is an uprise for 25ft.; thence a cross-cut tunnel was driven for 120ft., where it came against a slide. Another tunnel was driven for 200ft. following the line of reef; and it was from the end of this tunnel that the present prospecting-tunnel was constructed. The length of the prospecting-tunnel is 242ft., which, together with the repairs to the old tunnel, cost £300 8s. Of this amount a subsidy of £150 4s. has been paid. The total subsidy authorized for this work is £400.

Deep-level Tunnel, Reefton, Nelson.—This tunnel has been in course of construction during the last five years. It is now constructed for 2,447ft., at a cost of £5,512. Of this amount a subsidy of £2,787 has been paid, still leaving a balance of authorized subsidy amounting to £663, on the pound-to-pound principle, to continue this work. It is estimated that this tunnel will have to be constructed for about 1,000ft. further before it will reach the country where the auriferous-quartz reefs have been met with on the surface.

Deep-level Tunnel, Boatman's, Nelson. — Although this tunnel was originally commenced by six different companies, there are now only two companies (the Homeward Bound and Specimen Hill) which are likely to be benefited by it. The former company's mining-claim adjoins the Welcome Company's ground, and it is supposed that the Welcome reef will pass through this claim. The tunnel is now constructed for a distance of 2,200ft., and will be of great service to the Homeward Bound Company in testing the reef, and also in getting the quartz from the same to a site where a crushing-battery can be erected. The total cost of construction has been £4,470, exclusive of the cost of air-compressing machinery. A subsidy to the extent of £300 has been paid.

Deep-level Tunnel, Cedar Creek, Ross, Westland.—Some rich auriferous quartz was discovered about two years ago in the bed of Cedar Creek, and tunnels constructed near the surface to work what appeared to be a large quartz reef. On driving into the reef at about 30ft. below the surface it was found to be about 2ft. thick, carrying gold, but not nearly so rich as found on the crown in the bed of the creek. The reef was found to have a heavy strike northwards, and consequently soon went below the level of the tunnel that was constructed to intersect it. A low-level tunnel is being constructed about 175ft. under the level of the former, which is expected to cut the reef at about 12 chains from the mouth. A subsidy of pound for pound to the extent of £603 15s. was authorized for this work, of which £303 15s. has been paid.

AIDS TO PROSPECTING.

Waipu Prospecting Association, Whangarei, Auckland.—This association was formed for the purpose of prospecting for gold in quartz reefs near Waipu. A subsidy was authorized for this object on the pound-for-pound principle to the extent of £100, of which amount £90 has been paid.

Oterongia Prospecting Association, Auckland. — This association is formed of Natives and Europeans to prospect the Native lands in the King-country. A subsidy was authorized for this purpose to the extent of £99 8s. 7d., which has been paid.

Cromwell Prospecting Association, Otago.—This association was formed for the purpose of prospecting in the Cromwell District. A subsidy towards this object was authorized to the extent of £250, of which £207 10s. 7d. has been paid.

Manuka Flat Prospecting Association, Lyell, Nelson. — This is a tunnel that is being constructed for the purpose of prospecting Manuka Flat, where it is believed there exists a lead of auriferous-gravel wash. The tunnel requires to be a great length to reach the ground, and a subsidy was authorized to the extent of £500, on the principle of £1 subsidy to every £1 10s. spent out of the funds of the association: £100 of this subsidy has been paid.

Deep-level Prospecting Association, Waipori, Otago. — This association confined their operations to testing the washdrifts in Waipori Flat, near the township. A subsidy was authorized on the pound-for-pound principle for this purpose to the extent of £300, of which amount £216 4s. 10d. has been paid.

Tuapeka Prospecting Association, Otago.—This association has been in existence for a number of years, and has done a great deal of prospecting in the district, but so far has not been successful in finding any fresh ground of a payable character for working. A subsidy was authorized to the extent of £150, on the pound-for-pound principle, on the prospecting-works undertaken by the association; of which amount £138 10s. has been paid.

Cardrona Prospecting Association, Otago.—This associatien is prospecting the valley of the Cardrona, about six miles below the present township, with the view of discovering the rich lead of gold which was lost in the early days on this flat. A subsidy was authorized for this purpose, on the pound-for-pound principle, to the extent of £400; of which £303 12s. has been paid.

Royal Oak Prospecting Association, Otago.—This association has been for a considerable time prospecting on the Carrick Range, in the Cromwell District, to try and discover the quartz reef at deep levels which proved very rich on the surface some twelve years ago. A tunnel was driven in from the face of the range at the head of Smith's Gully for some 400ft. by the former company who held the ground, and this association has extended this tunnel for over 600ft. A subsidy was authorized, on the pound-for-pound principle, to the extent of £300, to assist them to carry on their operations; of which amount £103 4s. 7d. has been paid.

Star of the East Company, Cromwell, Otago.—This company's mine is situated on the Carrick Range, adjoining the ground held by the Royal Oak Prospecting Association. A subsidy was autho-

rized, on the pound-for-pound principle, to the extent of £150 to this company, for the purpose of testing the reef at deeper levels. Of this amount £75 has been paid.

Red Hill Mineral Company, Cascade River, Westland.—A company was formed about eighteen months ago in Christchurch to prospect in the vicinity of Red Hill, which lies between the head-waters of the Cascade and Gorge Rivers. A subsidy was authorized for this purpose, on the pound-for-pound principle, to the extent of £500; of which amount £204 has been paid. This company has, however, suspended operations, so that it is unlikely that any further subsidy will be required.

West Coast Prospecting Association, Otago.—This association was formed in Southland for the purpose of prospecting the southern portion of Westland and the south-west portion of Otago. A subsidy was authorized and paid to the extent of £150, on the pound-to-pound principle, to provide equipments and stores for thirty men for six months to prospect this part of the country.

Miscellaneous Aids to Prospecting.—Miscellaneous aids have been authorized, through County Councils and other bodies, from time to time during the past year, and for prospecting-works in progress previously authorized—but not completed until after the commencement of the past year—to the extent of £3,690 19s. 2d.; of which amount £1,719 9s. 5d. has been paid.

AIDS TOWARDS THE TREATMENT OF ORES.

Testing-plant, School of Mines, Thames.—The great difficulty that the miners in the North Island districts have to contend with is a proper manipulation in the treatment of the ores. They are desirous of having an experimental or test plant connected with the School of Mines at the Thames, whereby tests of small parcels of stone could be made, and the best and cheapest method of treatment adopted for saving the gold and silver from the various classes of ore that are found in the locality. A subsidy on the pound-for-pound principle, to the extent of £200, was at first authorized, but lately this subsidy has been increased to the extent of £600, which, together with another £600 raised by the miners, will be sufficient to erect a very good test-plant.

Vulcan Smelting Company, Onehunga, Auckland.—This company has erected a smelting-furnace at Onehunga for the purpose of treating gold- and silver-ores. The furnace has not yet been tried, but the proprietors have every confidence that it will fully realize their expectations. Of its success, however, I have grave doubts. In order to assist the proprietors to test its capabilities and complete the furnace, a subsidy was authorized on the pound-for-pound principle to the extent of £25, of which amount £15 has been paid.

SUBSIDIZED ROADS TO MINES OTHER THAN GOLD.

Track to Coal-mines, Ohinemuri, Auckland.—Coal was discovered, about three years ago in a creek near the old road leading from Waitekauri to Paeroa. A horse-track was constructed from the old road up to the mine, which is estimated to cost £300. Of this amount a subsidy was authorized to the extent of £200, of which £103 11s. 8d. has been paid.

Road to Kanieri Coalfield, Westland.—Coal has been discovered on a range known as the Camel's Back, which is about eighteen miles up the Hokitika River from its mouth. A road from Hokitika and Kokatahi Road is in course of construction to get to these coal-seams that have been discovered. The estimated cost of the work is £600. Of this amount a subsidy to the extent of £300 was authorized, out of which £285 14s. 8d. has been paid.

ROADS UNDERTAKEN AND CONSTRUCTED WHOLLY BY GOVERNMENT FOR THE DEVELOPMENT OF MINES AND OPENING OF LANDS.

Road, Collingwood to Karamea, Nelson.—There is a dray-road up the Aorere Valley from Collingwood for eighteen miles, and it is from the end of this dray-road that the present track commences. It is laid off with tolerably good grades, and can be widened into a dray-road whenever required. The track is surveyed for eight miles, and is taken over the top of the saddle (about 2,500ft. above sea-level) between the Aorere and Big Rivers. The track will be continued round the head of the principal branch of the Big River, so that only small tributaries will have to be crossed, and where good fords can be got. £1,000 was authorized for this track, and £400 has been expended. This is a portion of the district where no tracks have ever been constructed, and where a main track through the country is greatly required.

Road, Motueka to Takaka, Nelson.—This forms portion of the main road between Nelson and Collingwood. The portion constructed and in course of construction, under the direction of the Mines Department, is from the Upper Takaka Valley over the range towards Motueka, a distance of sixteen miles and a half. Three sections, of an aggregate length of eight miles, are completed, and three more sections, of an aggregate length of six miles and a half, are in progress. Tenders have been invited for the remaining section, of two miles in length, but have not yet been accepted. The total expenditure on this road amounts to £4,795 2s. 7d.

Road, Wangapeka to Karamea, Nelson.—There is a dray-road constructed to the accommodation-house on the side of the Wangapeka River, and after leaving this accommodation-house there is a bridle-track for more than five miles, which, although not constructed, is available for traffic; and it is from near the end of this bridle-track that the present work commences. The whole of the track has been surveyed to the saddle, a distance of sixteen miles, and six miles of it is under contract for construction. The grades are all good, and will form a good track when completed. From the top of the Wangapeka Saddle, a good grade can be got for the continuation of the track at some future time down the side of one of the branches of the Mokihinui River, to join the track already made from Mokihinui Township to Specimen Creek. The amount authorized for the construction of this track is £2,000, of which sum £1,825 15s. 10d. has been paid.

Owen Valley Road, Inangahua, Nelson.—This is a dray-road, 8ft. in width, from Lyell–Nelson Road to the Mount Owen Reefs. The road commences about two miles up the Buller River from

its junction with the Owen River, and terminates at the battery-site near the junction of the Owen River and Bulmer Creek. The length of road is 9 miles 22 chains, which, when completed, is estimated to cost £1,542 7s. 6d. This amount has been authorized, and £1,233 12s. 3d. was expended up to the end of March last. This road was required to get crushing-machinery on the ground. From information come to hand there is a large body of auriferous quartz in some of the reefs in this district which is generally admitted to be of a payable character, but which cannot be worked, or even prospected, without crushing-machinery on the ground. The nearest crushing-plants to this district are at the Lyell, a distance of more than sixty miles. Contracts have been entered into for the erection of two crushing-batteries, which will be completed this winter. The road is only metalled for a portion of the distance, and possibly during the winter months will not stand heavy traffic; consequently a further expenditure may be required to complete the metalling,

Mokihinui–Karamea Road.—This road commences at the end of the horse-track which was made in the early days by the Provincial Government from the Mokihinui Township, at the mouth of the river, to Coal Creek. The road is now completed to the top of the saddle between the Mokihinui and Wanganui Rivers, a distance of seventeen miles from the Mokihinui Township. The only drawback on this road, so far, is the crossing of the Mokihinui River, near the junction of Rough and Tumble Creek. At the present time there is a chair for foot-passengers, but no means for crossing horses. A bridge was first proposed at this place; but, as it would cost upwards of £3,000, it is now proposed to make a road to a good ford in the river, where cattle and horses can cross. From the saddle towards the Wanganui River there are nine miles under contract. When this portion is completed it will be within 30 chains of the Wanganui River. The distance from this point to the Karamea River—which is surveyed, but the construction not yet put in hand—is 8 miles 70 chains. This road, when completed, will be a great boon to the settlers in the Karamea District, as it will give them an outlet for their stock. It will also open up a good deal of agricultural land in the Wanganui Valley, as well as open up the whole country, where no roads or tracks have ever been constructed. Gold has been got for years in the valley of Rough and Tumble Creek, but very few miners have ever been located in the district. This road is now constructed to a point which will give the miners every facility for getting into the country and prospecting it. The cost of this road up to the 31st March has been £10,511 16s. 1d.

Karamea–Collingwood Road, Nelson.—There are four sections of this road, of a length of 2 miles 2 chains, under contract. The portion under contract commences at the end of the road leading up the Karamea Valley, and when completed will extend to a point on the Oparara River about four miles from the Karamea wharf. The expenditure on this road up to the 31st March has been £457 17s. 6d.

Specimen Creek Road, Mokihinui, Nelson.—This road is now completed up the Mokihinui River to the forks, about two miles and a half below the gold-workings at Larrikin's. It forms portion of the road from Mokihinui to the Lyell. The expenditure on this road up to the 31st March has been £1,238 7s. 5d.

Lyell–Mokihinui Road, Nelson.—This is an extension of the Eight-mile Road towards the Mokihinui River. It is now completed to a point about seven miles from the Lyell Township, and within one mile of the saddle which divides the watersheds of the Mokihinui River and Lyell Creek. The expenditure on this road up to the 31st March was £5,015 7s. 10d.

Barrytown–Brighton Road, Nelson.—This forms portion of the main coast-road from Greymouth to Westport. A horse-track was constructed in the early days by the Nelson Provincial Government; but it is now in such a bad state of repair that in some places it is almost impassable. Besides, the track is constructed with such steep grades in places that it cannot be utilized to convert into a passable road. A survey was made, and a new line of road laid out between Barrytown and Brighton; and it is on this line where two sections of the road are in course of construction. Contracts for two sections near Buller Creek were let in July last, the length being 1 mile 51 chains. A survey is being made to connect this road with the road up the Four-mile Valley, with a view of ascertaining the best line of road to Charleston. The information received from reconnaissance surveys shows that the line by the Four-mile Valley is much the best for opening up the country, and also gives the best grades. The expenditure on this road up to the end of March last has been £1,213 14s. 4d.

Cobden to Seventeen-mile Beach, Grey, Nelson.—There was a dray-road formed from Cobden to Coal Creek many years ago by the Road Board, and about four years since a horse-track was constructed from Coal Creek to the mouth of the Seven-mile. In the country through which this horse-track was constructed no gravel nor any stone fit for metal could be procured nearer than the ocean-beach at the foot of the Seven-mile Creek. It was deemed advisable to widen this track, which was laid out with good grades, into a dray-road, as that would admit of the metal being brought from the beach by drays. The formation is completed, and contracts have been accepted for metalling, and also for the construction of two bridges for the sum of £1,060 18s. This work was formerly carried out under the Public Works Department, but it has been handed over to the county to complete. The expenditure on this work up to the end of March last is £2,102 1s. 4d.

Hatter's Terrace to Bell Hill, Grey, Nelson.—This is the continuation of a horse-track which was constructed about three years ago by the Lands Department from Hatter's Terrace to the Pakihi, being six miles distant in the direction of Bell Hill and Haupiri Flat. At Bell Hill there has always been a certain mining population, to which there has never been any made road or track; therefore the present track is being extended to meet the requirements of this portion of the district. The work is being done under the county. Tenders have been accepted for two miles and a quarter of the track for £385. It requires another mile to be constructed before communication with pack-horses is established to Bell Hill. The expenditure on this road up to the 31st March was £100.

Road, Cedar Creek, Westland.—This road commences at what is known as the Woolhouse Road, leading from Ross to the Totara River, at a point about half a mile west of the river, and follows the sidling along the Totara River to the Cedar Creek quartz reefs. The first four sections, of one mile each, were completed in October last at a cost of £2,790. A contract has been let for the fifth mile for £703. There still remains about four miles to construct in order to complete this road. The road is formed 12ft. wide, with 8ft. of metalling, the clearing being 33ft. in width. It is well laid out, and formed with easy grades. The expenditure on this road up to the 31st March has been £2,790 1s.

Track, Jackson's Bay to Junction of Track, Martin's Bay to Lake Wakatipu.—This track commences at the end of the track leading from Arawata Township to the Cascade River, about sixteen miles south of Jackson's Bay, and follows through the country, crossing near the heads of the Cascade, Gorge, Jerry, and Pyke Rivers. The survey has been completed for twenty-one miles and a quarter. The highest point of the road is that on the ridge directly above the Jerry River, where it is 1,580ft. above sea-level. It crosses over the saddle of the Pyke River at 1,050ft., the hills on each side being 3,500ft. and 4,000ft. above sea-level. The top of this saddle is a wide flat, running almost to the Jerry River, and ending abruptly in terraces. Very good dray-road grades have been got for the whole distance. A contract has been let for the construction of the first four miles for the sum of £729 10s., and tenders have been invited for another four miles, but not yet accepted. But before the track is of any practical service it will require to be constructed for thirteen miles, which will open up communication with the valley of the Gorge River. The expenditure on this track up to the end of March last was £560 14s. 3d.

Waitahuna Bridge, Tuapeka, Otago.—This is the reconstruction of the bridge over Waitahuna River on the main road. The old structure is decayed and unsafe for traffic. The new bridge is estimated to cost £1,500. Of this amount a subsidy was authorized to the extent of £750 from the votes under the control of the Hon. the Minister of Mines. This amount has been paid, but the work is not yet completed.

Waikaia Bush, Switzer's, Otago.—This is a road up the side of the Waikaia River, commencing at Piano Flat, about twenty-five miles above Switzer's, and terminating at Whitcombe Creek. The length of road partially constructed is about eight miles. From Piano Flat to Post Office Creek, a distance of three miles, the road can at any future time be widened for dray-traffic; but from Post Office Creek to Whitcombe the road is not laid out with such grades as are suitable for dray-traffic. This work was carried out under the supervision of the Southland County, and £1,000 expended on its construction; but a large amount of the money has not been judiciously expended. No survey was made of the road, and the work was carried out by day-labour under a foreman in charge. This is a case which points out the necessity of having plans and specifications approved before any money is expended on any road proposed to be constructed out of either grants or subsidies from Government.

Tracks, Merivale District, Wallace, Otago.—Tracks have been made in several directions in this district for the purpose of opening up the country in the Longwood Ranges. Gold has been got in several places, but, the country being densely timbered, and covered with thick underscrub, prospecting operations have been greatly retarded. These tracks will afford the miners an opportunity of getting into this part of the district and getting their supplies. The cost of these tracks has been £400, which has been paid.

Skipper's Road, Lake County, Otago.—This road was constructed from the Arthur's Point Road to the top of the saddle two years ago, and also the portion from the end of the contract which has just been completed up to the crossing of the Shotover River at Skipper's Point. The portion that was constructed last year was to avoid the zigzag horse-track over the bluffs near Stapleton's Beach, which was the most dangerous portion of the road. The length of the contract recently completed is 2 miles 6 chains, which involved very heavy rock-cutting round steep bluffs, as well as a very heavy retaining-wall in one place. About 50 chains of the distance constructed is only a horse-track, 6ft. in width. This is merely to get upon the original track again until the remaining portion of the road, which is 4 miles 57 chains in length, is constructed. There is now over ten miles of a dray-road constructed, with good grades, but it cannot be utilized for dray-traffic until the portion in the centre is completed. The expenditure on this road up to the end of March last has been £7,570 4s. 1d.

WATER-RACES.

Waimea Water-race, Westland.

This branch of the Waimea-Kumara Water-race is in a fair state of repair. The long fluming near Kawhaka, which has now been erected for nearly thirteen years, appears to be defective, as portions of it show a state of decay which necessitates careful supervision. The legs of the fluming have to be replaced from time to time, as well as some of the cap-pieces and stringers. During the Christmas holidays all portions that were greatly decayed were replaced; and new legs are now being brought on the ground to replace any that appear unsafe from time to time as they are required. The superstructure is also beginning to show considerable signs of decay; but, so long as the understructure is kept good, the boxing can always be repaired without interfering with the supply of water to the mining-claims. The flumes, however, are the only portion of the water-race that any extra expenditure will be required to maintain; and even these will be kept in repair without incurring any heavy outlay beyond the cost of the ordinary maintenance staff. The ditching and tunnels are in good repair. The only troublesome portion of the tunnels on the line of race is the one near Fox's, where a good deal of extra timber has had to be put in to keep the ground secure during last year; but it is not anticipated that this portion will give any further trouble beyond strict supervision to keep it in good repair.

A survey was made during last year of an extension of the water-race from the end of Branch

B to the Scandinavian, Second, Third, and Fourth Terraces, to ascertain the cost, and also the probable extent of auriferous ground that would be commanded if the extension were constructed. The total length of the extension would be 2 miles 3½ chains, which would have to be constructed for nearly the whole distance with iron piping. This, however, only represents the horizontal distance. The actual length of iron piping required to follow the undulations of the ground is 1 mile 72¼ chains. This would bring the water to one end of the Fourth Terrace; but it also requires 22 chains of open ditching to convey the water further along so as to command the auriferous ground. The piping would cross four deep valleys in the distance previously stated. The maximum pressure on the pipes at the bottom of each of these valleys would be as follows: From Branch B to Scandinavian Terrace, 156lb. per square inch; from Scandinavian to Second Terrace, 152lb. per square inch; from Second to Third Terrace and from Third to Fourth Terrace, each, 80lb. per square inch. To bring on a supply of water to these terraces equal to eighteen sluice-heads would require a pipe 26in. in diameter; the hydraulic gradient being 1 in 200. This is estimated to cost about £12,800.

As far as can be ascertained, the quantity of auriferous ground that would be commanded if this extension were constructed would be as follows: On Chapel Terrace, which can be connected with Scandinavian Terrace, 49 acres; on Scandinavian Terrace, 22 acres; on Second Terrace, 43 acres; on Third Terrace, 4 acres; and on Fourth Terrace, 24 acres: making a total of 142 acres. There is no doubt a portion of this area will not pay for working. The estimate of the quantity of auriferous ground is to a certain degree problematical; but it is nevertheless a purely speculative one, as no one can tell (however well acquainted with the ground) by merely passing over the surface of alluvial-drift terraces, and seeing the nature of the gravel-wash here and there, whether they will actually pay for working or not. When this water-race was first laid out a branch was surveyed to command these terraces; but that survey was eleven miles in length, and was estimated to cost £20,000. The late survey was undertaken with the view of taking the water across Waimea Creek in a siphon instead of going round its head, which is now found to be a less expensive line to construct than the one originally surveyed.

The following table will show the results of the working of this portion of the water-race during the past financial year:—

Month.	Sales of Water.	Amount of Cash received for Sales of Water.	Expenditure.	Amount of Outstanding Moneys at the End of each Month.	Number of Men employed.	Approximate Amount of Gold obtained.	Value of Gold.
1886.	£ s. d.	£ s. d.	£ s. d.	£ s. d.		Oz.	£ s. d.
April	174 3 8	321 16 1	59 9 8	254 17 5	108	312	1,185 12 0
May	98 2 0	117 0 2	100 18 2	235 19 3	104	273	1,037 8 0
June	179 18 9	146 5 1	81 4 7	131 1 5	102	298	1,132 8 0
July	154 5 4	121 17 9	68 1 6	163 9 0	102	312	1,185 12 0
August	158 11 2	206 17 0	89 8 9	115 3 2	95	277	1,052 12 0
September	164 2 11	174 1 0	75 1 0	105 5 1	101	280	1,064 0 0
October	165 8 8	137 10 6	124 6 6	133 3 3	102	295	1,121 0 0
November	151 9 1	134 11 9	181 13 1	150 0 7	102	264	1,003 4 0
December	123 9 1	199 8 1	87 11 0	74 1 7	106	184	699 4 0
1887.							
January	27 8 4	..	110 11 3	101 10 2	103	47	178 12 0
February	116 5 9	58 13 8	61 14 0	159 12 1	95	219	832 4 0
March	162 14 7	70 2 1	76 10 6	252 1 3	99	260	988 0 0
Totals	1,675 19 4	1,688 3 2	1,116 10 0	..	1,219*	3,021	11,479 16 0

* Average, 102.

From this table it will be seen that the sales of water have been £1,675 19s. 4d. The sales for the previous year were £1,790 16s., which shows a falling-off during the past year of £114 16s. 8d. The actual cash received for sales of water is £1,688 3s. 2d., and the amount of arrears for water at the end of March last was £252 1s. 3d. The expenditure on maintenance last year was £1,116 10s., while that of the previous year was £1,131 10s. 1d. The actual profit on this branch of the Waimea-Kumara Water-supply last year was £577 13s. 2d., against £618 16s. 9d.; but if the sales of water for the year were to be taken as receipts, the actual profit for the year would be £559 9s. 6d., against £658 17s. 11d.; or, in round numbers, the profit this year is £100 less than the previous year. The value of free water given to the miners to open out their claims during the year was £22 16s. 8d., against £20 3s. 4d. of the previous year. The average number of miners employed in mining by aid of this water-race during the year has been 102; and the approximate amount of gold obtained by them was 3,021oz., representing a value of £11,479 16s. Their average weekly earnings would therefore, after deducting the value of the sales of water for the year, be £1 16s. 11d. per man; or 4s. 10d. per week less than the previous year. The total cost of constructing this portion of this branch of the water-race has been £118,862 11s. 8d.; and, taking the actual profits for the year, £577 13s. 2d., it shows that it has only paid about ½ per cent. on the cost of construction.

Kumara Water-race, Westland.

This is the most important branch of the Waimea-Kumara Water-supply, and furnishes water for mining purposes for about three-fifths of the miners on the field. The main head-race and tunnel from Kapitea Creek are in a good state of repair; and, unless in wet weather, when there is an abundant supply of water in the creek, their carrying-capacity is equal to the supply. The branch flumes require strict supervision on account of some of the ground being driven out underneath the surface on which they stand. Also, the height of some of these flumes offers considerable opposition to high winds; consequently they are liable, when these occur,

to get broken down in places, or otherwise damaged, unless a strict watch is kept. The supply-race from the Kawhaka Creek to the Kapitea Valley is also in good repair, as well as the whole of the works in connection with the reservoir and dam. The following table shows the results of the working of this water-race during last year :—

Month.	Sales of Water.	Amount of Cash received for Sales of Water.	Expenditure.	Amount of Outstanding Moneys at the End of each Month.	Number of Men employed.	Approximate Amount of Gold obtained.	Value of Gold.
1886.	£ s. d.	£ s. d.	£ s. d.	£ s. d.		Oz.	£ s. d.
April	758 0 4	1,460 19 7	166 5 7	1,086 15 11	227	1,290	4,902 0 0
May	19 10 8	465 19 5	185 7 3	793 19 2	219	1,047	3,978 12 0
June	488 3 9	962 0 3	119 0 0	470 18 8	218	1,167	4,434 12 0
July	315 7 11	654 1 10	78 18 0	394 3 1	218	1,292	4,909 12 0
August	599 5 0	406 10 5	135 8 0	454 15 1	204	1,185	4,503 0 0
September	643 7 11	862 11 6	113 16 10	377 11 5	213	1,212	4,605 12 0
October	632 8 9	732 9 7	88 2 4	325 13 9	210	1,228	4,666 8 0
November	686 7 5	576 3 8	89 19 7	341 0 6	210	1,160	4,408 0 0
December	562 0 10	781 1 0	149 19 0	347 6 6	211	811	3,081 16 0
1887.							
January	345 12 7	489 6 4	106 7 3	75 9 2	216	807	3,066 12 0
February	673 0 0	450 5 4	87 8 4	91 9 3	216	1,161	4,411 16 0
March	747 9 2	619 18 0	78 6 8	71 16 10	216	1,280	4,864 0 0
Totals	6,470 14 4	8,461 6 11	1,398 18 10	..	2,578*	13,640	51,832 0 0

* Average, 215.

This shows that the sale of water for the past year was £6,470 14s. 4d., while that of the previous year was £9,788 16s. 8d., which shows a falling-off in the sales of water of £3,318 2s. 4d. during last year. This can partially be accounted for by the reduction in the price of water at the beginning of the year, which was reduced from £2 10s. per sluice-head per week to £2 ; also, by one month's free water being given to all claim-holders who were prepared to pay for water in advance in future. This system has been the means of £1,992 18s. 2d. of arrears for water being paid during the past year. On the 31st March, 1886, the outstanding moneys amounted to £2,064 15s., while on the same date this year they were only £71 16s. 10d. The actual cash received during the year for sales of water was £8,461 6s. 11d., against £10,381 11s. 2d. for the previous year. The expenditure on maintenance during the year has been £1,398 18s. 10d., against £1,454 19s. 5d. of the previous year. The value of free water given to the miners to open up their claims during the year was £1,547 18s. 11d., against £221 3s. 2d. during the previous year. To take the expenditure from the actual receipts, it leaves a profit of £7,062 8s. 2d., which would be about 18⅞ per cent. on the cost of construction, which was £37,400 2s. 11d. ; but, seeing that a large portion of the receipts last year was by the payment of outstanding moneys, the actual difference between the value of water sold and the expenditure would more fairly represent the actual profit, which would be £5,071 15s. 6d., or about 13⅝ per cent. on cost of construction. The average number of miners employed during the year by the aid of this branch of the water-race was 215, and the approximate amount of gold obtained by them was 13,640oz., representing a value of £51,832. Deducting the value of the water sold during the year from the value of the gold obtained, the average weekly earnings of the miners amount to £4 1s. 1d. per man.

Kumara Sludge-channel, Westland.

The completion of No. 2 Channel has greatly relieved this channel, and made it far more accommodating to those who are using it. The effect, also, of having two main tailings channels is that the tailings are more distributed ; and, the No. 2 Channel being at a higher level, it gains a great deal more room for tailings to be deposited. The dump for tailings from the sludge-channel is a serious drawback, the whole of the available ground being covered, and now depending wholly on the freshes and floods in the Teremakau River to carry away the tailings that accumulate between each flood. This entails a serious expense in shifting and extending the tail-boxes of the several branches to get clear of the tailings. The cost of this alone last year amounted to £2,142. The working of the channel may therefore be said to depend on frequent floods in the river to carry away such a portion of the accumulated *débris* to allow room for further discharge.

With regard to the expenses connected with the maintenance, it is still found that stone pavement is far more economical in the portion of the channel underground ; but the manager is of opinion that for paving the extensions and branches at the tail end of the channel the wood pavement is preferable. This is obvious, as the wooden paving blocks are much lighter and more easily handled when they are placed in any position requiring to be shifted. The great source of expense in connection with the maintenance of this channel is the great number of tail-boxes that require to be added to the different branches in order to get clear of the tailings. The whole of the available tailings-site is so filled up that it now depends on floods in the Teremakau to clear the tailings away. This was foreseen long ago, not only by the department, but also by the miners using the channel, and was the means of getting a second channel constructed to relieve this one. This second channel is maintained by the miners themselves, and, as it is at a much higher level, they will be able to work more economically than by the old channel, as there is more fall for the tailings, and a large area over which they can be deposited before they are dependent on the river to wash them away. It is only a question of time—and that time is limited—when the present channel will become useless for the purpose of carrying away tailings. The bed of the river will gradually become filled up. The light material will wash away for a time, but the heavy *débris*

lies on the bottom and raises the river-bed. The following table will show the result of working the channel during the past year :—

Month.	Channel-fees.	Value of Gold-dust obtained from the Channel.	Amount of Cash received for Channel-fees.	Expenditure.	Amount of outstanding Moneys at End of each Month.	Number of Men using the Channel.
1886.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	
April	173 12 3	..	310 18 11	484 8 7	96 6 10	149
May	5 3 9	..	120 3 2	559 0 8	64 14 1	163
June	168 4 6	..	277 10 9	540 9 1	5 11 3	132
July	138 6 10	..	141 4 8	622 8 0	6 0 4	156
August	119 15 2	153 16 0	267 5 7	998 19 2	12 4 6	105
September	123 6 3	139 13 0	269 14 11	540 7 4	6 1 6	116
October	95 12 6	177 14 0	107 5 11	387 2 4	3 5 0	83
November	110 1 4	145 11 0	93 8 4	469 6 9	3 5 0	95
December	84 19 7	93 19 0	109 18 0	289 8 9	8 13 9	95
1887.						
January	57 8 9	79 1 0	27 13 8	317 10 7	14 12 6	91
February	115 11 3	84 16 0	89 14 2	288 4 0	10 13 4	91
March	112 1 6	83 9 0	80 17 2	460 6 2	10 5 0	91
Totals	1,304 3 8	957 19 0	1,895 15 3	5,957 11 5	..	114 average.

The value of channel-fees for the year has been £1,304 3s. 8d., against £2,219 18s. 7d. for the previous year; and the amount of cash actually received for fees, including the payment of arrears which were standing on the 31st March, 1886, was £1,895 15s. 3d. In dealing with the receipts from the channel it is only fair to treat the value of channel-fees for the year—viz., £1,304 3s. 8d.; to which must be added £957 19s. which was obtained for gold got in the channel; thus making the total revenue £2,262 2s. 8d., or £42 4s. 1d. more than the previous year. The expenditure on maintenance has been £5,957 11s. 5d., against £6,215 13s. for the previous year. The expenditure has to a certain extent been lightened by the number of persons who left the channel to sluice into the new one; and the revenue has been greatly increased, although there are not so many using it, by the amount of gold that has been obtained. Previous to this year the expenditure on maintenance was nearly £3 for £1 obtained as fees; but this year, taking the amount of gold into account, it cost about £2 14s. for every £1 of fees and value of gold. The amount of outstanding moneys on the 31st March, 1886, was £149 0s. 9d., and on the 31st March last this was reduced to £10 5s.

The average number of men using the channel last year was 114, against 161 during the previous year. The value of free use of channel given to the miners during the past year was £261 12s. 6d., against £12 12s. 8d. the previous year. The total cost of this channel to date has been £17,200 12s. 6d.

Waimea-Kumara Water-race and Sludge-channel.

Although the whole of the different works have been dealt with separately, they have to be taken conjointly to get at the advantages accruing from their construction, as they are all one work and under one management. The following table will show the results of the working of this water-race and sludge-channel conjointly :—

Month.	Sales of Water and Channel-fees.	Cash received for Sales of Water and Use of Channel.	Expenditure on Maintenance.	Arrears of Sales of Water and Channel-fees at the End of each Month.	Number of Men employed.	Approximate Amount of Gold obtained.	Value of Gold.
1886.	£ s. d.	£ s. d.	£ s. d.	£ s. d.		Oz.	£ s. d.
April	1,105 16 3	2,093 14 7	710 3 10	1,438 0 2	335	1,602	6,087 12 0
May	122 16 5	703 2 9	845 6 1	1,094 12 6	323	1,320	5,016 0 0
June	836 7 0	1,385 16 1	740 13 8	607 11 4	320	1,465	5,567 0 0
July	608 0 1	917 4 3	769 7 6	563 12 5	320	1,604	6,095 4 0
August	877 11 4	1,034 9 0	1,223 15 11	582 2 9	299	1,502	5,709 8 0
September	930 17 1	1,446 0 5	729 5 2	488 18 0	314	1,529	5,809 5 0
October	893 9 11	1,155 0 0	599 11 2	462 2 0	312	1,569	5,965 2 0
November	947 17 10	949 14 9	740 19 5	494 6 1	312	1,462	5,556 15 0
December	770 9 6	1,184 6 1	526 18 9	430 1 10	317	1,020	3,874 19 0
1887.							
January	430 9 8	596 1 0	534 9 1	191 11 10	319	872	3,324 5 0
February	904 17 0	683 9 2	437 6 4	261 14 8	311	1,402	5,328 16 0
March	1,022 5 3	854 6 3	615 3 4	334 3 1	315	1,562	5,935 9 0
Totals	9,450 17 4	13,003 4 4	8,473 0 3	..	..	16,912	64,269 15 0

The total value of the sales of water and channel-fees for the past year was £9,450 17s. 4d., while the previous year they amounted to £13,799 11s. 3d.; thus showing a decrease of £3,348 13s. 11d., which is due principally to the cause already mentioned when dealing with the Kumara branch supply—namely, the reduction in the price of water, and a month's free water being given to the claim-holders to establish the system of payment in advance. The total expenditure on maintenance for the year has been £8,473 0s. 3d., while that of the previous year was £8,802 10s. 6d.; thus showing a decrease in the expenditure for last year of £329 10s. 3d. The arrears for sales of water and channel-fees on 31st March, 1886, were £2,623 5s. 7d., and on the same date this year they amounted to £334 3s. 1d. This shows that £2,289 2s. 6d. of outstanding moneys has been

paid by the miners during the last year, which must be considered very satisfactory. The average number of miners employed by aid of these works has been 316, exclusive of bushmen engaged in getting blocks and timber for the claims. Deducting the value of the sales of water and channel-fees from the value of the gold obtained, the average weekly earnings of the miners would amount to £3 6s. 9d. per man. The total cost of construction of the works has been £173,463 7s. 1d., and the amount of receipts over the expenditure during the last year was £3,572 5s. 4d., which gives direct interest at the rate of a little over 2 per cent. on the capital expended. However, a large amount of this surplus is due to outstanding moneys having been paid up during the year, which should not be taken as actual profit.

Nelson Creek Water-Race.

The ground that this water-race commands is gradually getting worked out. The upper end of Try Again Terrace, where the principal water was formerly used, is nearly sluiced away, only small blocks here and there remaining. A great deal of prospecting has been done, and free water given for this purpose, but no new ground of any extent has been discovered that will prove payable for working. The limited amount of gravel-drift on the sides of the ranges which the water commands does not hold out much hope that this water-race will continue long to pay the expense of its maintenance. Indeed, unless payable gold be discovered in the flats to utilize the water, the heavy expense of maintaining the large number of bridges and flumes, which are decaying fast, the revenue accruing from the sales of water will not be sufficient to provide for the increased expenditure necessary to keep those structures good.

A survey has been made from the bridge at Wilson's Creek to Riverview, with a view of extending the race to command the several terraces and gullies of the watershed on the western side of the Ahaura River, below Irishman's Creek. There has also been a survey made from near the northern corner of Lake Hochstetter to command the same ground. These two surveys were made for the purpose of obtaining definite information as to the cheapest and most advantageous route. The line from Wilson's Creek is four miles and three-quarters in length, and would consist of a series of tunnels and one flume over Calaghan's Creek. The longest tunnel on this line would be 40 chains in length. The estimated cost of this line is £11,000; but in order to utilize it the upper portion of the main race would have to be taken into account, which requires the whole of the bridges and flumes, and also the timbering and lining of the tunnels, to be replaced. This is estimated to cost £15,000; thus making the total cost of this route to be £26,000. The direct route from the northern corner of Lake Hochstetter is seven miles in length, and consists of thirty-two tunnels, the longest of which would be 95 chains. With this exception the other tunnels vary from 3 to 48 chains in length. The estimate of the cost of this line and headworks is £21,300, and will bring the water at an elevation of 60ft. higher than the other line. The whole of the ground on both lines through which the tunnels would have to be constructed is what is locally termed "Maori bottom," or "old-man reef," which is usually the best description of ground to construct tunnels through, as it is tolerably soft, yet firm and compact enough to stand without being timbered. In selecting both of these routes the great object sought to be obtained was to get a line where works of a permanent character could be constructed, which would cost a minimum amount to maintain. For this reason a line with a series of short tunnels was selected, the tunnels to break out in every gorge and gully, from whence water can be taken to the several terraces and flats.

The following table will show the results of working this water-race during the past year:—

Month.	Receipts.	Expenditure.	Number of Men employed.	Approximate Amount of Gold obtained.	Value of Gold.
1886.	£ s. d.	£ s. d.		Oz.	£ s. d.
April	115 12 1	61 14 8	68	187	715 5 6
May	89 14 7	111 15 8	62	181	692 6 6
June	68 12 1	83 8 8	57	167	638 15 6
July	69 6 3	77 7 8	58	164	627 6 0
August	63 11 8	74 14 8	61	171	654 3 6
September	95 8 4	77 14 8	63	187	715 5 6
October	77 6 8	74 1 8	65	210	803 5 0
November	147 16 8	127 11 6	70	244	933 4 0
December	67 17 6	111 16 8	47	150	573 15 0
1887.					
January	52 18 4	103 6 8	44	137	524 0 6
February	110 6 8	160 1 2	56	184	703 16 0
March	113 8 4	109 16 8	60	197	753 10 6
Totals	1,071 19 2	1,173 10 4	711	2,179	8,334 13 6

This shows the receipts for last year to be £1,071 19s. 2d., against £1,073 14s. 2d. for the previous year; and the expenditure £1,173 10s. 4d., as against £1,104 13s. 4d. for the year ending the 31st March, 1886. The receipts only show a decrease of £1 15s., whereas the expenditure shows an increase of £68 17s. The average number of miners employed by aid of water from this race during the year has been fifty-nine; and their average weekly earnings, after deducting the value of the sales of water from the value of the gold obtained, was £2 7s. 4d. The value of free water given to assist the miners in prospecting and opening out their claims during the year was £1,054, as against £488 during the previous year. The cost of constructing this water-race up to date is £90,721 4s. 8d.; and the loss on the working of it last year was £101 12s. 2d.

Argyle Water-race.

The returns from this water-race have not been so large as was anticipated. The ground on the upper end of the flat, where the principal water was used in former years, is almost worked out; and the future returns will depend in a great measure on the amount of payable auriferous ground in the vicinity of Ballarat Terrace and the Back Lead. The water-race was extended to the latter place in October last, where there is a considerable area of new ground that was represented to be of a payable character. The whole of the works in connection with the main supply-race are new, and should require very little expense to maintain them for several years, as they are all of a permanent character, wrought-iron piping being substituted for wooden fluming across the deep gullies. The branch supply-race is troublesome to keep in repair on account of the ground being liable to slips. The following table will show the results of working this water-race for the past year:—

Month.	Receipts.	Expenditure.	Number of Men Employed.	Approximate Amount of Gold obtained.	Value of Gold.
1886.	£ s. d.	£ s. d.		Oz.	£ s. d.
April	32 7 10	30 13 8	18	40	152 0 0
May	38 5 9	29 10 10	18	50	190 0 0
June	27 8 5	28 3 4	17	40	152 0 0
July	39 19 9	29 5 0	19	52	197 12 0
August	56 1 7	31 7 10	18	60	228 0 0
September	35 18 4	28 3 4	17	46	174 16 0
October	41 1 4	36 14 2	17	51	193 16 0
November	47 12 4	29 3 7	19	57	216 12 0
December	35 13 3	31 1 0	17	40	152 0 0
1887.					
January	40 1 7	39 19 8	19	48	182 8 0
February	40 16 6	35 2 6	21	52	197 12 0
March	45 1 9	33 1 6	21	64	243 4 0
Totals	480 8 5	382 6 5	221	600	2,280 0 0

It will be seen from this table that the receipts for the year have been £480 8s. 6d., whereas the previous year they amounted to only £435 2s. 8d.; thus showing an increase of £45 5s. 10d. Last year the expenditure was £382 6s. 5d., as against £391 17s. 8d. for the previous year. The value of free water given to the miners to open out their claims this year was £16 10s., as against £4 2s. 6d. for the previous year. The average weekly earnings of the miners, after deducting the value of the sales of water from the value of the gold obtained, amounts to £1 18s. 6d. per man. The total cost of this water-race to date is £14,711 3s. 11d., and the profit on working £98 2s., which shows about $\frac{5}{8}$ per cent. on the amount of capital invested.

Mikonui Water-race, Westland.

There has been no work done on this water-race during last year. Three miles of the lower end is constructed and leased to the Mont d'Or Gold-mining Company at a rental of £100 per annum. This water-race has cost up to the present time £25,644 9s. 6d.; and it would require an additional £60,000 to complete it before a supply of water can be obtained. Unless some new discoveries of payable auriferous drifts be made, or deep leads requiring machinery, there is no prospect of the undertaking ever being a payable venture if it were constructed.

Mount Ida Water-race, Otago.

Since this water-race has been extended to Spec. and Home Gullies a great many claims have been taken up, and are being profitably worked. This race supplies water to forty-three claims, in which 130 miners are employed. A considerable number of slips have occurred during the year, which have increased the expenditure on maintenance to some extent, and at the same time caused a loss in the sales of water during the time repairs were being made. The following table will show the results of the working of this water-race during the year ending 31st December, 1886:—

Month.	Sales of Water.	Amount of Cash received for Sales of Water.	Expenditure.	Amount of Outstanding Moneys at the End of each Month.*	Number of Men employed.†	Approximate Amount of Gold obtained.	Value of Gold.
1886.	£ s. d.	£ s. d.	£ s. d.	£ s. d.		Oz.	£ s. d.
January	17 16 8	206 0 2	103 8 7	..	..	220	825 0 0
February	35 16 1	90 6 7	127 11 1	..	..	210	787 10 0
March	125 14 11	72 8 0	105 15 4	..	..	170	637 10 0
April	206 14 0	82 12 8	114 19 9	..	..	180	675 0 0
May	161 8 9	117 12 4	169 0 0	..	..	250	937 10 0
June	78 17 3	131 15 9	124 1 8	..	..	270	1,012 10 0
July	..	56 14 8	114 3 4	..	..	200	750 0 0
August	99 16 2	49 6 9	135 10 4	..	..	190	712 10 0
September	166 7 6	143 6 11	272 2 10	..	..	300	1,125 0 0
October	235 8 8	156 17 11	147 19 1	..	..	370	1,387 10 0
November	198 16 5	142 8 1	92 19 10	..	..	440	1,650 0 0
December	127 15 6	185 17 3	105 9 6	..	..	400	1,500 0 0
Totals	1,454 11 11	1,445 7 1	1,613 1 4	..	..	3,200	12,000 0 0

* No monthly record kept. The outstanding accounts in December, 1885, were £1,185 18s. 6d. During the year this sum was increased £9 4s. 10d., or a total of £1,135 3s. 4d. These outstanding accounts have accumulated during the last ten years. About one-half of this sum is considered good, and recoverable.

† A full supply of water gives employment to about a hundred and thirty men. The number of men employed is regulated in a great measure by the quantity of water supplied. When water is scarce they are engaged in "falling," and other dry work.

From this it will be seen that the sales of water for the year have amounted to £1,454 11s. 11d., and the cash received for the same, £1,445 7s. 1d., while the expenditure on maintenance was £1,613 1s. 4d. The receipts for the previous year were £893 6s. 5d., and the expenditure £1,338 2s. 5d. This shows an increase in the revenue derived from this water-race during the last year of £561 0s. 8d., and in the expenditure of £274 18s. 11d. The outstanding moneys due for water at the end of December last were £1,135 3s. 4d., while the outstanding moneys at the end of the previous year were £1,125 18s. 6d.; which shows that the arrears have increased £9 4s. 10d. This water-race is managed by a Trust, but the Government has to find any deficiency to keep up the maintenance. During the last year the Trust received £350 towards maintenance and clearing away slips. The total cost of constructing this work was £65,766 3s. 8d., and the loss on the working during last year was £167 14s. The average number of miners employed working claims with water from this water-race last year was 130, and the approximate quantity of gold obtained by them was 3,200oz., representing a value of £12,000. Deducting the value of the sales of water from the value of the gold obtained, the average earnings of each miner amount to £1 11s. 2d. per week.

Summary of Water-races.

In order to show the results accruing from the construction of water-races constructed by the State, either worked directly by Government or by a Trust, the direct profit does not show the whole of the collateral advantages derived by their construction. They have been treated as any private commercial venture; but the State derives other revenues, which may be termed indirect profits, such as Customs and goldfields revenue. It may be said that if those miners who are employed by aid of these works had turned their attention to something else, it would not have affected this source of revenue. Possibly some of them might have done so, but to take the majority of the mining population, they are of a migratory character, and believe in following up the occupation which years of hard labour have accustomed them to; so that when they do not find profitable employment in one place at their accustomed avocation, they seek fresh fields. These water-races have been the means of a large amount of gold being obtained that otherwise would have been still lying buried in the ground. It is therefore only fair to take into account the duty on the gold obtained by their aid as direct profit to the State. On this basis, the profits accruing from their working last year would be as follows: Waimea Water-race and Sludge-channel gave a profit of £6,221 4s. 1d., which gives interest at the rate of nearly $3\frac{5}{8}$ per cent. on the capital invested; Nelson Creek Water-race, £106 6s. 10d., which is $\frac{1}{10}$ per cent.; Argyle Water-race, £158 2s., which is a little over 1 per cent.; and Mount Ida Water-race, £152 5s. 9d., which is a little over $\frac{1}{5}$ per cent. on the cost of construction. Even taking this into account, they do not appear to be profitable investments, as there is no provision for the redemption of capital, which may be considered as entirely sunk.

The following table shows the results of water-races and sludge-channels constructed by the State, and either worked directly by the Government or by a Trust:—

Name of Water-race.	Receipts.	Expenditure.	Profit or Loss on Working.	Average Number employed.	Approximate Amount of Gold.	Value of Gold obtained.	Duty received on Gold obtained.	Total Profits or Losses, and Value of Duty.	Total Cost of Construction.
Waimea-Kumara and Sludge-channel.	£ s. d.	£ s. d.	£ s. d.		Oz.	£ s. d.	£ s.	£ s. d.	£ s. d.
Eight years ending Mch. 31, 1886	60,337 10 2	42,543 16 9	17,793 13 5	451	140,861	538,359 5 6	..	..	..
Year ending 31st March, 1887	13,003 4 4	8,473 0 3	4,530 4 1	316	16,912	64,269 15 0	..	..	..
Total	73,340 14 6	51,016 17 0	22,323 17 6	436	157,773	602,629 0 6	15,777 6	38,101 3 6	173,463 7 1
Nelson Creek.									
Eight years ending Mch. 31, 1886	13,719 14 9	9,533 15 8	4,185 19 1	60	26,341	100,754 6 6	..	..	..
Year ending 31st March, 1887	1,071 19 2	1,173 10 4	*101 11 2	59	2,179	8,334 13 6	..	..	..
Total	14,791 13 11	10,707 6 0	4,084 7 11	60	28,520	109,089 0 0	2,852 0	6,936 7 11	90,721 4 8
Argyle.									
Eight years ending Mch. 31, 1886	3,528 18 10	3,218 10 11	310 7 11	17	5,478	20,953 7 0	..	..	..
Year ending 31st March, 1887	480 8 5	382 6 5	98 2 0	19	600	2,280 0 0	..	..	..
Total	4,009 7 3	3,600 17 4	408 9 11	17	6,078	23,233 7 0	607 16	1,016 5 11	14,711 3 11
Mount Ida.									
Eight years ending Dec. 31, 1885	11,715 1 1	14,555 13 10	*2,840 12 9	87	17,711	67,493 0 0	..	..	..
Year ending 31st Dec., 1886 ..	1,445 7 1	1,613 1 4	*167 14 3	130	3,200	12,000 0 0	..	..	..
Total	13,160 8 2	16,168 15 2	*3,008 7 0	92	20,911	79,493 0 0	2,091 2	*917 5 0	65,766 3 8
Grand Totals ..	105,302 3 10	81,493 15 6	23,808 8 4	605	213,282	814,444 7 6	21,328 4	45,136 12 4	344,661 19 4

* Loss on working.

It will be seen from the foregoing table that the total cost of these works has been £344,661 19s. 4d.; the total receipts from sales of water and channel-fees, £105,302 3s. 10d.; the total value of gold duty obtained by their aid, £21,328 4s.: making the total revenue £126,630 7s. 10d. The total expenditure on maintenance is £81,493 15s. 6d.; leaving a profit of £45,136 12s. 4d. during the nine years they have been in operation. The Mount Ida Water-race stands in the worst position, showing a direct loss of £917 5s. for the period named.

NORTH ISLAND MINING GENERALLY.

COROMANDEL.

Gold was first discovered in this district in 1852 by C. Ring, in a creek which now bears his name; but little or no work was done to prospect for the precious metal for eleven years after that. It was not until the rich finds in Wetherstone's, Waitahuna, and Gabriel's Gully, in Otago, were attracting the attention of the mining community from every part of this and the adjacent colonies that the rush set in for Coromandel. Ever since this period the district has maintained a fair mining population, and very rich auriferous-quartz lodes and leaders have from time to time been discovered. The general characteristic of this field is that the rich deposits of gold are generally found in small leaders branching off from the foot-wall of the main lodes; still, rich patches of gold have been got in some of the main lodes—for instance, in the Tokatea Mine and the Union Beach Company's ground.

The Tokatea Hill is interstratified with a mass of quartz leaders running in every direction, some of which are only like a thread in places, but, when followed up, occasionally widen out to 2in. and 4in. thick. Even in some of the small threads almost solid gold is sometimes in the seam. Claims have from time to time been worked and abandoned, the owners believing them to be worked out; others have taken them up, and taken out as much, and sometimes more, gold than the original holders. Still, this hill is being worked with success, and continues to pay some of the holders of the ground handsome profits.

This is a portion of the district that is more suitable for individual miners than for large companies, as the leaders are very thin, and a great deal of prospecting has to be done, there being no occasion for a large outlay in plant. The quartz is very rich, but there is no large body of it, requiring expensive crushing-machinery to be erected. It takes a considerable time to get even 10 tons of quartz from these leaders. The rich specimens are all picked out as the leaders are worked, and the rest stacked until a quantity is obtained, when it is then taken to the crushing-battery on the Coromandel side of the range. A great deal of the quartz from these leaders averages 10oz. of gold to the ton; but the quantity takes a long time to obtain. A stranger visiting the quartz-workings on Tokatea Ranges would compare them to a complete network of rabbit-warrens, burrowed in every direction. Quartz-mining here requires men acquainted with the district. There are many excellent miners, well acquainted with the mode of working large mines, that would not be successful here for a time, until they attained a thorough knowledge of the characteristics of the district, to enable them to adopt an economical method of working; and the same could be said of the quartz-miners in this district if they were to engage in this branch of mining in other parts of the colony, especially in the Middle Island. Many failures of quartz companies all over the colony may be attributed to this reason. They engage mine-managers holding high testimonials from England and elsewhere, without having any knowledge of the character of the lodes in a particular district, and before that knowledge is obtained they open out the mine in a systematic manner, such as they have been accustomed to, and find, when it is too late, that large sums of money have not been judiciously expended. The success of quartz-mining companies depends in a great measure on the skill and knowledge of the mine-manager, who ought to have local experience of the character of the lodes in the particular district where the mine he has charge of is situate.

There are about fifty individual miners employed on the Tokatea Range, and, from what I could learn, all are making fair wages; but they also informed me that they sometimes have to work for six and twelve months prospecting on the small leaders before they get paid for their labour. The same remarks apply to Waikoromiko, which is a continuation of the Tokatea Range, and the same character of country.

Recently a new discovery has been made by Mr. McGregor in the Waikoromiko District. He has been for some time past prospecting with aid under the prospecting regulations. He discovered a very rich leader on the top of a high spur at the head of the Waikoromiko Creek, about three miles from the Tokatea Saddle. The leader is about 8in. in thickness, and contains very rich specimens on the surface; but, having only been lately discovered, nothing is known respecting it beyond what is seen on the surface. If the leader continues to go down, it is situate in a very favourable place for working—1,000ft. of backs can easily be got by a short distance of tunnelling. Mr. McGregor has been prospecting in this locality for the last eighteen months, and from the appearance of the stone that he has now got is likely to be well rewarded for all his labour. It was from this locality that a very rich specimen was obtained, which was forwarded to the Indian and Colonial Exhibition.

This district has so far proved extremely patchy. The gold has not gone down to any great depth. Whether this new find will be an exception to the general character of the district remains yet to be proved.

Tokatea Company.—This company's ground is situate on the Tokatea Range. In former years a large amount of gold was taken from their mine. Latterly they have driven a low-level tunnel for nearly 3,000ft. about 800ft. underneath the crown of the hill; but, so far, no payable lode has yet been got. The upper levels on the lode they were formerly working on are now nearly worked, out, a few tributors being engaged in taking out the remaining blocks. In the low level the quartz lode is greatly broken up, and filled with mullock; but the manager informed me that there is payable quartz underneath the foot of a portion of this level, which cannot be worked, on account of the large body of water there is to contend with, until another tunnel is constructed, which would require to be about 4,000ft. long; but the company is not in a position at the present time to incur so large an expenditure as this would require. They have commenced to prospect on the third level, and have constructed a tunnel, which was, at the time of my visit, 285ft. in length, with a view of cutting a large reef that can be traced on the surface for a long distance, but which does not contain sufficient

gold to pay for working at the points where it is exposed. It was on this level where the gold commenced to make on the reef where they have been working, and which was almost of a barren character above this to the surface. The former remarks only apply to the main lode; but there are numerous veins and leaders branching off the main lode which, although very small, are yet, some of them, very rich. From a little over twenty-four tons that was obtained during last year from these leaders close on 699oz. of gold was obtained, representing a value of £1,956 17s.

Kapanga Company.—This is a purely English company, which was formed for the purpose of purchasing the ground held by the old Kapanga Company, and opening it out at a lower level, to thoroughly prospect and test it. The capital of the company is £185,000, which is divided into 185,000 shares of £1 each; 29,885 of which have been declared paid up, and 17s. per share has been declared paid up on the balance; thus leaving the available capital of the company to be £23,267 5s. This company commenced operations on the 4th August last, to do preliminary alterations to the machinery and foundations of the pumping-gear before commencing active operations in the mine. These alterations were so far completed by the 28th September that a commencement was made to pump out the water from the old workings. The water had to be taken out with the original pumps which were in the shaft previous to the old company suspending operations, which consisted of a 10in. plunger working from a depth of 218ft.; below which there was one draw-lift 10in. in diameter, which lifted the water 84ft.; and below this another draw-lift was placed which raised the water from the bottom of the shaft, about 118ft.; the total depth of the shaft being 420ft. The whole of the water was pumped out in December last, when the company dispensed with the draw-lifts, and placed new pumps in the shaft previous to commencing active mining operations. These pumps consisted of three plungers, one of which is 12in. in diameter, and lifts the water to the surface from a depth of 215ft. Below this another plunger is fixed, 10in. in diameter, which lifts the water 72ft.; and below this there is another plunger, 9in. in diameter, lifting the water 132ft.; below which a 9in. draw-lift is fixed, and used for sinking the shaft to a deeper level. They expect to cut the Kapanga lode in the shaft at about 70ft. below the present depth, and Scotty's Reef at 40ft. deeper. Since the new pumps have been fixed sinking has commenced, and at the time of my visit in April 17ft. had been sunk. The company has also commenced to drive on Scotty's lode at the 300ft. level. This was formerly cut in the main level at 600ft. from the shaft, and the lode worked for 240ft., when a split occurred, forming two leaders. The company is at present driving on one of these leaders with the expectation that the two will again unite, and at the junction a good shot of gold will probably be got. The pumping-engine is one of the old type of Cornish beam-engines, which has undergone a thorough overhaul. The framing of the intermediate shaft which works the pumps has been replaced with two new trestles. The connecting-rods, balance-bob, with foundations, are all new, and erected in a very creditable and substantial manner. The main shaft, which is 14ft. by 8ft. in the clear for the first 300ft., and 10ft. by 7ft. 6in. below this depth, is all framed and slabbed, and framed off into two compartments for winding and one for the pumps and ladder-shaft. Everything has been done in a substantial manner to work the mine. There is a battery of twenty heads of stamps, which is worked by a horizontal high-pressure engine, 13in. cylinder, which also drives two berdans and one Borlase buddle. The manager intends, when he commences crushing, to use quicksilver-tables, and also blanket-tables. The winding-engine is one that was formerly used by the old company—portable, but has also undergone a thorough overhaul, so that it may be said is now equal to new. The total expenditure on the mine and plant up to the 14th February last was £4,300.

Coromandel Company.—This is a company formed with partly English and partly colonial capital to work the mine formerly known as the "Union Beach." The capital is £40,000, in 40,000 shares, of which £25,000 has been subscribed and paid up: £15,000 is held as reserve-capital on the 15,000 shares which have not been allotted, but are held by the company. This company commenced operations about two months ago, and had up to the time of my visit expended about £900. There are two shafts on this mine—one 180ft. deep, 8ft. 6in. by 6ft. 8in., in which is fixed a 12in. plunger, with 9in. column. The other shaft is not so deep as this one; but it is intended to sink it down to a depth of 280ft., to make it the winding-shaft for working the mine. In order to sink the shaft to a greater depth, and also to provide sufficient power to lift the water, the company has ordered from England a Cornish beam-engine, with a 40in. cylinder, with 9ft. or 10ft. stroke, and purpose to provide sufficient pumps and gearing to sink to a depth of 800ft. if the lode proves payable for working from this depth.

South Kapanga Company.—This is a new company which has been formed to work some ground adjoining the Kapanga Company. One of the principal shareholders is Mr. Copley, one of the proprietors of the Thames, and also one of the shareholders in the famous Shotover claim, where a large amount of gold was obtained near the surface. A new shaft has been sunk down to a depth of 97ft., which is 12ft. long by 4ft. wide, and which will be divided into four compartments—viz., two for winding, one for pumping, and a ladder-shaft. They are also erecting a steam-engine for winding and pumping. A tunnel has been put in for 115ft. from the shaft at 90ft. below the level of the surface, and in about 50ft. more it is expected to strike the reef, where very rich stone was obtained some eighteen years ago. It is considered by those who are acquainted with this ground that it is likely to turn out well.

Tiki District.

This is a district where a large amount of gold has been obtained; but it is extremely quiet at present. There are only a few miners at work, almost the only claim at work being Blackmore's, and in it prospecting is principally being carried on. I went into the workings on the road-level, and inspected the reef, which is about 18in. thick; but, from what I could learn, there is little or no payable quartz on this level. There are two lodes on the top of the hill—one 3ft. and the other 2ft. wide, having an underlie of 1½ to 1, which have been worked to a depth of 70ft. The top reef appears to be a slip from some reef on the top of the range, but cannot be traced, although

blocks of quartz containing gold have been got on the surface along the face of the range. The shareholders now wish to put in a tunnel higher up the hill than any of the reefs which have been worked, to prospect the ground, and try to find where the loose boulders containing rich specimens have come from. The company has a battery of ten heads of stamps, and three berdans, driven by a twelve-horse-power portable engine, which is now standing idle. There is a party of tributors working either in this ground or close adjoining it who have struck a small leader of quartz, out of which some rich specimens are being obtained; but it is not yet known to what extent it will run.

Vizard Claim, Castle Rock.—This is a claim of five acres held by one man, who has done a large amount of work, and is now likely to be recouped for his outlay. This claim was taken up about four years ago, and has been almost steadily worked during the whole period. Gold was first struck in the reef near the surface; but, as the claim was situated some distance back in the bush, in a rough part of the country, the stone could not be tested until the county constructed a road to enable the quartz to be conveyed to the crushing-battery at Matawai Creek. A deeper level has lately been constructed, and the same lode struck at a distance of 83ft. in from the mouth of the level, which averages from 9in. to 18in. in width. Some of the stone from this lode on the upper level went as high as 23oz. of gold to the ton. The new tunnel gives 83ft. of backs, and the stone looks equally as well as it did on the upper level; but there is a large percentage of antimony in the lode, which interferes greatly with the present appliances at the battery for saving the gold—copper-plates and quicksilver being used; but the antimony sickens the silver, causing a black scum on the top, consequently a large portion is carried off in the tailings. Mr. Vizard had at the time of my visit about ten tons of quartz ready for the battery; but previously to crushing he has to break it up as fine as possible, and burn it in a kiln, in order to get clear of a portion of the antimony. This will assist him to some extent; but quartz of this description should not be brought in contact with quicksilver. A far larger percentage of the gold could be saved on blankets. At the end of the low level that is constructed there is a great body of water continually flowing out of the face, which indicates that the tunnel is near a watercourse or another lode of quartz; but the flow of water being so great driving for a time had to be discontinued in this direction, until the ground is drained. The length of the run or shot of gold-bearing quartz in the lode that is being worked is 66ft., and it still continues to go down.

Vaughan's Claim, Matawai.—This is a claim where a rich shot of gold was struck on the surface; but the upper portion of the lode is worked out. A low level has been constructed, and the reef struck; but as yet no gold-bearing quartz has been found. The reef has been followed for a long distance, but the character of the stone and the surrounding rock is totally different from that on the upper level, where the gold was previously got. The country through which the reef has been followed is extremely hard tufaceous rock, having in places the appearance of rocks of a highly-compressed sedimentary character, and in other places a brecciated appearance. The proprietors do not expect to find gold in the reef until they get into a softer country, which is shortly expected.

Manaia District.

There are several claims in this district taken up, but as yet very little work has been done. The only place I saw men at work was at Lynch and Company's claim. They obtained good payable quartz near the surface, and sank down a winze on the lode for 30ft., at the bottom of which they drove on the reef in the direction of a creek which runs close by the mouth of the winze. In doing so they struck a large body of water, which drove them completely out, scarcely allowing them time to get up their tools. The reef here is from 3ft. to 5ft. wide, and the stone that came from the drive looks very well. However, nothing can be done here without pumping-machinery. They contemplate to drive into the side of the range with the view of striking another lode, as they are not in a position at the present time to erect machinery. The quartz contains a small percentage of sulphide of silver along with gold, and arrangements have been made to test five tons taken from the lower drive at the new quartz-smelting works at Onehunga.

This is a district well worthy of being prospected, and one which I think is likely to contain good lodes of auriferous quartz. The great drawback at the present time is that the quartz has to be packed on horses to the end of the dray-road near Lynch's paddock, a distance of nearly eight miles, and thence carted to the crushing-battery at Coromandel, a further distance of three miles. Therefore low-grade quartz will not pay for this expensive transit—it is only rich parcels that could be treated.

Tapu District.

This is a district where very rich auriferous specimens have been found, and where a deal of gold has been obtained. At one time there was a large population on this field, but now it is very limited. There are still some claims being worked successfully; but the general impression of the residents here is that the low-level tunnel at present under construction will cut a great many lines of reefs at the low levels, some of which have been tested to within 150ft. of the level that this tunnel will command. They carried rich auriferous quartz to this depth, but could not be worked from a shaft owing to the large influx of water. The low-level tunnel is now in 423ft.; but it is not expected to cut any of the lines of reef before the tunnel is in 1,500ft. From the appearance of the country the tunnel is being constructed through, it is likely to contain reefs of auriferous nature. The rock is compact, but still of a soft kindly nature, such as that in which rich auriferous quartz is found.

Bullion Company's Claim.—This claim is situated on the opposite side of the hill from the deep-level tunnel that is being constructed. The owners have recently cleared out and retimbered an old tunnel, which was constructed several years ago for a distance of 750ft. Of this distance 100ft. at the extreme end was driven on a slide. At the end of this tunnel a cross-cut has been

driven for 20ft., where a reef, known as the Half-moon, has been struck; but at the time of my visit scarcely any stone had been broken out; but some of the quartz that came from this reef in the cross-cut showed a few colours of gold. This tunnel is constructed in a line which goes in the direction of the low-level tunnel on the opposite side of the hill; but it is at about 180ft. higher level. It will, however, be useful in working the ground when the low level gets this distance.

Alluvial gold has also recently been found in this locality, in some of the small gullies falling into Tapu Creek a short distance above the township. The gold is of a shotty character, a 3oz. nugget being obtained in one instance; but the whole of it is mixed with quartz. A party of miners have taken up a claim in the bed of Tapu Creek, and cut a tail-race for about 500ft.; but they found this would not drain the ground. They sank a shaft some 17ft., but were beat out by water. They afterwards erected a water-wheel and pumps to drain the water into the tail-race, to test the ground, but were not successful.

Waiomo District.

Gold was discovered in this district in June, 1886, by Messrs. R. Lowery, S. Lowery, and H. Plummer. They first found alluvial gold in the Paroquet Creek—a tributary of the Waiomo Creek—and traced it up until they came on a quartz reef on the side of the creek, at an elevation of about 1,100ft. above sea-level. Loose gold was got on the cap of the reef, which was of a soft nature; but on sinking down a well-defined reef was found, from 5ft. to 7ft. thick, carrying gold all through the stone. This reef has now been opened out on, and shows extremely well-defined walls, having all the appearance of a permanent character. The first crushing that was taken from the cap of the reef, 33 tons of quartz, gave 337oz. of gold, of the value of £1,146; and at the time of my visit 11 tons were crushed at the Tapu Battery, which gave 29oz. of gold from the stamps. The tailings were being put through the berdans, but I have not heard the result of their manipulation. Lowery and party's claim is about three miles back from the ocean-beach, and about one mile north of the Waiomo Creek.

Since this discovery of the Paroquet quartz reef a number of claims have been taken up; but, with the exception of the prospectors', there has been little or no quartz tested. About 20 chains east of the prospectors' claim another large reef from 8ft. to 10ft. thick has been found; and I was informed that two tons were taken promiscuously from this reef which gave 6oz. 18dwt. of gold; but, judging from the general character of the stone in this reef, I am inclined to think it was picked stone. The whole of the formation here is of a soft tufaceous sandstone, resembling the country about the Thames where the rich deposits of auriferous quartz have been obtained. The whole of the country is densely timbered and covered with undergrowth, which renders prospecting a difficult undertaking. This district has the appearance of having permanent auriferous reefs; but nothing can be done with the exception of prospecting until a road is constructed and a crushing-battery erected near the scene of operations. Arrangements were said to have been made for erecting a crushing-battery at the junction of Waiomo and Paroquet Creeks, and the county is constructing a road, with subsidy from the Government, from this battery-site to the claims. At the present time the transit of the quartz alone to the crushing-batteries either at Tapu or Grahamstown costs fully £7 10s. per ton; therefore nothing but extremely rich quartz will pay for this expense. And where quartz has to be packed on horseback at so much per ton nothing but the bare weight is taken; whereas at the Thames a dray-load is taken as a ton, which means from 25cwt. to 30cwt.

Thames District.

This field is looking quieter than I have ever seen it. At the time of my visit there were no rich finds, as in the case of recent years in the Prince Imperial and Cambria Mines; still, some of the mines continue to give a steady yield of gold. The heavy drainage-rates that have to be paid by the principal claims near Grahamstown to keep the Big Pump going is a heavy drag on them, especially when calls have to be made to meet the ordinary expenditure. In former years this big engine and pump was deemed to be the salvation of the district, and the Government gave £50,000 towards its purchase and erection; but those days are gone by, and people now are complaining greatly of the heavy expenditure that is required to keep the pump at work. After the pump had been erected at the public expense it was handed over to the county, who allowed it to be sold to meet their liabilities. The Deep Level Cross Company became the purchasers; but they found the expense of maintenance so heavy that they were glad to get clear of it again. A Drainage Board was formed to levy rates on the claims benefited by this pump, and, in order that they should have perfect control of the drainage, they purchased it for £2,500, on terms of £500 in cash and balance to be paid at the rate of £100 a month until the amount of the purchase-money was paid. About £600 of this has been paid; but the Drainage Board now find that they cannot get rates sufficient to pay off the balance and keep the pump at work. They now contemplate dispensing with the steam-power, and altering the gearing so that water-power can be applied, which will cost, in round numbers, about £4,000. The saving of water-power over steam-power will amount to about £25 per week, or about £1,300 per annum.

Cambria Company.—This company has now amalgamated with the Darwin Company, and is working between No. 1 and No. 2 Levels. The reef carries gold for about 200ft. in length, with a very tortuous course, forming in one place a regular horseshoe-bend. The reef varies considerably: in some places it is very narrow, and in other places, especially where the rich patch of gold was obtained, it widens out to 20ft.; but the average width of reef that they are now working is about 3ft., and it has an underlie northerly of about 2¼ to 1. The general direction of the reef is easterly and westerly, but no strike is discernible. They are also driving a tunnel to cut the Prince Imperial reef, which they expect to find in another 100ft. The workings are carried on night and day, with thirty-two men employed, who, together with the dead-work that they are at present engaged in, send up from three to four tons of quartz per day. The reason of the small amount of quartz

raised is owing to the gold being generally on the hanging-wall, and therefore the stone is picked, and nothing sent to the surface but that which is payable. Since the Cambria and Darwin Companies have been at work they have crushed, up to the end of October last, 14,164 loads of quartz, which yielded 37,659oz. of gold. This is produced from their stamping-battery; but recently they sent four tons of tailings to England to be treated, and received back £260, after paying all expenses connected with the treatment. This seems almost incredible, but is nevertheless true. The loss of gold in the Thames District must be enormous when the tailings are worth £65 per ton after paying the expenses of treatment.

The character of the gold on the whole of the northern goldfields is so extremely fine, and it is so closely disseminated through the quartz, that it is impossible to save it by the ordinary battery-process; but the great question arises, what class of machinery or process is to be adopted? One thing is certain—so long as crushing is resorted to, it must be made into the finest powder, and when this has to be done a large percentage of the gold will be carried away with the water over the present quicksilver-tables that are now in use. Where rich quartz has to be crushed the dry process would be preferable; but then the sulphurets would require to be roasted and afterwards put through the chlorination process. It is true that this is expensive, but it could be done for about £3 per ton, which is a mere nominal amount to the value of the gold that is lost by the present method. It is also true that low-grade quartz would not pay to put through this treatment; but there is no question about quartz that would average by the present method 1¼oz. of gold per ton. At least, the experiment is worth a trial, and I feel certain that the results would be so astounding that greater care would be taken in the manipulation of gold-bearing ores. There is no country in the world where the gold is so finely disseminated through the stone as in the northern districts of this colony, and there is no field that requires a more careful mode of treating the ores. In America and in some of the Australian Colonies, where the gold is of a much coarser character, there is an assayer employed by every company of any note. Assays are made from the general average of the material to be treated, and the companies know exactly what they lose in manipulation. Here we act in a haphazard manner, and are totally in the dark as to whether the lodes that are being worked contain payable minerals or not.

The Cambria Company has a crushing-battery of twenty-one heads of stamps and fifteen berdans, which are driven by a Pelton water-wheel. The ordinary quicksilver-tables are used, having blanket-tables at the end of the riffle-tables. They have also a National compressor, and two Ingersoll rock-drills, which are used in putting in levels and cross-cuts. The original capital of this company was 31,500 shares of £1 each, but since they have amalgamated with the Darwin the number of shares has been increased to 44,700. The dividends paid amounted, up to March, to £77,100, of which £4,500 was paid during the past year.

Prince Imperial Company.—The whole of the rich lode which in former years enabled large dividends to be paid is now getting pretty well worked out. The reef they are at present working on is of a poor character; still, they manage to make it pay the ordinary expenses. The place where the rich shot of gold was found was between the third and sixth levels (the deepest of these was 492ft.), on a lode 18in. thick, being an offshoot from the main lode. The ground here is stoped out for 600ft. in length; but the run of gold was confined to about 200ft., and occurred in ledges or benches through the reef for this distance. For instance, there would be a rich shot of gold for 5ft. or 10ft. high, and then there would be a poor place for the next 10ft. or 15ft., and so on. The main lode is about 15ft. thick, having an underlie of about 1 in 1, and was payable for working on the same level as the offshoot reef, but contained no rich specimens. Prospecting is now being done on this lode, but as yet no rich stone has been got. The shaft has been sunk to a depth of 562ft., and a level constructed at this depth for 290ft. in length. The total length of levels constructed in this mine is 7,290ft. The gold in this company's mine on the upper levels is of a far coarser nature than a great deal of the gold on the northern fields; but as the depth increases the gold gets finer, and poorer in quality. It was worth £2 16s. 6d. per ounce on the upper levels, but loses its value as it gets down. Whenever a rich shot of gold was got, the quartz was mixed with carbonate of lime, and in the old stopes large crystals of melanterite (almost pure sulphate of iron) are hanging down the sides in stalactite form, and as a rule these occur adjacent to the place where rich shots of gold have been found. This company has a crushing-battery of twenty heads of stamps, and berdans, which are driven by a Pelton hurdy-gurdy water-wheel. The total amount of quartz crushed from this mine since the present company have been at work, which is five years up to the 31st October last, has been 31,725 loads, which yielded 43,094oz. of gold, of the value of £119,314; and the amount of dividends paid was £60,750. This company had fifty tributors at work and ten men on wages. The capital of this company is £18,000, in £1 shares, on which 1s. per share has been called up.

Caledonian Company.—This has been one of the richest mines in the colony in former years—within one twelvemonth over half a million sterling was paid in dividends; but of late years nothing of any consequence has been found. Recently the company have struck a block of stone which, according to the recent crushing, averages about 3oz. of gold to the load. The thickness of the lode is about 2ft., with an underlie of 1 to 1, and the shot of gold appears to be about 300ft. in length, with about 120ft. of backs. This new find is between No. 2 and No. 3 Levels. They are also working on No. 2 Level on another lode; but this is not nearly so rich. This mine of late years has been carried on by calls, but the recent find is likely to reimburse the shareholders for all their outlay. In addition to the rich lode already mentioned, they have struck what is known as the Young American Reef, which is about 12in. in thickness; but very little work has yet been done on this reef—five loads of quartz have been crushed, which yielded 52oz. of gold to the load. Among the specimens which were shown me antimonial or ruby silver and gold were intricately mixed together. These specimens came from what is known as the Crown Reef No. 6. There are nineteen tributors and fourteen wages-men at work in the mine. In travelling through some of the old

workings I found large quantities of white transparent threads hanging down in bunches from the sides and roofs of the drives—which appear to be a form of mirabilite, or sulphate of soda. The taste is quite bitter, corresponding with the taste of Epsom salts. The rock adjoining the lodes where these crystals ooze out from is a tufaceous sandstone, having a brecciated appearance. Melanterite is also found in this mine in large crystals in the old workings. The deepest level that the company are working on at the present time is 360ft. They are dependent on the Big Pump, as well as the whole of the adjoining mines, to keep the water down.

Deep Level Cross.—This company hold a large area of ground, and have spent a large amount in working and prospecting it; but, so far, have been unsuccessful in finding a payable lode. They were the proprietors of the Big Pump, which has been, and still continues to be, the means of enabling several of the gold-producing claims in the district to be worked. The great expense involved in keeping this Big Pump at work in former years, together with prospecting without getting any return, crippled their finances to such an extent that lately they have suspended operations, having sold the Big Pump to the Thames Drainage Board. During the time they were carrying on active operations they occasionally came across some stone that was payable for working; but it was limited in extent. Last year they crushed 519 tons of stone, got partly on wages and partly by tribute, which yielded 810oz. of gold, representing a value of £2,209.

Waiotahi Company.—This company has the most systematically-worked mine I have visited on the northern goldfields: everything is carried out on a system which reflects the highest credit on the mine-manager, who has been in charge of the mine for over twelve years. During the whole of this period the company have been enabled to pay dividends, although no rich finds have ever been got. They are working from their No. 3 and No. 4 Levels, 296ft. and 360ft. respectively, on leaders which form a network of branches running in every direction. These leaders are sometimes nothing but apparently a seam in the tufaceous rock; but by following them up they occasionally widen out to from 2in. to 4in., and sometimes thicker. There is a large cross-reef running in a northerly and southerly direction containing a little gold, but not sufficient to pay for working; but the leaders and branches running at right angles to this reef generally contain payable quartz. This mine has been continuously worked since 1873, but from this up to the latter part of 1877 nothing was found of a payable character. The first dividend was paid in September, 1877, and since that date it has become a regular dividend-paying mine. There have been 22,211 tons of quartz crushed, which yielded 29,905oz., representing a value of £81,821, out of which £18,750 has been paid in dividends. Any stranger visiting this mine cannot fail to be impressed with the idea that its success has depended in a great measure on careful and systematic management. There are from thirty to forty men steadily employed on wages varying from 7s. to 8s. per day. During the whole time the mine has been worked it has never been let on tribute, which, as a general rule, is resorted to as a last resource when it cannot be made to pay by employing labour. Adjacent to the mouth of the shaft is a crushing-battery of twenty heads of stamps and five berdans, which are driven by a steam-engine, and are generally kept employed by the company during the day.

Moanataiari Company.—This company are working from a low-level tunnel, which is about 30ft. above sea-level. This tunnel is constructed for about 2,800ft. in a straight line, and thence bends a little towards the Waiotahi Creek. It is constructed 7ft. 6in. in height by 6ft. 6in. in width, having a double roadway laid with iron rails, one for the full and the other for the empty trucks. If anything were found in the low levels in the back country this would make an excellent roadway to convey the quartz to the batteries. From this tunnel there are several cross-cuts made on each side, one of which goes towards the old Shotover claim and another towards the Waiotahi Creek; the latter is 1,300ft. in length, and connected with a shaft below the Waiotahi Company's mine. At 1,450ft. from the mouth of the main tunnel a shaft is sunk, and payable quartz obtained therefrom, to a depth of 80ft. This mine is cut up in blocks and let on tribute: some of the tributors are doing very well, and the company have also about twenty-seven men employed on wages. The tributors pay the company from 10 to 20 per cent. of the gross yield of gold, and the company haul the quartz from the main tunnel and crush it at their battery, for which they charge the tributors 6s. per ton. They have a crushing-battery of forty heads of stamps, but only employ twenty heads for eight hours a day at present. The capital of this company is £135,000, in £10 shares, and £9 15s. per share has been paid up. They have done a great amount of work, and expended large sums in prospecting, with but indifferent success. In former years this company paid large dividends, but of late years the mine has been worked on calls.

New Alburnia Company.—This company has been in existence for eighteen months. They hold the same ground that belonged to the old Alburnia Company, which was in existence in 1867. Indeed, it is only a re-formation of the original company. There are 20,000 shares of £1 each, 10,000 of which were allotted to the original company for their interest, with 4s. paid up. The mine is situated at the head of the Moanataiari Creek, near the crown of the range. They have a low-level tunnel driven in from the side of the range, 460ft. above sea-level, which is 2,000ft. in length. It was originally commenced by the Sons of Freedom Company, who constructed it for 1,400ft. It was afterwards continued by the old Alburnia Company for another 600ft., following a large reef for the last 1,000ft. This is the same lode that is being worked on the upper levels; but, although there is a great body of stone in the low level (from 3ft. to 10ft. thick), there is not sufficient gold to pay for working. This is 160ft. below the next level, where the reef contains payable quartz, and from 60ft. above this there was a continuous shot of gold up to the surface, with the same size of reef as there is at the low levels. The foot-wall of this reef is hard diorite rock, and the hanging-wall soft tufaceous sandstone. The main lode is almost worked out, but the company have thirty tributors at work on leaders, the quartz from which averages about 3½oz. of gold to the load. The main lode in this mine runs easterly and westerly, having an underlie to the north. A great deal of work has been done in this mine, but it cannot be said to be satisfactorily prospected. Although a low-level tunnel has been driven on the reef for 1,000ft. and nothing got, it does not follow that

the whole of the reef between this and the next level—160ft.—is barren. The general character of the whole of the reefs here is that the gold runs in ledges and benches: very seldom is any reef found to have gold uniformly distributed all through it; and, unless uprises were made at short intervals, or intermediate levels constructed, there may still be payable quartz in this lode above the low level.

North Star Company.—This company's mine is situate at Te Papa Gully, from which they have driven a tunnel into the range for 1,140ft., costing £1,800. This tunnel will give them, at the place where the reef was struck, about 140ft. of backs. The reef is 15in. in width, but, judging from the appearance of the quartz, I should not expect it give a large yield to the load. They have twenty tributors and men employed in their mine.

Auckland Company.—This company's mine is situate on the left side of the Lucky Hit Creek, a tributary of Karaka Creek, which they have only recently taken up. A tunnel is being driven into the hill to cut some of the lines of reef that were worked on the surface in former years; and when only a short distance in they struck a reef which promises to give good returns. The reef is from 2ft. to 3ft. wide, and contains a great abundance of very white crystallized quartz, in some of which I saw gold finely distributed through the stone. As they are only opening out the mine, very little can be said respecting it; but they have about twenty tons of stone lying in the paddock ready to send to the crushing-battery at Grahamstown as soon as a road is constructed. This mine is held by only a few shareholders, and at the time of my visit had eight men employed.

There are about a hundred miners employed about Karaka Creek, some of whom have been steadily at work for many years, and are doing very well. The claims are principally held by private individuals, who have from two to eight men employed in each claim.

Otanui.

The mines here at the present time are not looking very bright. There were no men at work at the time of my visit, but I was informed that the Oriental and Eureka Companies were still working their mines. I inspected the Oriental Company's workings in company with Mr. Aitken, the County Engineer, when we were going over the subsidized goldfields roads and tracks; and, judging from the manner in which the mine was worked, it would require very rich auriferous quartz to pay for working. The workings in this mine appear to be carried on in such a haphazard manner, without any system, that it would be impossible to make low-grade quartz pay. Great hopes are still entertained for this district, and there is every convenience for getting the quartz crushed at the battery which is erected at the junction of the Otanui and Maungakirikiri Creek, from which there is a good dray-road to the mines. The crushing-battery consists of ten heads of stamps and three berdans, which are driven by one of Climo and Bowden's water-wheels. These wheels are a combination of the tangent and Pelton hurdy-gurdy wheels, and are said to give a high percentage of the power of the water.

Waihi District.

The mining-claims in this district promise to give good returns to shareholders. The district was originally opened by Government aid for prospecting, which resulted in the opening of the Martha Reef, which has been steadily worked for the last four years by the Martha Company. During the whole time that this reef has been at work the quartz has only averaged 4½dwt. of gold per ton, and the value of the gold varies from £2 16s. to £3 5s. per ounce. The gold is of the most value near the surface, and deteriorates in value as it goes down; still, the mine has been conducted in such a systematic manner that this has paid all expenses for working, including the erection, stamping-battery, and berdans. 30,000 tons of quartz have been obtained and crushed, which has to be brought from the mine by a tramway upwards of a mile in length. This shows that the average value of the stone was only 13s. per ton. Yet, this low grade having been made to pay expenses for working speaks for itself as to the judicious management of the mine, which has been under Mr. Moore since shortly after it was opened. The upper levels are now nearly worked out. There is a low level driven for 1,000ft., which is the lowest tunnel that can be driven without sinking a shaft. The reef is about 4ft. wide in the lowest level, but the portion that they have been working on has been very poor of late. This company has a crushing-battery of thirty heads of stampers and six berdans, driven by water-power from the Ohinemuri River.

Union Company.—This company's mine is situate about half a mile south of the Martha Reef, and contains a very large percentage of silver in the stone. The reef varies from 2ft. 6in. to 6ft. thick, and is of a very soft friable nature, requiring scarcely any blasting. The most of it can be taken out with picks. They have driven about 200ft. on the reef, and broken out one stope for 60ft. in length. 350 tons of the quartz which was treated by the ordinary battery-process yielded 1½oz. of gold per ton; but the last parcel that was treated only gave 15dwt. to the ton. Recently a parcel of over 16½ tons was sent to England and sold to a German firm for £43 5s. per ton. The assays taken from this parcel gave 9¼oz. gold and 55oz. silver. This was picked out from among 300 tons which was taken out of the upper levels and crushed at the battery.

During the time that the La Monte smelting-furnace was in operation 18 tons was sold, to be treated by this process, which realized £348 10s. The ore from this lode contains both gold and silver, the latter occurring as sulphide of silver, and also telluride of silver was found in specimens sent to the Colonial Laboratory for analysis. The following is a report on the analysis by Dr. Hector, which shows the ore contains 66oz. of gold and 186oz. of silver to the ton. The report also shows that by simply amalgamating it in its natural state very little of the silver can be saved.

"*Results of Analysis of Specimen No. 4,386. (Three small Specimens, for Silver and Gold.) Locality, Waihi. Received, 25th August, 1886. Reported on, 1st September, 1886.*

"Amorphous and crystalline quartz, containing electrum (alloy of gold and silver) in pale-yellow grains; and also a telluride of silver (probably hessite) in the form of dark-grey streaks of granular

mineral. The specimens are exactly the same as those from Karangahake in which I first detected the occurrence in New Zealand of telluric silver, in October, 1883 (L/3599). The former specimens were given to me by Mr. Pond, who had determined the percentage of silver and gold in them, but had not detected the presence of tellurium. Mr. Skey's analysis showed only traces of gold in the telluric silver, which led him to think that the mineral was hessite, and not sylvanite, as I at first took it to be. There is still some doubt on the subject, which can only be cleared up when more ample specimens are submitted for analysis.

"The three specimens were separately examined. No. 1 was treated for gold and silver in various ways, with the view of ascertaining the proportion in which each of the precious metals existed in the various forms of combination indicated by the minerals present. The specimen was finely ground, well mixed, and divided into small portions, which were treated as follows, and gave the results stated, as calculated upon the ton:—

"No. 1.

——	Gold.			Silver.			Total Alloy.		
	Oz.	dwt.	gr.	Oz.	dwt.	gr.	Oz.	dwt.	gr.
A. Amalgamated in natural state	44	0	20	11	4	4	55	5	0
B. Amalgamated after roasting	46	1	16	52	4	11	98	6	8

"The residue, after amalgamation of portion *B*, treated by several additional processes, gave results as follows, as per ton:—

"No. 2.—*B, continued.*

——	Gold.			Silver.			Total Per Ton.		
	Oz.	dwt.	gr.	Oz.	dwt.	gr.	Oz.	dwt.	gr.
(*a.*) By reamalgamation with cyanide of potassium	13	0	16	52	12	14	65	13	6
(*b.*) By treatment with *aqua regia* of residue from (*a*)	6	18	6	79	1	4	85	19	10
(*c.*) Obtained by assay of residue from (*b*) ...	0	4	4	2	1	6	2	5	10
	20	3	2	133	15	0	153	18	2
Brought down from Table No. 1, first amalgamation	46	1	16	52	4	11	98	6	3
Total from stone, as per ton ...	66	4	18	185	19	11	252	4	5

"These results show—first, that about one-third of the gold is left in the stone when it is merely amalgamated in its natural state, and 95 per cent. of the silver; second, that by roasting well and then amalgamating in presence of cyanide of potassium, about 9 to 10 per cent. of gold and 40 per cent. of silver is lost; third, that by the *aqua regia* process almost all the gold and silver may be extracted.

"The other specimens assayed as follows:—

	Oz.	dwt.	gr.	
"No. 2	211	10	10	alloy of gold and silver per ton.
"No. 3	135	11	4	alloy of gold and silver per ton.

"As it is very desirable that the precise nature of the ores present be determined, a richer specimen should be forwarded to the laboratory for this purpose. When this is known with certainty, the best method of extraction can be selected without any difficulty, as it is simply a chemical question. So far as may at present be gathered from these results, it appears that the Mexican or Colorado methods would suit this ore—that is, amalgamation, after its treatment with certain iron and copper salts, in presence of sodium chloride.

"Ores of this character are not usually, and can hardly be profitably, reduced by the miners and the simple appliance employed by them for crushing low-grade ores. I visited the works of a large company at Black Hawk, in Colorado, in 1876, the business of which was to purchase high-grade ores, tailings, and ores of base metals, such as zinc, lead, antimony, &c., which are obtained as accessories in ordinary gold- and silver-mines in the district. All these are manufactured into a concentrated *matte* of uniform composition. Up to 1872 the products in this form were transported to the Eastern States, and shipped to Swansea for reduction and separation; but in 1876 a new process of reduction was discovered and introduced that enabled the gold and silver to be separated without the use of acids. I was allowed to inspect the whole of the process except one stage, which was kept a strict secret.

"I have always been of opinion that the Thames Goldfield, and also that at Collingwood, will never prosper until works for the reduction of the ores are established similar to those at Black Hawk, so that the miners can have a satisfactory market on the spot for the crude ores. In this way the miners can attend to their own business of mining, and leave the difficult and risky chemical

processes required for reduction of the metals to metallurgical companies. The works necessary for this are costly, and require a large prime outlay of capital, besides heavy working expenses, and a large area of mining-country, with considerable variety in the character of the ores, in order to maintain them on a sufficiently broad and permanent basis.

"In any case it is very useless for the miners to mill such ores as are represented by the samples submitted by the ordinary wet stamper-mill. They should be—first, spalled (*i.e.*, broken and sorted); second, calcined; third, crushed and amalgamated with cyanide; fourth, the residue should be buddled and treated chemically, or, better still, sold on assay for export to where metallurgical works are established. This was the state of things in Colorado and other mining districts of America during the period of slow change which transferred the production of mineral wealth from the individual interests of miners to highly-organized companies. The correspondence submitted discloses that the same organic changes are asserting themselves in this country, and that the mining-managers are feeling unable to cope with the new phases arrived at by the industry."

Rosemont Company.—This company's ground adjoins the north-eastern boundary of the Union Company. They are at present engaged in constructing a level about 30ft. under the tunnel of the Union Company, and are in about 500ft. They expect to cut the reef in their own ground in about 20ft. further. Previous to commencing this tunnel they stoped out a portion of the reef near the surface, which yielded bullion to the value of from £4 to £33 per ton. A better idea can be got of the value of this ground when it is stated that from 110 tons the company received for their ore £923. This claim was taken up about three years ago, and a tunnel driven at a higher level. When the reef was struck about twenty tons of the quartz was taken out and stacked on the surface; but, as gold could not be seen in the stone, the claim was for a time given up. A gentleman from Paeroa—Mr. McCombie—was going over the district, and picked up a stone promiscuously from the heap and sent it to Mr. Pond, of Auckland, to be analyzed; but before he could ascertain the value of the stone the present company had taken up the ground. This stone gave at the rate of 5oz. of gold and 500oz. of silver to the ton; but, although so rich in gold, nothing could be distinguished but a number of black streaks, and the weight of the stone, which showed that it contained some mineral, but what that mineral was, or its value, Mr. McCombie had no knowledge of. However, since Mr. Montgomery has been resident in the district many of the miners and others are getting acquainted with the various minerals that the ore contains, and Mr. McCombie and the agent of one of the banks at Paeroa have erected an assay office at their own expense, and are making themselves acquainted with the mode of analysing ores and ascertaining their value. The establishment of a school of mines in this district has been an incalculable benefit to the miners, and every one speaks in the highest terms of Mr. Montgomery, who has charge of it.

Nil Desperandum Company.—This company's ground adjoins the Rosemont. They have sunk a shaft and put in a tunnel for 250ft., and struck the reef; but with the present appliances for saving the silver and gold they do not consider it payable, and have stopped operations for a time.

Silverton Company.—This company is working on a different lode from the Union, Rosemont, and Nil Desperandum Companies; but, like these companies as well as the Martha Company's mines, it is situated on an isolated hill about 20 chains in a north-east direction from the Rosemont Mine. The reef is running at nearly right angles with the other reefs in the district, its course being north-west and south-east. There is a large outcrop of loose boulders along the summit of the hill; but on sinking a winze the reef formed a more compact body of stone, rich in both silver and gold. The company was formed with a capital of £24,000, but nothing has yet been called up. They are crushing the best of the stone by the ordinary battery-process at the Martha Company's battery, and have, after paying all expenses, £700 to their credit. After picking out the best of the stone, the rest is stacked awaiting some different process of treatment. They first sank a winze on the reef, and afterwards put in a tunnel at the deepest level they could get, and are now working from this tunnel. The reef is from 12ft. to 15ft. thick, having well-defined walls, and shows gold thickly disseminated through the stone, of a remarkably fine character. The reef itself is of a peculiar formation. It forms the apex of a triangle at the outcrop on the surface, and widens out as it goes down. At a depth of 60ft. the length of the block was 40ft. The company are sinking a winze from the tunnel level on the reef, which shows the stone to contain both gold and silver of a highly payable character. There is a similarity in all the stone from this district—the quartz is very white, having seams or bands through the reef with alternate black and yellowish streaks, which contain sulphide of silver and gold. 150 tons of stone have been crushed by the ordinary battery-process, which yielded about 3oz. of gold per ton, value £2 18s. per ounce. The loss in crushing this class of ore with the ordinary battery-process is something enormous. When the stone is rich in silver not more than 20 per cent. of the bullion is saved, the whole of the silver being carried away with the water. It is quite disheartening to the owners of these claims to know that they have a valuable property, and cannot extract the metals from the ore. They are now making themselves acquainted with the mode of assaying and ascertaining its value, but are yet unable to get a cheap method of treatment. The La Monte furnace, although a failure in treating this class of ore, has nevertheless been a great benefit to the colony, inasmuch as it has been the means of the miners taking up, proving, and working lodes containing silver, which two years ago they would have looked on as mere rubbish. This, together with the School of Mines, will ultimately be the means of opening up reefs which hitherto have been deemed barren.

The country about Waihi has at some time been covered with a deposit of volcanic mud such as that which now covers the ground in the vicinity of Tarawera and Rotomahana. In entering the mouths of the tunnels that have been constructed, this layer of volcanic deposit can be distinctly seen, especially at the foot of the conical hills there are in the district. The mud has been washed down from the top, and forms a great thickness near the base; while in the Ohinemuri River, which runs

through the plain, there can be seen bars of lava in its bed, which would indicate that the volcanic eruptions in this part of the district were sometimes igneous and sometimes aqueous.

Karangahake District.

Gold has been found in this district for many years, but until recently nothing of any importance has been obtained. The Ivanhoe and Sir Walter Scott Companies have worked with success for the last two or three years, but beyond this the other claims have not attracted much attention. It was known several years ago that there was silver in this district. Samples of quartz were forwarded to Melbourne from the Maria claim for analysis, which showed the stone to be rich in silver; but, being unacquainted with the mode of treatment, it was thought nothing about. Another company, called the Woodstock, have now taken up the ground that was formerly held by the Maria Company; but they cannot make it pay with the ordinary battery-process. A great deal of work has been done in this mine. Over 300 tons of the ore was selected and treated at the battery, which averaged 2oz. of gold per ton, the average value of the gold being £1 5s. per ounce. This company have two lines of reefs in their ground, one of which is 6ft. wide, and the other averages 3ft. wide. A low level has been constructed on the latter lode, which is rich in sulphide of silver. Some of this was treated at the battery, but only yielded from ½oz. to 1oz. of gold per ton, while the silver was nearly all lost in the treatment. A few tons of this lode was sent to the La Monte smelting-furnace, which was erected by Mr. Davis at Karangahake, from which 600oz. of bullion was obtained, of the value of 9s. 6d. per ounce. This furnace was afterwards purchased by the company. The lode contains a larger percentage of gold near the surface, but the deeper the workings the richer it gets in silver, and poorer in gold. The capital of this company is £36,000, with 10s. per share declared paid up, and calls have been made to the extent of 1s. 9d. per share on 36,000 shares.

Kenilworth Company.—This company is a re-formation of the Hauraki Company, which was one of the oldest companies in the Karangahake District. In former years there was some rich auriferous quartz obtained at a high level. Their mine adjoined the Woodstock Company's ground on the south end. They sent some of the picked quartz to the La Monte Smelting-works, which yielded from £4 to £15 per ton, and the remainder of the stone was treated at the battery, and yielded 10dwt. of gold per ton, the gold being worth £2 9s. per ounce. This stone was taken from a high level. There are 25,000 shares in this company of £1 each; 40,000 shares are held in reserve, and a call of 8d. per share has been paid on the remainder. This company had also suspended operations at the time of my visit, pending the trial of the new plant that has been erected here by Mr. J. Railey.

Crown Company.—This company has been at work, off and on, for about four years without giving any return to the shareholders. There are nine different lodes in their ground, averaging from 6in. to 10ft. wide. The lowest level that they have yet constructed is over 500ft. above the level of the creek. The lode in the lowest level is from 4ft. to 6ft. in width, and contains very rich sulphides of silver. About five hundred tons of the ore is taken out and stacked at the mouth of the tunnel awaiting treatment at Railey's battery. There is another level on this lode 80ft. higher up, which is stoped out for 68ft. in length. Fifty-one tons of the ore from this level was treated at the smelting-furnace, and averaged £8 16s. per ton. There have also been several parcels of picked stone from the upper levels treated by the ordinary battery-process, which yielded from 5oz. to 6oz. per ton, the bullion of which was of a value of £1 7s. per ounce. This has every appearance of being a valuable mine as soon as a proper plant is erected to treat the ore. There are 20,000 shares in this company, of £1 each, and £2,000 has been paid in calls.

Adeline Company.—This company's mine is situated the furthest south of any of the claims in the Karangahake District, and is about 840ft. above the level of the junction of the Waitawheta Creek and the Ohinemuri River. The reef that they are working on averages about 12in. wide. Sometimes it gets as narrow as 6in., and in one place it widened out to 2ft. They have stoped out about 60ft. along the reef, and about 70ft. high. The quartz from this lode was assorted in two divisions—the best quality put in one heap, which averaged 24oz., and the second quality 8½oz., to the ton. A large parcel of this stone was crushed at the Moanataiari battery at Grahamstown, where the tailings were afterwards purchased by Mr. Brown, of Tararu, for £12 10s. and £6 8s. per ton respectively. The total quantity of quartz crushed from this mine up to March last was 168 tons from the upper level and 38 tons from the lower level, which made a general average of 9¼oz. of gold per ton. The value of the gold got from the quartz already crushed is £2 13s. per ounce. There are two reefs in this claim, both of which are being worked. They run about 20° east of north. The level that the company were working on is stoped out, but they have a No. 3 Level constructed which gives them 85ft. of backs. This company has only been at work for fifteen months. They have ten wages-men and four contractors. The capital of the company is £20,000, in £1 shares, none of which has been called up, while dividends to the amount of £2,500 have been declared.

Rose Company.—This company's mine adjoins the Adeline, and has the same two reefs which pass through the latter company's ground. The stone is similar in character, but not nearly so rich. The ground has been worked, off and on, for three years. It was formerly held by the Martha and Hidden Treasure Companies. Several parcels of stone have been crushed, which went from 3oz. to 7oz. of gold per ton, and the value of the gold was £2 10s. per ounce. Mining operations were for a time suspended, pending the erection of Railey's reduction-plant, but they are now breaking out quartz, and getting it treated at these works. The capital of this company is £20,000, in £1 shares, very little of which has yet been called up.

Diamond Company.—This company's mine is further north than the Adeline and Rose Companies on the same line of reef. Nineteen tons of stone was crushed from a high level, which

yielded 95oz. of gold, of a value of £2 10s. per ounce. Five tons was taken from a parallel lode about 12in. thick, and sold to the smelting company, but I could not get at the amount that it fetched. Both these lodes contain sulphide of silver. They were, at the time of my visit, constructing a level from the county road which will give them 70ft. of backs, all other operations being suspended until this level is completed. There were only four men at work. The capital of this company is £20,000, in £1 shares, of which 2d. per share has been paid up.

There are several other mines at work which I did not visit, amongst which is the Sutro Company's mine, who are getting their quartz treated by the new plant recently erected by J. Railey. The large amount of silver in the lodes in this district requires a different mode of treatment from that which has been adopted.

New Reduction-works.—A full description, with plans, of these works, is given further on; therefore it is only necessary to show some of the results of the treatment adopted. There can be no doubt that these works have been a great benefit to the mining companies in this district, as by the treatment of the ore a much larger percentage of bullion has been attained than hitherto has been extracted by the battery-process. At the same time these works do not give the percentage of bullion which may be expected from a more complete plant. Mr. Railey estimates that his present mode of treatment gives about 75 per cent. of the bullion; but even this percentage is very questionable. He states, however, that he is certain a much larger percentage would be got if a roasting-furnace was erected in connection with his works. This new plant, however, has been the means of active mining operations being commenced in the whole of the mines in the district, and has done a great deal in showing that they can now be profitably worked. Since this plant was erected in November last about 400 tons of stone has been treated; and the following statement will show the results from some of the ore from various mines:—

Name of Company.	Number of Tons crushed.	Amount of Bullion.	Value of Bullion per Ounce.
		Oz.	
Woodstock	8	264	...
"	10	170	8s. 3d. and £1 2s. 5d.*
"	18	59	£1 3s.
Adeline	5	85	£2 7s. to £2 14s.†
"	34	75	...
"	5	9	...
Diamond	25	200	‡
"	10	74	‡
Sutro	28½	128	...
"	16	92	16s. 6d.
Crown	10	75	19s. 4d.
"	10	25	18s. 10d.
Comstock	2	49	4s. 1d.
Tui	1	8	‡
Rose	14½	63	19s. 7d.
Dubbo	12	54	19s. 6d.
Monastery	23	164	£1 4s. 6d.
Kenilworth	10	44	14s.

* The bullion from the plates was worth £1 2s. 5d., and from pans 8s. 3d. per ounce.
† From plates the bullion was worth £2 14s., and pans £2 7s. per ounce.
‡ Value of bullion not ascertained.

It will be seen from this that the bullion is of low value, owing to the large percentage of silver in the ore, and so long as ore was treated by the ordinary stamping-battery very little of the silver was obtained.

Tui District.

This district adjoins Te Aroha. It is about two miles and a half north of the quartz-workings on the watershed of the Waiorongomai Creek.

A large lode of quartz containing gold, silver, and galena was discovered on the top of the saddle between the watersheds of the Thames River and the Waitawheta Creek, at an elevation of about 2,200ft. above the level of the sea. The reef is from 8ft. to 12ft. wide, showing an outcrop on the surface in a southerly direction for a considerable distance. This reef was discovered by Mr. C. A. Cornes about two years ago, but it was not until the La Monte Smelting-furnace Company commenced active operations that any special attention was given to this find. On the top of the saddle the stone contains sulphide of silver, a little gold, and galena, but on following the lode southward it was found to be rich in galena—the ore that was specially required for flux for smelting the quartz at the La Monte Company's furnace at the Thames. The first two tons taken from the galena lode was purchased by the Smelting Company for £22 10s. per ton, after which 25 tons were sold at £12 10s. per ton. Subsequently 150 tons were sent Home to Europe for treatment, which, I have since been informed, gave the value of gold, silver, and other metals contained in the ore as from £11 10s. to £12 10s. per ton.

This is one of the largest quartz lodes on the northern goldfields, and shows, as far as it yet has been prospected, likely to prove a valuable find; but there is really very little work done yet to

prove the lode beyond cutting across the reef in different places on the surface, and driving a short tunnel into the face of the hill. A winze has in one place been sunk to a depth of about 50ft., which carries the same character of stone all the way down. Still, the large amount of stone that is exposed on the surface, the well-defined walls of the reef, give it every appearance of going down to a considerable depth. Its natural situation and close proximity to the railway give it great advantages over many of the lodes that are found in the back country. In several places where the reef has been cut across on the surface it shows a portion of the lode to contain cinnabar, although not of a very rich quality. On the face of the range, before the lode begins to strike across the head of a gully falling into the Te Aroha Flat, the reef seems to branch off in two directions, one following the face of the range, and the other crossing the head of the gully, going southwards; but this is not traced beyond what can be seen on the surface.

About 30 chains to the southward of the southernmost workings, and to the eastward of this lode, there has been found another lode containing a good deal of carbonate of lead, but there is not sufficient work done to prove if this is of any great extent; but if it were traced it may prove to be an offshoot from this main galena lode. The character of the ore here is quite different from that of any yet found in the district, and will require a different mode of treatment to get the whole of the metals the lode contains. One thing is quite certain, it is totally unsuitable for the ordinary battery-process; but if it is proved by the process of treatment adopted in Europe to contain metals to the value of £11 10s. per ton—which is equal to the value of 4oz. 5dwt. of gold per ton—a plant can be erected in close proximity to the mine to treat the ore by a proper method.

While stating that I look on this mine as one likely to prove a valuable property, it will require a large capital to develop it. It is not an undertaking for a small company. The mine requires to be prospected on various levels to prove its extent, roads and tramways require to be constructed, and when once the mine is well opened up an efficient plant will be required for the proper treatment of the ore. Indeed, it is questionable if it will not be found more profitable in the early stage of the workings, considering the close proximity of the mine to the railway at Te Aroha, which is about two miles and a half, to assort the ore and forward the best samples to Swansea for treatment, where there is every appliance and workmen specially educated in the various methods of dealing with refractory ores.

Te Aroha District.

New Find Company.—This company is the principal one at work on the Te Aroha Goldfield. The mine is situated on the side of the Te Aroha Mountain, about two miles and a half distant from Waiorongomai Township, on what is known as the Buck Reef, which can be traced for over three miles in length. The reef is 20ft. wide in places, but the portion this company find payable for working is from 6ft. to 8ft. wide, next the hanging-wall. They have three shots of gold in this reef. The northern run is about 150ft. in length: this has been stoped out to a depth of 240ft. from the surface for an average of 6ft. in width. The gold here was very regularly distributed through the whole of the stone taken out, and went close on 1oz. of gold to the ton. Some of it went considerably higher than this when it was first discovered on the surface: as much as 2oz. per ton was obtained from the stamping-battery, and the tailings were afterwards treated in berdans, which also gave high returns. A lower level is now in course of construction, and is now in for a distance of 340ft.: when the reef is cut in this level there will be about 90ft. of backs to work on. The southern shot or run is about 130ft. in length. This has been stoped out for a distance of 200ft. from the surface, and yielded in places 2oz. of gold per truck, which is calculated to hold 1½ tons. A winze is sunk down from the lowest level for 20ft., and from this winze eight trucks of quartz was taken, which yielded 15oz. There is about 300ft. between the north and south run, which until recently has been deemed to be too poor for working. Indeed, the company could not make the mine pay, and finally arranged with Messrs. Firth and Clarke to work it on terms. These gentlemen have recently commenced to break out the reef between the northern and southern run, and have found a rich shot of gold. They are taking about 8ft. in width of quartz from the hanging-wall, which contains a large amount of tellurides and free gold: 5½ trucks from this place yielded 75oz. of gold. But the manner in which this reef is worked, although cheaply got at the first, will in the long run be an expensive one: the whole of the reef is stoped out from the surface and left open, so that every shower of rain brings a large amount of water into the workings. I did not go through the whole of the mine, but from what I could learn from the mine-manager (Mr. McLiver) there is no filling done when the quartz is taken out—the ground is merely kept up with timber. There is no doubt that if this mine was systematically opened it would give good returns—the large body of stone containing gold; its situation, where 1,000ft. of backs could be easily obtained by driving in from the side of the hill; its connection with a good tramway leading to one of the most complete crushing-batteries in the colony—although, at the same time, this battery is in itself yet greatly deficient in saving the character of gold that is found in this neighbourhood. In conjunction with this mine the owners are working the Colonist and the May Queen Mines. The run or shot of gold in the Colonist Mine is on the same line of reef as the New Find. It is about 130ft. in length, and has been stoped out for 100ft. from the surface.

The *May Queen Mine* is on a different reef from the New Find and Colonist, being more to the eastward. The reef here is about 6ft. wide. Messrs. Firth and Clarke purchased this mine about two months ago, and are working it in connection with their battery. Previous to the former company disposing of the mine, they sent to the crushing-battery about 200 trucks—1½ tons—which yielded about 2oz. of gold per truck; but even with this handsome yield the mine could not be made to pay. A winze was sunk on the reef, carrying good gold all the way down; but the water was too much to contend with, and consequently they abandoned it, and commenced to construct a lower level from the side of the range. But, after getting this level in for a distance of 100ft.,

the company sold the mine to the present proprietors, who continued the tunnel and struck the reef; but they have to drive another 60ft. before they are under the winze where good gold was formerly obtained. About 3ft. wide of this reef is highly impregnated with galena, and the other 3ft. is free milling-ore. The assays from the galena portion of the lode, when picked, show 40 per cent. of lead, 2oz. of gold, and 4oz. of silver to the ton. A quantity of this ore is now being broken out and picked, with the intention of forwarding it to America for treatment.

Messrs. Firth and Clarke carry on their mining operations principally by contract: they pay the miners from 7s. to 12s. per truck of 1½ tons for getting the quartz and taking it to the tramway-hoppers; they also pay 4s. 6d. per truck for conveying it on the inclines and tramway to the battery. They have forty-two men employed about their mines, and sixteen men at the crushing-battery and tramway. These gentlemen are now making an application for a special claim on the southern end of the Buck Reef, with the view of floating a large company in England; and from the returns obtained from this reef in the New Find and Colonist Mines there is a good prospect of striking good shots of gold in different portions of this reef. The whole of this reef, wherever it has been tested, will yield from 5dwt. to 7dwt. of gold per ton; but this is too poor to pay for working. However, when the whole of this large reef is auriferous, it is well worthy of being properly tested, as this may be the means of rich discoveries being made. To sum up the whole, the proposed project has a reasonable chance of success. The crushing-battery, which consists of forty-one heads of stamps, as well as a large tailings-plant of berdans, is kept at work for eight hours per day. The tailings, after being treated on the quicksilver- and blanket-tables, are carried away in a chute to the tailings-plant, and treated a second time. From what I could learn from the manager (Mr. Adams), about one-quarter of the bullion in the ore comes from the tailings-plant. In connection with the crushing-battery a small reverberatory furnace has been erected to treat samples of the ore by roasting. The experiments made with this furnace prove conclusively that in order to treat the different ores successfully a roasting-furnace is indispensable, as any ores containing tellurides, sulphides, and arsenicides carry away gold and silver unless they are got clear off before commencing to collect the metals the ore contains. I have been trying to impress this on the miners for several years, and now look forward with pleasure to the time when a better system of treating ores is likely to be adopted. Plans of a White-Howell furnace have been made, and the manager informed me that this will be ordered from America at once, and erected near the crushing-battery.

New Era Company, Waiorongomai, Auckland.—This was formerly a crushing-battery company, but after the crushing-battery was erected the company found no support from the claim-holders, consequently only about 200 tons is all the quartz that has yet been treated at these works. As a description of this plant, with drawings, is given further on, it is needless to refer to it here, but merely to give a sketch of the steps taken by the proprietors to utilize the plant that has been erected at a considerable expense. The claims that this plant depended on for quartz to crush have been abandoned one after another, and the New Era Company have applied for a special claim, comprising the Premier and other mines, with the view of floating a large company in the English market to work the ground in connection with the battery.

Mr. Fraser, of the foundry, Auckland, one of the principal proprietors of this crushing-plant, finding that it would not realize the expectations formed with regard to successfully treating the ore, began to make experiments with a small testing-plant he erected at his foundry for the purpose of perfecting the large plant that was erected here. With this testing-plant he has been very successful in treating samples of different ores that he could obtain from every part of the district. Indeed, so successful has he been in the treatment that it is looked on as a great favour, besides payment, to get him to test samples of two tons or so from the different mines which contain refractory ores. The principle on which he conducts the treatment is by first crushing the ore dry, then roasting it in a reverberatory furnace, which, with the addition of salt at a proper stage of roasting, converts the sulphates formed from sulphides into chlorides, and makes the ore suitable for either amalgamation with the pan-process or ready for chlorination and leaching. The reverberatory furnace which he is erecting is too small to treat a large quantity of ore, and he now proposes to erect a testing-plant at the Thames whereby he can treat, say, forty tons of ore per week. The roasting-furnace he proposes to erect is somewhat on the White-Howell principle, being about the same length and diameter, with a rotary movement; only, instead of having a smooth lining of fire-brick inside, he proposes to have a certain number of the ends of the bricks projecting, to form a kind of screw-motion, thereby preventing the material from getting too fast down to the lower end. He also advocates that these projections will cause better disintegration of the material in the furnace, consequently will cause it to be more perfectly roasted.

The New Era Company, having watched with interest the experiments made by Mr. Fraser at the testing-plant at his foundry, and the successful issue of treating the various samples of ore, intend to make such alterations and improvements in their crushing-plant before they commence crushing-operations again, that they can treat the ores in a somewhat similar manner to that adopted by Mr. Fraser.

The Te Aroha Goldfield at the present time is in a very low state. Most of the mines that were originally taken up have changed hands or have been abandoned; but there is little doubt that the whole of the ground will yet be worked when a better method of treating the ores is adopted.

New Discovery at Waihou.—A new discovery has lately been made on Mr. J. B. Smith's property at Waihou. It is situated between the Waihou or Thames River and the Waitoa River, about four miles distant in a westerly direction from Waiorongomai. The whole of the country forms a large plain for, say, eight or ten miles wide and for over thirty miles in length, which has been covered at different periods with volcanic mud, somewhat similar to the mud ejected from the

Rotomahana crater. In portions of this flat near Matamata the strata of this formation shows that it has been deposited in thin layers, as by the action of water; but on Mr. Smith's property it does not present that stratified appearance, but is more of a homogeneous mass. Shafts have been sunk in various places which show the depth of the deposit to vary considerably. In one of the shafts there is a layer of about 12ft. thick, then a layer of peat about 2ft. in thickness, and under this again is another layer of volcanic-mud deposit. It shows distinctly that there have at least been two distinct periods of volcanic eruptions, which have covered this large plain with such a heavy deposit, and there must have been a considerable time between the eruptions. Probably before these eruptions commenced the Hauraki Gulf extended for a long distance further inland and it got filled up with erupted matter; at least, it shows in some of the shafts that previous to the last deposit the surface of the previous one was of a swampy nature, by the fibres and pieces of wood that are intermixed in the layer of peat. On the surface in places the mud is formed into rhyolitic brecciated rock, and from this rock several assays were made which showed that it contained gold, silver, and copper. This led to shafts being sunk to test the material under the surface. Samples forwarded to Mr. Pond, of Auckland, for assay gave the following results:—

	Oz.	dwt.	gr.	
Sample No. 1, Gold	17	19	8	
Silver	4	8	4	
				Bullion per ton, 22oz. 7dwt. 12gr., worth £72 15s. 6d.
Sample No. 2, Silver	0	19	4	
Gold	A trace			

Samples taken by Mr. Wilson, Inspector of Mines, and assayed by Mr. Adams at Waiorongomai:—

	Oz.	dwt.	
Sample No. 1, Gold	4	10	
Silver	0	10	
			Bullion per ton, 5oz., worth £18 1s. 9d.
Sample No. 2, Gold	1	12	
Silver	1	6	
			Bullion per ton, 2oz. 18dwt., worth £6 13s. 6d.
Sample No. 3, Gold	0	9	
Silver	0	3	
			Bullion per ton, 12dwt., worth £1 16s. 6d.

After this a large sample of the material was forwarded to Mr. Fraser to treat at his testing-plant at Auckland: an assay from this gave per ton:—

	Oz.	dwt.	gr.	
Gold	0	10	0	
Silver	9	14	4	
				Bullion per ton, 10oz. 4dwt. 4gr., worth £3 18s. 4d.

The sample treated in the ordinary manner by grinding, roasting, and amalgamation gave at the rate of £1 14s., the bullion consisting of gold, silver, and copper.

Further samples were sent to Mr. A. Montgomery, School of Mines, Thames. The first sample tested only gave a trace of gold: the second sample gave at the rate per ton, gold, 2dwt. 12gr.; silver, 2dwt. 3gr.

Further assays have been made by Mr. Adams, of Waiorongomai, which gave at the rate per ton as follows:—

	Oz.	dwt.	
Sample No. 1, Gold	2	8	
Silver	0	6	
			Worth £9 13s.
Sample No. 2, Gold	0	8	
Silver	0	6	
			Worth £1 13s.
Sample No. 3, Gold	0	5	
Silver	0	4	
			Worth £1 0s. 8d.

Recently one ton of this material was treated at Messrs. Firth and Clarke's battery in one of the berdans, which gave bullion to the value of 12s.

To examine this deposit closely, it is all of a crystalline structure, but nothing can be seen, even with a good microscope, that would lead to a supposition of its containing any gold or silver beyond a trace; but the precious metals are now found in so many forms and situations that it is very difficult to say what formation contains these metals and what does not. Judging by the appearance of this deposit, I should not anticipate any rich finds being got, and it is very questionable if any of it will pay by the ordinary method of treatment. Getting assays made of ore, and manipulating the ore on a large scale, are entirely different things where the ore is refractory. The present methods of treatment used in the colony will not give an average of more than 33 per cent. of the metals contained in the ore, and it is even very questionable if this percentage is obtained on the whole.

The following table will show the amount of quartz crushed by the various companies, as far as can be ascertained, from the Te Aroha Goldfield since it was opened, and the yield of gold therefrom; also the average yield of gold per ton from the various companies' mines:—

Name of Company.	Number of Tons crushed.	Yield of Gold.	Average Yield per Ton.		
		Oz.	Oz.	dwt.	gr.
New Find	13,121	13,146	1	0	1
Colonist	7,581	4,712	0	12	13
Premier	1,124	918	0	16	8
Waiorongomai	344	372	1	1	17
Inverness	261	202	0	15	12
Galena	800	374	0	9	9
Vulcan	64	28	0	8	18
Hero	26	13	0	10	0
Werahiko	326	307	0	18	20
Waitaki	123	36	0	5	21
Welcome	2	113	56	10	0
Canadian	726	347	0	9	13
Eureka...	418	174	0	8	8
May Queen	76	123	0	12	9
Phœnix...	27	37	1	7	9
Silver King	32	63	1	19	9
Success...	36	36	1	0	0
	25,087	21,001			
From different small parcels	1,512	1,281			
Total since field opened... ...	26,599	22,282	0	16	18

The following table also shows the amount of quartz crushed and yield of gold from the whole of the northern goldfields since returns have been supplied to the Mines Department. The returns of the Thames include the Ohinemuri Goldfield.

District.	Number of Tons of Quartz crushed.	Yield of Gold.	Average Yield of Gold per Ton.*		
		Oz.	Oz. †	dwt.	gr.
TE AROHA.					
1st April, 1883, to 31st March, 1884...	4,262	4,629	1	1	17
„ 1884, „ 1885...	11,042	9,506	0	17	5
„ 1885, „ 1886...	6,552	4,489	0	13	17
„ 1886, „ 1887...	4,743	3,658	0	15	10
Total, 4 years	26,599	22,282	0	16	18
COROMANDEL.					
1st April, 1880, to 31st March, 1881...	720	4,960	6	18	0
„ 1881, „ 1882...	3,358	7,351	2	4	0
„ 1882, „ 1883...	2,907	7,577	2	12	0
„ 1883, „ 1884...	1,043	4,018	3	17	0
„ 1884, „ 1885...	456	3,201	7	0	0
„ 1885, „ 1886...	550	3,382	6	3	0
„ 1886, „ 1887...	305	4,170	13	13	0
Total, 7 years	9,339	34,659	3	14	4
THAMES.					
1st April, 1878, to 31st March, 1879...	41,917	57,207	1	7	7
„ 1879, „ 1880...	33,017	59,576	1	16	2
„ 1880, „ 1881...	32,405	53,154	1	12	19
„ 1881, „ 1882...	30,698	45,803	1	9	20
„ 1882, „ 1883...	25,867	43,311	1	13	12
„ 1883, „ 1884...	34,228	54,874	1	12	2
„ 1884, „ 1885...	31,496	37,705	1	4	0
„ 1885, „ 1886...	35,998	61,540	1	14	4
„ 1886, „ 1887...	34,827	38,142	1	1	22
Total, 9 years	300,453	451,312	1	10	1

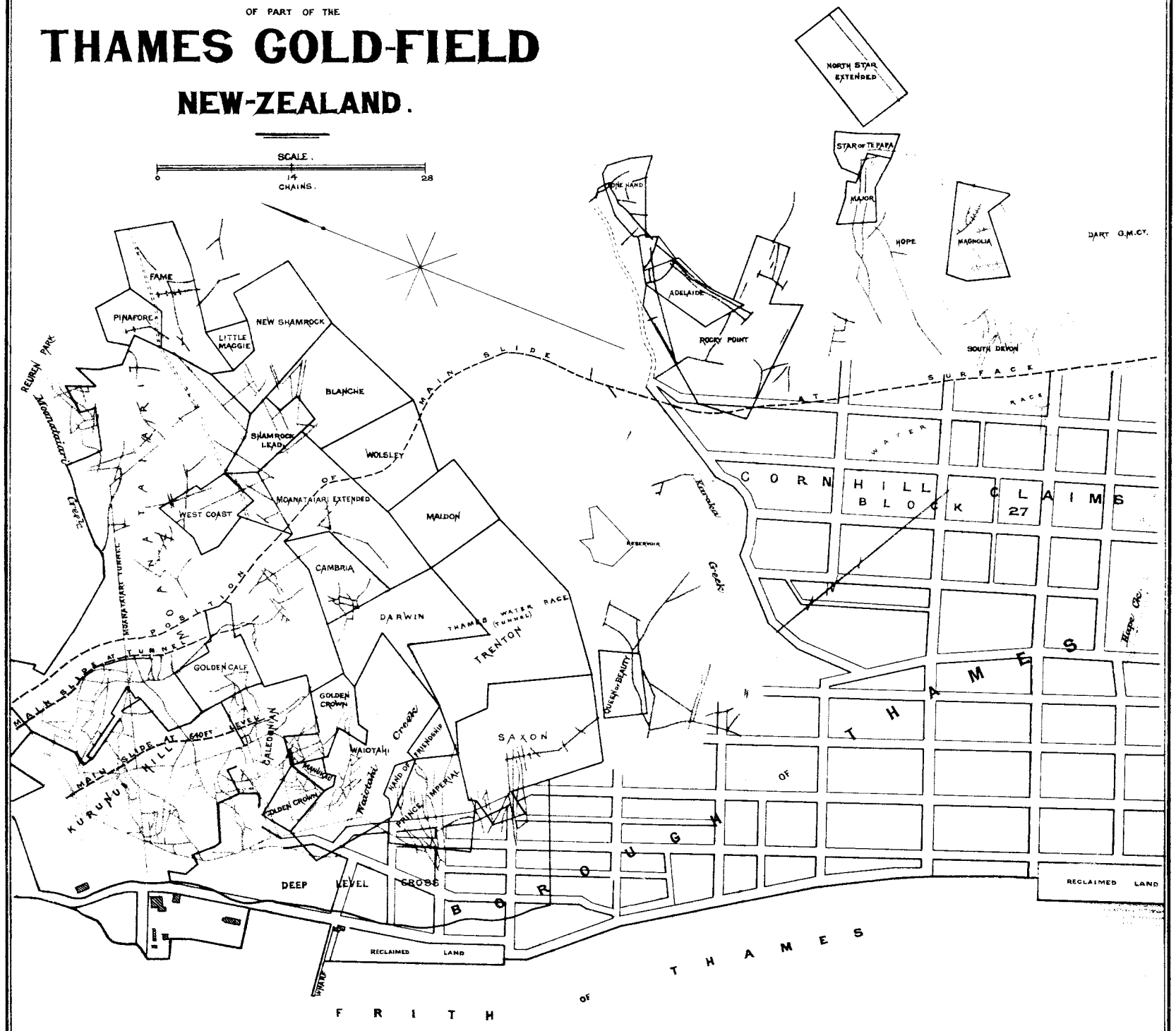
* No returns kept unti 1880. † Since field was opened.

PLAN

OF PART OF THE

THAMES GOLD-FIELD

NEW-ZEALAND.



Whangarei, Auckland.

It was reported a few months ago that gold of a payable character was discovered near Whangarei. The place where this discovery was made is on the ocean-beach, in a narrow inlet about six miles north of Whangarei Heads. The gold was found among a cemented wash lying on the beach, which had evidently come there by a slip from the cliffs, which are at this particular place about 100ft. in height. The rock in the cliffs is of a metamorphic nature, full of small veins of crystalline sand cemented with iron solution, and in these thin seams or veins colours of gold are obtained. The gold found on the beach has evidently come from these thin seams. At the very place where the gold is found the face of the cliff is sloped back for some distance at the top, as though a large slip had taken place at some period, which, no doubt, has been the case. The action of the waves in breaking up the rock and scattering it has left the heaviest particles behind. The quantity of this wash is very limited, but it contains a little gold, copper, and zinc-blende.

There is a large lode of iron-pyrites, about 6ft. wide, exposed on the beach at low water. The action of the sea-water has given this lode a peculiar golden-yellow appearance, so that it was at first mistaken for copper-pyrites, but afterwards it was found that it contains very little copper, being chiefly sulphur, arsenic, and iron. Some of the gold that was obtained on this beach was assayed by Mr. Fraser, of Auckland, and found to contain a good deal of copper. From the appearance of the country in the vicinity where the gold has been found on the beach I should not expect to find gold in payable quantities. The discovery was made by Colin Urquhart and brother, who have the only claim there is on the sea-beach. There are others tunnelling into the face of the cliff with the view of finding a reef; but their chance of doing so is very remote.

Ohaeawai, Bay of Islands, Auckland.

Metallic Quicksilver.—At Ohaeawai, which is about eighteen miles from Kawakawa, there are hot springs, which are not generally known except by the people living in the district. They are situated about two miles from the main Hokianga Road at a point nearly opposite the Ohaeawai Hotel, in a barren-looking country, covered with short, coarse fern and low manuka scrub. These springs are found here and there over a large area; and where some of these springs are the mud all around them is completely saturated with very minute globules of metallic quicksilver. At one of the places visited quantities of cinnabar were seen, which, no doubt, exists in large deposits in this district. From what I could learn, no one seemed to pay any attention to the cinnabar, but looked more for the quicksilver. The persons living in the neighbourhood stated that in some places the quicksilver can easily be collected, although not in large quantities.

This is a part of the country where a valuable cinnabar lode is likely to be found; but from the depth at which it would most likely be found in the vicinity of the springs, which are in low-lying ground, the difficulty of drainage would render it costly to work a lode, even if it were found and proved to be rich; but there is moderately high ground adjoining the springs that is likely to contain lodes of cinnabar, and that is well worth prospecting. Portion of the land where the springs exist belongs to the Natives, and a portion of it is Crown land.

Independent of the mineral value of this land, the springs are said to be very efficacious in cases of skin-diseases and rheumatic complaints; but, really, the whole of their curative properties are not known. A deal of sulphuretted-hydrogen gas is given off, and sulphur is found all round and about them. The water seems to contain a large amount of potash, but this can only be ascertained by analysis. One thing is certain—they are in a country where sulphur, arsenic, and mercury abound, and with these combinations the springs might be converted into a valuable sanatorium. At the present time there is a boardinghouse erected beside one of the springs for the reception of invalids from the northern districts, who bathe in the open pools.

MIDDLE ISLAND MINING.

Collingwood.

This is a field where a variety of minerals exists. Copper, tin, zinc, silver, iron, galena, graphite, molybdinum, gold, iridium, platinum, and coal can be got in close proximity to each other; still, although this is a district where a great variety of minerals are found, very little has yet been done towards prospecting the country and testing the value of the minerals that exist.

Gold was first discovered here in the end of 1856, and since that date this field has continued to support a limited mining population. The amount of gold taken from this district previous to the Otago goldfields being opened, or to take it up to the end of 1861, was 41,564oz., representing a value of £161,066. This gold was obtained from the washdrift in the beds of creeks. Indeed, it may be said that the principal gold that has been obtained in this district has been got in shallow alluvial deposits, for, to judge from the appearance of the old workings, very little work has ever been done. The principal gold-workings in the vicinity of Collingwood are on the east side of the Aorere River, and also on the branches of this river on the eastern side. On the western side of the Aorere River there are belts of crystalline limestone and calcareous sandstone. Underneath the latter coal-seams are found, but towards the West Wanganui there are belts of Silurian rocks, where gold is obtained. The auriferous belt of country goes from Collingwood towards Anatoki, on to the Salisbury Plains and Mount Arthur. The whole of the country is very rough and broken, without any roads excepting those up the valleys of the Aorere and Takaka Rivers. This may account to some extent for the small amount of prospecting that has been done, but the chief reason appears to be that the gold that has been found is widely scattered about, in patches here and there, without any continuous lead. It may be termed a good diggings for individual miners, but a portion of the country which is not suitable for companies to invest a large amount of capital to carry on gold-mining operations, as the patches of rich auriferous deposits in both alluvial and quartz have been found to be limited in extent. This assertion is well borne out by the fact that the

whole of the gold that has been obtained in the Nelson District—which includes Collingwood, Anatoki, West Wanganui, Tadmor, Sherry, and Wangapeka—since 1856 has only been 223,612oz., representing a value of £888,564, which is only a little over what was taken out of the Caledonian claim at the Thames in about two years.

There is a large extent of country between Collingwood and Karamea where scarcely any prospecting has been done; but this is not to be wondered at, seeing that there are no roads or tracks in the locality. Good coal-seams are known to exist south of West Wanganui Inlet, and small samples of gold have been from time to time got here and there; but the difficulty of access has prevented the ground from being thoroughly prospected.

There are several companies holding mining leases in the Collingwood District, but none of them are doing much. Lately an English company has been floated, with a capital of £150,000, to work the Red Hill. This hill has been worked on and near the surface for many years, and very rich leaders of auriferous quartz have been traced down for 30ft. below the surface. A low-level tunnel has been constructed for a distance of 600ft. with subsidy from the Government, but no quartz has been struck in this tunnel. The reefs or quartz veins that have been worked are about 4in. in thickness. It is estimated by the company's mining engineer, according to the prospectus of the company, that the yield of gold from the surface down to the low-level tunnel, which is about 300ft. below the surface-level, will be 229,425oz., representing a value of £883,286, or more gold than has been taken from the whole of the Nelson goldfields since 1857.

The following is an extract from Mr. Russel's report on the subject, dated October, 1885, as quoted in the prospectus of the company in the *Mining Journal* of 6th November, 1886:—

"Before estimating the outlay on works, however, I will proceed with this report in respect to the capabilities of the mine for yielding gold-bearing quartz, taking for my basis the area of ground proved, but which, in my opinion, is not 5 per cent. of the total likely to be worked: Length of reef proved, 600ft.; depth, 90ft.; average thickness of quartz, 6in.; number of reefs, five. 600ft. by 90ft. by 6in. by 5 = 5,000 cubic yards; or equal to 9,500 tons of quartz, at $6\frac{9}{10}$oz. of gold per ton, at the value of £3 17s. per ounce = £252,367 10s. The tunnel, which is now being pressed on with, will cut these reefs 230ft. lower than the present workings, from which I estimate that 33,250 tons of gold-bearing quartz will be mined, which will yield 229,425oz. of gold, or in value £883,286."

Mr. Russel reports "that the mine is well situated for economical working, there being adequate water-power and an abundant supply of mining and other timber." He estimates the cost of permanent works sufficient to carry on mining operations economically and on a large scale at £20,000. He considers that the value of the return to be expected from the mine has almost been placed beyond the region of speculation, and states that, with his experience of the gold-mines of New Zealand, he knows of no other having such good prospects as the Red Hill.

To analyse this report, the gold-bearing quartz that has been proved represents a value of £252,367 10s., which he represents as not 5 per cent. of what will be worked. To take this basis and the yield to remain the same, the value of the gold in the mine would represent £5,047,350, or six times the value of the gold that has been taken out of all the goldfields in the Nelson District since they were first opened in 1857.

It is to be hoped that this company's expectations may be realized, for if so, it will certainly greatly encourage capital to be expended in developing the mineral wealth of the colony. On the other hand, if results do not come up to expectations, as has been seen in some cases, capital is for a time withheld from mining enterprises which afterwards were proved to give handsome returns.

Johnston's United Company.—This company hold a mineral lease of ninety-seven acres of ground, and are working an auriferous-quartz lode on the range near the saddle of Bedstead, Kelly's, and One Speck Gullies. In the early days gold was found in mullocky schist on the saddle between Kelly's and One Speck Gullies, but this has been worked out. The gold is now found in a rotten, decomposed quartz vein, resembling to a great extent the quartz that was obtained from the Golden Crown claim at Terawhiti. This quartz lode runs in a somewhat alternately vertical and horizontal position: in some places the reef is found at a high inclination, and at other places it is nearly flat. The best gold is obtained near the place where the reef commences to take a horizontal position; but at the present time very little rich quartz is found. The company is only just managing to clear their expenses. The reef is about 2ft. 6in. in width. I had not an opportunity of seeing the whole of their workings, as they were partially locked up at the time of my visit, which was during the Christmas holidays. The company have a battery of ten heads of stamps, which they keep employed. This company was formed in 1881, with a capital of £20,000, in 20,000 shares, of which £18,332 is subscribed, and £7,375 19s. actually paid up: £1,668 has been given to shareholders in paid-up scrip. During the time the company have been carrying on operations they have paid no dividends; neither do their prospects look bright, as 10,720 shares have been forfeited.

There appears to be an auriferous-drift wash on the ranges here, and all the way up to the Quartz Ranges. From what I could learn there is a little gold all through the ground, but there is no water that can easily be brought on to work it. The only source from which this could be obtained is from the Boulder Lake, on Lead Hill, or from the Clarke River, which is one of the tributaries of the Aorere River: either of these supplies would cost a considerable amount to bring on to the ground. From what I could learn, and from the appearance of the country in the vicinity of the Quartz Ranges, there is a great depth of auriferous cemented gravel-drift that would be likely to pay for working if a good supply of water could be got; but whether this could be got I am not in a position to say. However, it is a likely-looking portion of the district for hydraulic sluicing operations if a large supply of water was available.

In Rocky River, which is a tributary of the Slaty River, some very rough gold has been got, such as 10oz. and 15oz. pieces, and a few people are still working in this locality. Gold has been more or less obtained in every gully and creek between the Clarke River and the ocean-beach on the

eastern side of the Aorere River; and in a small creek alongside the Hæmatite Range gold and iridium has been obtained.

Richmond Hill Silver-mine.—This property is situated about three-quarters of a mile to the eastward of the Red Hill, on the opposite side of the Parapara River. Silver was first discovered here several years ago, in a thin vein, about 7in. wide, in gneiss rock in the bed of the Parapara River. The ore is different from any of the silver-ores in the North Island. It is of an iron-black crystalline form (fahlerz), and has been termed by Dr. Hector richmondite. Two shafts have been sunk on the lode: the one close to the river is down to a depth, I was informed, of 100ft., and the other shaft is sunk about 50ft. from the first one, and is down to a depth of 106ft. The lode continued to go down about the same width for 56ft., but at this depth it branched off into thin strings or veins in a soft micaceous schist, in which the ore is found, enclosed between walls of hard gneissic rocks. At the 56ft. level a few tons of ore was taken out, which yielded from 40oz. to 300oz. to the ton. Above the 56ft. level the ore was carried down in the shaft, but below this it went to the eastward of the shaft. On reaching the depth of 106ft. in the second shaft, a cross-cut was made to the eastward, and the lode cut, which proved to be the same micaceous schist as found on the upper levels, mixed with thin strings of fahlerz or richmondite, chalcopyrite, galena, and blende. The walls of the lode widened out here to about 5ft. wide. On sinking a little further here samples of the ore were obtained from the thin strings which yielded at the rate of from 85oz. to 110oz. of silver to the ton. The lode was driven on for a short distance north and south at the 56ft. level. On the north end the ore seemed to wedge out, and on the south end it branched off into thin strings among the micaceous schist. Beyond this nothing has been done to prospect for the lode higher up the hill. The assays made of the richmondite at the Colonial Laboratory from forty samples ranged from 2½oz. to 1,793oz. of silver per ton, the average of the lot giving 184oz. per ton.

It is difficult to understand why these two shafts were sunk close alongside each other, and that no cross-cuts were made. From the appearance of the lode it is probably an offshoot from the main lode, and this may be found further to the eastward. The reason assigned for this is, there is a large quartz lode about 70ft. further to the eastward, cropping out on the surface, which contains chalcopyrite, galena, and blende. This should have been cut into from the bottom of the shaft. The shaft should also have been sunk to a greater depth to see if the strings or veins of ore that are mixed among the micaceous schist joined again and formed into a solid lode of richmondite. The gneiss walls being so far apart at the bottom of the shaft, there is a prospect of a good lode being found at a greater depth. The quartz lode should also be cut to see what it contains, or if it continued to go down to the depth that the shaft was sunk to, as it is probable that a lode will be found here. The gneiss rock also adjoins the quartz on the eastern side. A little on the western side of the lode that has been worked there is a belt of steatite adjoining the gneiss; and on the western side of the steatite belt there is a micaceous schist exactly resembling the schist where rich silver-lodes are found in the Silverton district in New South Wales. Prospecting should also be carried on in this belt of country, as it is very probable that a rich lode of argentite (sulphide of silver) may be found.

There is no portion of this district that is better worth prospecting than Richmond Hill; but there has been nothing done beyond testing the small vein that was discovered in the gneiss rock. The great difficulty has been, that the companies that have hitherto held the ground have not had sufficient means to either work it, or properly test it, and the money that has been spent has not been judiciously laid out.

There is a large extent of ground held in this district in mineral leases—apparently held with the view of waiting an opportunity of either selling it to some one or of forming a large company, so as to make money without expending anything to either work or test it.

Hæmatite Works, Parapara.—These works are exclusively for the manufacture of hæmatite paint. They are owned by H. Washbourn. The mine or quarry is on the east side of the Parapara, about 60 chains from the ocean-beach. The whole of the range between the Parapara River and the Onakaka Creek is a mass of rich hæmatite-ore, with belts of felspathic schist running alternately between the belts of hæmatite. The assays that have been made of this ore show that it contains from 60 to 91 per cent. of iron; and this locality will, no doubt, at some future period be a place where the manufacture of iron will be largely carried on; indeed, it looks one of the best properties that I have seen in the district. Alongside the hæmatite belt there is a belt of crystalline limestone; and there is also a bed of fossiliferous limestone apparently dipping underneath the hæmatite; also good coal can be obtained in close proximity, or, at least, within a distance of three miles, which can be taken to the works by either a tram or railroad. There is no place in the colony that offers greater advantages for the manufacture of iron; but it requires a large capital to carry on operations of this description to make it a payable venture. It is a place where English capital might be profitably employed, and one where capitalists would be able to receive a good percentage on the capital invested. The operations at the present time are, however, confined to the manufacture of paint, of which there are eight different colours. The ore is taken from the quarry, some of it is ground in its raw state, and some of it is calcined in a kiln previous to grinding. The kiln is built with bricks, in a circular form. At the bottom of the kiln there is a grating, on which is first laid a thick layer of firewood, with some set on end round the sides of the kiln; then alternately a layer of hæmatite and firewood until the kiln is full. The kiln holds about 18 tons of ore, and it takes about twenty-four hours to calcine it. After calcining, the ore is put through a battery consisting of six heads of stamps, which has a grating in front of the mortar similar to that used in a quartz-crushing battery. After the crushed material leaves the battery it is run into four berdans, and crushed finer. On leaving the berdans the sediment goes into a series of settling-pits, from which it is taken and dried on a kiln built expressly for the purpose. This kiln is 17ft. long and 6ft. wide. The sediment is placed on this drying-kiln to a depth of 4in., and kept there until it is perfectly dry, after which it is taken out and put through a steel-roller mill while in a hot state,

when it is then ready for bagging, or to be taken to the mill to mix with oil. The greater portion of it is sold in powder, and mixed by those requiring it. The mixed paint is sold in five-gallon drums. Each drum requires about four gallons of oil to reduce the paint to a proper consistency. The paint in this state is sold at £30 per ton, and the powder, in a dry state, is sold for from £15 to £17 per ton, according to the way it is made up. If put in 28lb. bags, and four of these bags placed in a wooden box, the price is £17; if put up in 28lb. bags, with two of such bags covered by an outer bag, the price is £16; and if put up in single bags of 56lb. each the price is £15 per ton. The colours of the paint vary from a dark brown to a dull yellow. The proprietor is endeavouring to get still a lighter colour. The dull colour seems to be the only objection to using it to paint town-buildings with. However, I observed a number of buildings in Collingwood and Nelson painted with this paint, and in no instance did it appear to change colour or have that mildewed appearance that many paints have after having been for some time exposed to the weather. There seemed to be great defect in the grinding-machinery. The berdans that are used are not suitable for grinding, as the process is far too slow for the quantity required to be put through; and also the settling-pits are defective. The machinery required for this work is a series of Mackay pans, similar to those used by Brown Brothers, at Tararu, Thames. One of these pans would grind far more than the four berdans that are at present employed. The settling-boxes or pits are also too narrow and shallow to allow the sediment to settle freely. On pointing this out to the proprietor he stated that this was the trouble he had to contend against: the stamping-battery crushed the ore faster than he could put it through the berdans, and he wished to get some different grinding-appliance to overcome this.

There are other paint-works near the Onehau Creek, owned by Mr. Cogan. These differ somewhat from Washbourn's principle: the paint is got from iron in the soil, and not from the ore itself. However, I had no opportunity of visiting these works, and cannot describe the method of preparation; but from what I could learn from those that have used the paint it does not retain its colour so well as that prepared from the ore.

Anatoki.—There are a few miners still employed up the Anatoki Valley and in the tributaries; but the want of tracks is a great drawback to prospecting this part of the country. Men have to carry for some distance their provisions on their backs, and unless the ground is rich men will not do this. From what I could learn the ground is very poor, and the miners are only making small wages.

To sum up the various workings in the Collingwood District, it is a place where a great many minerals exist. Some of them, especially iron and coal, are abundant; but, as far as the auriferous nature of the country is concerned, the gold seems to be widely scattered, with small although rich patches here and there, which makes it a diggings more suitable for individual miners than for large companies.

Wakamarina.

There is very little doing on this field of any note. There are from forty to fifty miners at work in the bed of the river and on the low terraces along its banks, extending for a distance of about twenty miles. As far as I can judge from the places where gold has been found, the gold has been washed down the river from time to time from heavy landslips that have taken place, and has then been deposited on the shallow bars in the bed of the river. Whenever the gold is got on the terraces it is in river-wash, which shows that the original bed has been changed, and that these terraces were at some previous period the bed of the stream. Gold has also been found in some of the creeks coming from the range on the northern side of the river, such as Deep Creek and Dead Horse Creek, in both of which rich deposits of gold have been found. This would lead one to look for gold being found in the range between these creeks. There is a large quartz reef runs through this range, and colours of gold have been found in it; but the character of the gold is different from that found in the creeks running into the Wakamarina River. Heavy pieces of gold have been found in these creeks, mixed with quartz, which have evidently come out of a slip from this range; but so far its source cannot be traced.

Extremely rich patches of gold have from time to time been got on the shallow bars in the bed of the river, but whenever these bars have been easily worked parties of individual miners have worked them in ordinary river-claims. About three years ago a company was formed in Nelson, which took up a certain distance of a gorge below the junction of Deep Creek, with the view of turning the river and working its bed in the gorge. After cutting a new channel through a terrace, and constructing a dam at each end of their claim, they tried to pump the water out of the gorge, but, after several attempts, completely failed to do this. The machinery they had was not capable of contending with the water that percolated through the shingle on which their dams were constructed. After expending about £7,000 without getting any gold, the company was wound up, and the claim and plant were sold to Mr. Turner, who is the representative of an English company called the Ravenscliffe Company, who, I am informed, hold several mines in different parts of the world. He was at the time of my visit making preparations to work the bed of the cutting that the Nelson company constructed to turn the river, and which now proves to have been the original bed at some previous period. The river is again turned through the gorge, and a dam constructed at the upper end of the cutting to prevent the flood-water from the river getting down the channel, and a dam is also constructed at the bottom of Deep Creek to raise the level of the water in the creek to work an overshot water-wheel to pump the water from the bed of the cutting, which is expected to be about 18ft. deep. The works are so far advanced that they expect to have the whole of the bed of the cutting worked out by the end of April. I have since learned that this channel has been worked out, and that it paid the company very well for working.

The same company have another claim about two miles higher up the river, in Maori Gorge, where they have built a substantial dam across the bed of the river at the upper end of their claim, with a timber flume at one side to carry the water of the river below their workings. They

have a portable steam-engine working elevators for a certain height to lift the water, and below this they use a Californian pump to lift the water into the hole or tank in which the elevators are fixed. The depth of the wash in the bed of the river is about 40ft. This company has been at work here for over two years, but have not yet got any gold to speak of. The floods in the river carried away the first dam that was constructed, and filled up all the workings with shingle. They expect to be in full operation in a few weeks, and apparently are now in a fair way of working the ground.

Galloway and party of three men have entered on a large undertaking at Quail's Gorge, which is about three miles up the river from its junction with the Pelorus. They are cutting a channel through a terrace which will be 12 chains in length, and in some places the cutting will be over 30ft. in depth. A portion of this cutting has been made, but it will take from twelve to eighteen months yet before the dams and cutting are completed. Unless they are men of considerable means the undertaking is of such magnitude that it is questionable if it will ever be completed. However, the men deserve great credit for the pluck and perseverance that they have hitherto displayed in prosecuting the work, which was commenced about two years ago, and they are fully confident that it will be a profitable investment as soon as the works are completed. It is only men that have been in the locality for a number of years, and are acquainted with the nature of the ground and the manner in which the gold is found in the river, that would undertake a work of such magnitude.

A few parties are tunnelling and sluicing on Quail's Terrace, but, from what I could learn, are only making small wages. The gold does not appear to go back any distance from the river.

Reefton District.

This district and the Thames promise to become large centres for quartz-mining. The formation of the country here is of an entirely different character from that at the Thames. Here the Silurian rocks contain the quartz, while the lodes in the North Island mining district occur in the volcanic rock. The latter district resembles more the formation of the country where gold- and silver-lodes are found in America; and the deposition and source of the ore appear to have been produced by the same effect.

In the Reefton District no eruptive rocks are to be found in the vicinity of the quartz lodes; but the slate and schistose rocks where the quartz lodes occur are full of stringers, seams, and small leaders of quartz, showing clearly that the ore was deposited in a state of solution, and that this solution was also under considerable pressure, causing it to permeate through the rock in every direction. Many theories are advanced as to the source and deposition of the minerals found in the lodes. Some say the solution came downwards; others think it may be matter of infiltration through the adjoining rock into the fissures and seams; while some affirm that the solution was pressed upwards. The latter appears most feasible, and seems to best fulfil the conditions required to put gold in a state of solution. It is well known that chlorine has this effect on gold, and that constituents for forming chlorine are to be found to a certain extent in the rocks. It is possible that sea-water, percolating through the seams and rents of the rocks, occupies a prominent part in the production of gold in the quartz reefs. This, following downwards by increased pressure from above, finds its way down to the eruptive rocks, which underlie the sedimentary—to that point under the earth's surface where the internal heat prevents it from getting further, or, at least, in the form of water. It is converted into a gaseous state, thus coming in contact with sulphur. Sulphurous acid, or sulphuretted hydrogen, and nitre form the chlorine, which dissolves the gold in the rocks. The upward pressure caused by the accumulation of steam on fusion formed by the internal heat of the earth forces solutions upwards, causing them to permeate through the rocks, whenever there are any rents and seams, into the large fissures in the earth's crust.

Another action takes place with regard to the silica in the lodes. Water holding carbonic, sulphuric, and other acids in solution decomposes the silicates and sets free their silicic acid. Newly-formed silicic acid being to some extent soluble in water, it therefore permeates through the joints of the rocks into the fissures and seams. It is well known that even rain-water contains carbonic acid in solution, although in small quantities, corresponding to the amount of carbonic anhydride in the atmosphere. The air filling the pores of the soil for a considerable distance from the surface is much more highly charged with carbonic anhydride than the free atmosphere—a fact, no doubt, due to the oxidation of organic matter—and the percolating waters are correspondingly charged with carbonic acid.

In whatever way the lodes were formed in the Silurian rocks, there is no doubt that the fissures and seams in the rocks were filled with ore-bodies in a state of solution; but the subject has not been sufficiently studied by scientists to arrive at correct conclusions. It is, however, a subject which is of the utmost importance to the miners, as it will be the means of enabling them to search for ore-bodies on some definite basis, with far more chances of success, and it will also give a more clear insight as to the probabilities of finding payable lodes at greater depths than have yet been penetrated.

The dense forest, undergrowth, and mountainous character of the country in the Reefton District render auriferous-quartz-reef discovery very tedious and difficult, involving a large amount of time, labour, and capital. Several of the mines are looking more promising than they have hitherto done, and a new discovery by the Globe Company during last year has given an impetus to mining which in future may lead to good results.

I have not visited this district during the past year, but from reliable information received it may be well to mention some of the principal companies, showing the results from their workings during the last year.

Welcome Company, Boatman's.—This is the leading company in the Boatman's district. The capital of this company is £15,000, of which £3,750 is paid up in cash, and paid-up scrip given to shareholders to the value of £7,500. Up to the 31st of December last dividends were paid to the amount of £110,250, of which £6,750 was paid as dividends during the year. The total value of

gold obtained from the mine up to the same period is £222,808 14s. 9d., and the total expenditure in connection with the workings was £116,836 1s. 9d. The quartz crushed last year amounted to 2,002 tons, which yielded 4,530oz. of gold, representing a value of £17,877.

Hopeful Extended Company, Boatman's.—This is a company that purchased the mine which belonged in former years to the Hopeful Company, from which mine a large amount of gold had been obtained previous to the purchase. However, of late years there have not been any large finds nor any dividends paid. The value of gold the present company have obtained is £5,291 19s. 9d., and the expenditure on the mine and carrying on operations has been £7,542 3s. 3d. The amount of paid-up capital is £2,020 7s. 1d. The amount of quartz crushed last year was 95 tons, which yielded 222oz. of gold, representing a value of £838.

Fiery Cross Extended Company.—This company's ground adjoins the Hopeful Extended Mine. During last year some rich stone was struck, which still continues to be worked, giving very satisfactory results. The capital of this company is £24,000, of which £19,400 has been subscribed; and of the latter amount £7,400 has been paid in calls and £12,000 given to the shareholders as paid-up scrip. Gold has been obtained to the value of £42,422 18s. 8d., and the expenditure connected with carrying on operations has been £37,948 14s. 8d. The amount of dividends declared has been £11,700; of this amount £6,600 was declared for the six months ending 16th December last. The amount of quartz crushed during last year was 3,227 tons, which yielded 4,212oz. gold, representing a value of £16,669.

Just in Time Company, Boatman's.—This company's ground adjoins the Fiery Cross Extended Company's mining-lease. This is a mine that has from time to time paid dividends to the shareholders. A great deal of dead work has been carried on of late years, but they have now discovered stone that is likely to give the shareholders some returns. During the six months ending 29th November last gold was obtained to the value of £6,114 11s. 8d., and the expenditure connected with carrying on operations was £3,839 19s. 6d. The dividends paid during this period were £2,100. Since then dividends have been declared to the amount of £1,400, making the total dividends paid during last year to be £3,500. The amount of quartz crushed was 3,033 tons for last year, which yielded 2,600oz. of gold, representing a value of £10,269. The nominal capital of this company is £28,000, in 28,000 shares; while the actual amount paid up in cash is £9,762 1s. 4d. The total dividends paid up to date have been £15,066 13s. 4d.

Reform Company, Boatman's.—This company's ground adjoins the Just in Time. Both of these companies sank a shaft and erected winding-gear conjointly to work their claims from. The capital of this company is £12,000, in 24,000 shares, of which £2,698 3s. has been actually paid up, and £1,200 given to the shareholders in paid-up scrip. This company is a re-formation of the company that originally held the ground, and was only formed in May last. For the six months ending the 31st December last gold was obtained to the value of £125 18s., and the expenditure in connection with carrying on the company's operations was £991 16s. 9d. During the year ending March last 328 tons of stone was crushed, which yielded 224oz. of gold, representing a value of £878.

Eureka Extended Company, Boatman's.—This company's ground adjoins the Welcome Company's mining-lease. They constructed an incline-tunnel from the surface over 2,000ft. long, to cut the Welcome reef, which was expected to run through their ground. They, however, so far, have not been successful in finding it. The whole of the company's expenditure had to be provided from calls made on the shareholders. The total expenditure to the 1st December last was £12,376 5s. 5d. Very little work has been done during the last year, but they are now preparing to again commence operations to drive the tunnel farther ahead, as they feel confident that they will yet cut the eastern line of the Welcome reef in their ground.

Specimen Hill United Company, Boatman's.—This company's ground is situated on Specimen Hill, which is north of the Welcome Mine. A great deal of work has been done in this mine without getting any beneficial results. The nominal capital of the company is £20,000, in 20,000 shares, of which £4,587 5s. 4d. has been paid, and £10,000 given to shareholders as paid-up scrip. The expenditure in connection with carrying on mining operations has been £5,671 5s. 11d.; and gold to the value of £670 14s. 2d. has been obtained.

Homeward Bound Company, Boatman's.—This company's ground adjoins the Welcome lease; and the Welcome Company has now driven on the reef so near the boundary that there is little doubt but that it will run into this company's ground. The company are now sinking a shaft with the view of cutting the reef. The capital of the company is £24,000, in 24,000 shares, of which £2,544 2s. 9d. is paid up, and £12,000 has been given to the shareholders in paid-up scrip.

Phœnix Extended Company, Reefton.—This company's mine is situated on the eastern slope of the range falling down to the Waitahu River. The ground has been held for a number of years, and gold has been obtained from time to time; however, during last year there has been very little work done in the mine. The capital of the company is £16,000, in 16,000 shares, of which £5,359 6s. 6d. has been paid up, and £8,000 given to the shareholders in paid-up scrip. The total value of gold, &c., obtained from the mine is £4,455 10s. 7d.; while the expenditure has been £8,561 14s. Dividends to the amount of £1,200 have been paid.

Inglewood Extended Company, Reefton.—This company's mine adjoins the Phœnix claim, and they work it by means of an adit-tunnel. The value of gold obtained from this mine is £10,677; and the expenditure connected with the company's operations £15,090 12s. The total amount of dividends paid to date has been £1,500: of this sum £300 was paid during last year. The quantity of quartz crushed was 920 tons, which yielded 495oz. of gold, representing a value of £1,908.

Venus Extended Company, Reefton.—This company's grant is between the Golden Fleece Extended and Murray Creek. It was formed in 1885, with a capital of £24,000, in 24,000 shares, of which £900 has been actually paid up, and £12,000 given to shareholders in paid-up scrip. This company has been in active operation since its formation, and has discovered a quartz lode of a

payable character. The crushing-battery formerly belonging to the Energetic Company was purchased and connected with the mine by an aërial tramway, similar to that erected from the Globe Mine to the Inangahua River. The amount of gold obtained has been 2,535oz., representing a value of £9,935 10s. 4d., and the expenditure in connection with carrying on the company's operations £9,307 7s. 6d.; while £2,100 has been paid in dividends. 3,603 tons of quartz have been crushed during the year, which yielded 2,212oz. of gold, representing a value of £8,611.

Golden Treasure Company, Reefton.—This company's mine is situate on the side of the range facing Murray Creek. It has been in existence since 1877, and done a great deal of work since in opening up the mine at various levels and prospecting the ground. Of late years the quartz has been of a very low grade. The capital of the company is £15,000, in 48,000 shares, of which £13,413 16s. 11d. has been actually paid up. During the period the company has carried on operations dividends have been paid to the amount of £2,400.

Golden Fleece United Company, Reefton.—The ground that this company hold has been continuously held since the Inangahua District was first opened. At first it was held by the Ajax Company and Golden Fleece. Afterwards these two companies amalgamated under the name of the Golden Fleece Extended, and obtained a deal of gold from this mine. Before the Golden Fleece Company amalgamated with the Ajax Company the former company paid a large amount in dividends; and during the time that it was held by the Golden Fleece Extended—from 1876 to the beginning of 1884—24,791oz. of gold was obtained, of the value of £95,540; the expenditure being £55,378. During the same period £40,800 was paid in dividends. The present company was only a re-formation of the former company, and is merely altered to the word "United" instead of "Extended." Since the formation of the present company nothing of any consequence has been got. The ground is worked from a shaft which is down to a depth of about 740ft. The quartz has been partially worked on the different levels all the way down to this depth, and from the level at the bottom of the shaft a winze has been sunk down following the reef for about 70ft., and portion of the lode stoped out. This company was the first to introduce the diamond and compressed-air rock-drill into the Reefton District—a plant which cost £2,531. Mining operations have for the present been suspended, and the claim is protected. The capital of the company is £48,000, in 48,000 shares. The amount of capital actually paid up is £6,773 18s. 6d., while £24,000 was given to the shareholders in paid-up scrip.

Keep It Dark Company, Reefton.—This is the leading company in the Reefton District. It has continued to pay regular dividends ever since the mine was opened out in 1877. The capital of the company is £20,000, in 20,000 shares; the amount of paid-up capital is £2,625, and £10,000 was deemed to be paid up at the time of registration. There has been obtained 45,477oz. 11dwt. of gold from the mine, of a value of £176,685 2s. 7d.; and the expenditure on the operations of the company has been £99,971 15s. 6d. Dividends to the amount of £82,166 13s. 4d. have been paid to the shareholders. During the year ending the 13th December last there were 9,360 tons of quartz crushed, which yielded 5,465oz. 12dwt. of gold, of the value of £21,324 3s. 10d., out of which £12,000 was paid in dividends: £4 2s. 2d. per share has been paid in dividends, and the amount of calls paid per share is 2s. 7½d.

Nil Desperandum Company, Reefton.—This company was formed in 1877, with a capital of £23,000, in 23,000 shares, of which £8,029 6s. 11d. has been actually paid up, and £11,500 given to the shareholders in paid-up scrip. The mine adjoins the Keep It Dark Company's lease. Operations were suspended for a considerable time; but last year arrangements were made with the Wealth of Nations Company to crush the stone at their battery. New winding-gear was also erected, so that mining operations could be systematically carried on. Up to the present time the amount of dividends declared has only been £143 15s.

Wealth of Nations Company, Reefton.—This company's ground adjoins the Keep It Dark Company's mining-lease. In former years a large amount of gold was taken from this mine; and also a large amount of money paid in dividends. The company was re-formed in 1882. Since then no dividends have been paid. The capital is £32,500, of which £30,631 5s. is actually paid up. The yield of gold since the re-formation of the company has been 1,118oz. 15dwt., of a value of £4,268 17s. 5d.; while the expenditure has been £22,667 9s. 4d. The quantity of quartz crushed during last year was 100 tons, which yielded 62oz. of gold, representing a value of £241.

Globe Company, Reefton.—This company was formed in 1882 to work a large reef that was discovered near the head of one of the branches of Devil's Creek, with a capital of £78,000, in 36,000 shares, of which £14,775 is actually paid up. Although the reef was from 8ft. to 12ft. wide, the quartz was of such a low grade that the company has up to the present been unable to pay any dividends to the shareholders. However, during last year, when it was contemplated to wind up the company, and shareholders were disposing of their shares at any price they would bring—not a few being given away—in order to relieve themselves from future responsibility (a parcel of a thousand shares was sold in July last for a shilling, so little faith had the shareholders in the prospect that anything of importance would be discovered in the mine), towards the end of September, the manager reported a valuable discovery near the western boundary of the company's lease, which promises to revolutionize the prospects not only of the Globe Company, but also of the whole of that portion of the district. A trial-crushing of 86 tons was taken from the newly-discovered reef, which is 10ft. wide, which yielded gold to the value of £688 5s. 6d., equal to about 2oz. of gold to the ton. This reef, which runs in an easterly and westerly direction, has been traced in an easterly course for 700ft. from the position of a winze that was sunk down, following the reef from the surface to a depth of 70ft., which proved the reef at this depth to be of a highly-payable character, quite equal in value to the trial-crushing taken from the surface. It has also been traced from this winze in a westerly direction, towards the Progress Company's ground, for 300ft. A tunnel has been constructed from the side of the hill underneath the bottom of the winze, where the reef continues about the same value. This

tunnel gives 130ft. of backs to operate on. A tramway, 16 chains in length, has been constructed to convey the quartz from this new discovery to the end of the company's aërial tramway, on which the quartz is conveyed for 96 chains over the range to the company's crushing-battery. The effect of this discovery was to raise the value of shares which before were unsaleable at any price to £2 4s.; and not only has this discovery had the effect of increasing the value of shares in this company, but it has given a new impetus to mining all over the district, and has been the means generally of increasing the value of mining property. The total value of gold obtained from this company's mine up to the 27th of November last was £12,231 13s. 11d.; and the expenditure connected with their operations has been £27,312 9s. 4d. The quantity of quartz crushed during last year was 420 tons, which yielded 408oz. of gold, representing a value of £1,611.

Progress Company, Reefton.—This is a company that was formed to work the ground adjoining the Globe Company's mining-claim, where the Globe reef was expected to run through. This company has found a payable reef in their ground; but they have only recently commenced operations. Up to the end of March last the quantity of quartz crushed was 300 tons, which yielded 400oz. of gold, representing a value of £1,585. This enabled dividends to the amount of £1,200 to be paid.

Inkerman Company, Reefton.—This company's mine is situate at Rainy Creek, about seven miles from Reefton. The ground has been held since 1876, but no work of any great importance was done until two years ago, when a crushing-battery comprising thirty heads of stamps, with several berdans, was erected, and the quartz taken in a body from the reef, which is in places over 20ft. wide. This quartz was of very low grade; nevertheless the proprietors deemed it of a payable character if treated on a large scale. The company has been steadily employed in working the mine, but has so far been unable to pay any dividends. The capital of the company is £20,000, in 20,000 shares, of which £12,371 12s. 8d. is paid up. During last year 800 tons of quartz has been crushed, which yielded 262oz. of gold, representing a value of £1,035.

Big River Extended Company, Reefton.—This company's mine is situated in the Big River district, about twelve miles south of Reefton. The company was formed in 1881, but for several years their operations consisted only of prospecting the ground. The mine was in an isolated position, without any road to get the quartz taken to a crushing-battery to be properly tested. During last year the road from Reefton to this district was completed, and machinery has now been brought on the ground and is in course of erection. The mine has been well prospected, opened out, and 200 tons of quartz has been raised to the surface ready for treatment. The reef varies from 6in. to 5ft. thick, and from primitive tests made from time to time from stone raised it is estimated that the gold from the stone already on hand will nearly pay for all the outlay. During the last six months the operations have been confined to the surface, in constructing paddocks, water-race, aërial tramway to convey the quartz from the mine to the crushing-battery, and the erection of battery, with berdans. The capital of the company is £24,000, in 24,000 shares, of which £5,422 9s. 3d. is paid up, and £12,000 given to shareholders in paid-up scrip.

Golden Point Company, Reefton.—This company was formed in 1878, with a capital of £24,000 in 24,000 shares, of which £7,000 has been actually paid up, to work a reef close to Soldier's Creek. Several years ago a body of auriferous quartz was struck, which induced the company to erect a battery of ten heads of stamps; but after being at work for some time the quartz did not prove of a payable character, and operations were for a time suspended, and the battery sold to another company. Lately this company have again commenced operations by further prospecting the ground. The amount of dividends paid by this company has been £189 14s. 10d.

Rainy Creek Company, Reefton.—This company's mine is situate at Rainy Creek, but mining operations are at the present time suspended. The company was formed in 1882, with a capital of £12,000, in 24,000 shares, of which £6,339 14s. 1d. has actually been paid up. During the period the company has carried on operations there have been no dividends paid.

Lyell District.

This is a district where rich finds of gold have from time to time been discovered, not only in the quartz lodes, but also in the alluvial deposits. The general character of the rock in which the quartz lodes occur resembles the character of the country in the Reefton District, especially on the side of the range facing Lyell Creek, but on the opposite side of the range facing New Creek, the rock is far harder and more compact, which leaves the impression that permanent auriferous-quartz lodes will not be found on this side of the range to any great depth.

United Alpine Company, Lyell.—This company's mine is situate on the side of the range facing Lyell Creek. The company was formed in 1874, and has carried on active operations ever since. The capital is £48,000, in 32,000 shares, of which £17,733 6s. 8d. has been actually paid up, and £16,000 has been given to the shareholders in paid-up scrip. The amount of dividends paid by this company has been £39,666 13s. 4d. This is the leading claim in the Lyell District. Indeed, it can be classed with the Welcome and Keep It Dark Mines in the Reefton District as being one of three of the best quartz-mines on the West Coast of the Middle Island, and a mine which will continue to give good returns for several years from the extent of the reef which has been prospected and proved, without calculating on further finds below the No. 6 Level, which is now used for stoping out. A commencement has been made to construct another level below the one on which they are working, which will take about two years to construct. There has been 8,364 tons of quartz crushed during the year ending the 31st March last, which yielded 5,846oz. of gold, representing a value of £22,360 19s. During last year the amount of dividends paid was £10,800.

Lyell Creek Extended Company, Lyell.—This company is driving a low-level tunnel to cut the same reef that is now being worked by the Alpine Company. This tunnel had been constructed on the 1st December last for 1,854ft.; but no body of quartz has yet been struck. The company was formed in 1881, with a capital of £24,000, in 48,000 shares, of which £5,510 12s. 1d. has been

actually paid, and £12,000 was given to the shareholders in paid-up scrip. The expenditure in connection with the operations of the company up to the 1st December last was £5,288 6s. 4d.

The Larnach Company, Lyell.—This company's ground adjoins the United Alpine Company's claim. Arrangements have been made with the latter company to prospect the ground, which is on the eastern boundary of the United Alpine Company's lease, from the Alpine No. 6 Level. This company was formed in 1885, with a capital of £24,000, in 24,000 shares, of which £596 9s. 2d. has been actually paid up, and £12,000 has been given in paid-up scrip to shareholders. The amount of expenditure in connection with the company's operations up to the end of September last was £456 19s. 9d.

Tyrconnel Company, Lyell.—This company was formed in 1882, with a capital of £24,000, in 24,000 shares, of which there has been paid up £1,800, and £12,000 has been given to the shareholders in paid-up scrip. This company has had good payable stone in their mine at times, from which they have paid £2,600 in dividends.

Crœsus Company, Lyell.—This company's ground is facing Lyell Creek. Some years ago a reef was struck in their mine, which promised to give good returns for working. A battery was erected and mining operations carried on for some time; but the value of the stone did not realize the expectations that were formed respecting it. Mining operations are now suspended. The capital of the company is £18,000, in 24,000 shares, of which £7,200 has been actually paid up, and £9,000 has been given to the shareholders in paid-up scrip. No dividends were ever declared.

United Italy Company, Lyell.—This company's mine is situate about five miles up a branch of Lyell Creek. Several years ago good stone was struck in this company's mine, which induced the Government to construct a dray-road from the Lyell to the mine, so that the stone could be taken to the crushing-battery. However, this mine has not, so far, turned out nearly so well as was anticipated. The capital of the company is £24,000, in 24,000 shares, of which £3,100 is actually paid up, and £12,000 has been given to the shareholders in paid-up scrip. The amount of dividends declared has been £900.

Summary of Mining Companies, Reefton and Lyell Districts.

To take quartz-mining as a commercial venture, the results from one or two companies cannot be taken as a criterion as to the value of any particular field. There is no doubt money has been lost in mining; but a great deal of this has been lost in purchasing shares in companies far above their real value. To take the companies in the Reefton and Lyell Districts that published their statements of affairs in January and February last in the *Gazette*, in accordance with the requirements of "The Mining Companies Limited Liability Act, 1886," the actual amount of money paid in calls made by companies in the Reefton District was £163,015 5s. 1d., while the value of dividends paid was £210,306 8s. 2d.; leaving a profit of £47,291 3s. 1d. In the Lyell District the calls amounted to £28,740 7s. 11d., while the dividends were £43,266 13s. 4d.; thus leaving a profit of £14,526 5s. 5d. The amount of dividends paid in excess of moneys paid in calls was £61,817 8s. 6d.

The following table will show the statement of affairs of the whole of the quartz companies that published their statements in the *Gazette* in the Reefton and Lyell Districts:—

Reefton District.

Name of Company.	Date of Registration.	Number of Shares.	Number of Shares allotted.	Nominal Capital.	Subscribed Capital.	Value of Scrip given to Shareholders.	Amount of Cash actually paid up.	Amount paid up per Share, including Scrip given to Shareholders.	Number of Shares forfeited.	Arrears of Calls.	Amount of Dividends paid.
				£	£ s. d.	£	£ s. d.	£ s. d.		£ s. d.	£ s. d.
Specimen Hill Extended	10th June, 1834	20,000	20,000	20,000	15,500 0 0	10,000	4,587 4 5	0 14 8	150	912 15 7	..
Homeward Bound	3rd September, 1883	24,000	24,000	24,000	24,000 0 0	12,000	2,544 2 9	0 12 2	375	55 17 3	..
Eureka	13th August, 1883	24,000	24,000	24,000	24,000 0 0	12,000	6,700 0 0	0 15 7	..	0 16 8	..
Welcome	20th August, 1875	15,000	15,000	15,000	15,000 0 0	7,500	3,750 0 0	0 15 0	..	..	110,250 0 0
Hopeful Extended	12th June, 1882	24,750	24,750	24,750	24,750 0 0	12,375	2,010 18 9	0 11 7½	..	..	..
South Hopeful	23rd November, 1877	20,000	20,000	20,000	10,000 0 0	..	4,968 3 4	0 4 11½	..	198 10 0	..
Fiery Cross	27th September, 1882	24,000	24,000	24,000	19,400 0 0	12,000	7,400 0 0	0 16 2	..	..	11,700 0 0
Just in Time	9th September, 1872	28,000	28,000	28,000	28,000 0 0	..	9,762 1 4	0 9 10	..	..	..
Reform	22nd June, 1885	24,000	24,000	12,000	12,000 0 0	1,200	2,698 3 0	0 2 3	..	42 12 10	..
Lord Edward*	3rd November, 1883	24,000	24,000	24,000	24,000 0 0	12,000	196 6 2	0 10 2	..	104 11 2	..
Inglewood Extended	25th August, 1882	24,000	24,000	24,000	24,000 0 0	12,000	5,627 1 1	0 14 8½	3,590	46 6 10	1,500 0 0
Golden Treasure	10th December, 1887	48,000	48,000	15,000	15,000 0 0	..	13,413 16 11	0 11 2½	..	36 3 11	2,400 0 0
Venus Extended	21st August, 1885	24,000	24,000	24,000	24,000 0 0	12,000	900 0 0	0 10 9	..	..	2,100 0 0
North Venus	23rd November, 1886	24,000	24,000	24,000	24,000 0 0	12,000	15 2 1	0 10 0½	..	34 17 11	..
Wealth of Nations Extended	12th April, 1882	32,500	32,500	32,500	32,500 0 0	..	30,631 5 0	0 18 10½	4,297	..	..
Keep It Dark	2nd March, 1874	20,000	20,000	20,000	20,000 0 0	10,000	2,625 0 0	0 12 7½	..	..	82,166 13 4
Nil Desperandum	5th April, 1877	23,000	23,000	23,000	23,000 0 0	11,500	8,029 6 11	0 17 1	13,910	116 9 6	..
Globe	8th August, 1882	36,000	36,000	18,000	18,000 0 0	..	14,775 0 0	0 8 2½	5,450	..	..
Inkerman	9th February, 1876	20,000	20,000	20,000	20,000 0 0	..	12,371 12 8	0 12 7	2,092	211 14 0	..
Eclipse	28th July, 1882	24,000	24,000	24,000	24,000 0 0	12,000	660 4 2	0 10 7	4,600	39 15 10	..
Happy Valley	22nd June, 1882	24,000	24,000	24,000	24,000 0 0	12,000	1,228 12 11	0 11 0½	13,925	21 7 1	..
Captain Cook	31st May, 1882	24,000	24,000	12,000	12,000 0 0	..	696 4 2	0 0 7	10,325	3 15 10	..
Rainy Creek Extended	22nd February, 1882	24,000	24,000	12,000	12,000 0 0	..	6,339 14 1	0 5 6	2,650	..	..
Golden Point	15th November, 1878	24,000	24,000	24,000	24,000 0 0	12,000	7,000 0 0	0 15 10	5,785	11 17 9	189 14 10
Morning Star	23rd December, 1878	16,000	15,375	16,000	16,000 0 0	..	519 18 9	0 0 5½	3,925	13 13 9	..
Royal Oak	23rd July, 1886	24,000	24,000	6,000	6,000 0 0	..	102 1 8	0 0 1	..	47 18 4	..
Inangahua Low-level Tunnel	18th October, 1880	24,000	24,000	12,000	12,000 0 0	..	3,796 4 6	0 3 3	3,406	21 2 2	..
Britannia	5th June, 1886	25,000	25,000	6,250	6,250 0 0	..	210 12 1	0 0 2	..	101 17 11	..
Walhalla	22nd September, 1883	24,000	19,400	24,000	12,000 0 0	..	1,033 19 1	0 0 10½	4,600	166 0 11	..
Dauntless Extended	21st August, 1877	24,000	24,000	24,000	24,000 0 0	12,000	3,000 0 0	0 18 6	..	..	..
Big River Extended	21st January, 1882	24,000	24,000	24,000	24,000 0 0	12,000	5,422 9 3	0 16 8	..	196 11 2	..
		760,250	755,025	624,500	593,400 0 0	196,575	163,015 5 1	..	78,080	2,084 16 5	210,306 8 2

Lyell District.

Alpine Company	7th August, 1883	32,000	32,000	48,000	33,733 6 8	16,000	17,733 6 8	0 11 1	..	..	39,666 13 4
Tyrconnel	27th October, 1882	24,000	24,000	24,000	13,800 0 0	12,000	1,800 0 0	0 11 8	..	185 17 10	2,600 0 0
United Italy	24th March, 1882	24,000	24,000	24,000	15,100 0 0	12,000	3,100 0 0	0 12 5	..	9 0 6	900 0 0
Lyell Creek Extended	25th May, 1881	48,000	48,000	24,000	24,000 0 0	12,000	5,510 12 1	0 12 3	..	97 7 11	..
Larnach	7th October, 1885	24,000	24,000	24,000	24,000 0 0	12,000	596 9 2	0 10 6	..	3 10 10	..
		152,000	152,000	144,000	110,633 6 8	64,000	28,740 7 11	..	..	295 17 1	43,266 13 4

WESTPORT DISTRICT.

Westport.—There is not a great deal of quartz-mining carried on in the Westport District. It is only of late years that any payable quartz lodes have been found. The only localities where quartz has been worked are at Waimangaroa and Mokihinui. At the latter place, although rich auriferous quartz has been found near the surface, the general character of the country, being very hard and compact, does not give much promise that the reefs will be found payable at any great depth.

Great Republic Company, Waimangaroa.—This company was formed in 1882 for the purpose of working a quartz lode which was then discovered in this locality, and which promised at the time to give good returns. After stoping out a considerable quantity of stone, the lode that was first discovered became broken, and the amount of gold got less. Still, the value of the stone in the outcrop justified the expenditure that was made in further testing it. Recently a rich lode has been struck in another direction, which again promises to give good returns. The company, having a battery of their own, with necessary paddocks, tramways, &c., are now in a position to work the ground to its best advantage. The capital of the company is £38,000, in 38,000 shares, of which £28,816 13s. 4d. is subscribed, and out of which £9,816 13s. 4d. has been paid. The amount of dividends paid is £1,900.

Red Queen Company, Mokihinui.—This is the only quartz-mining company in the Mokihinui District that has given any returns to the shareholders. The company's mine is on the south side of the Mokihinui River. The rock adjoining the quartz lode is of a very hard and compact character. The lode itself is from 6in. to 18in. in thickness, and is formed between well-defined walls. The capital of the company is £48,000, in 48,000 shares, of which £29,300 has been subscribed, and out of which £5,050 14s. 2d. is paid up. There has been £2,400 paid in dividends.

Other Companies, Mokihinui.—There are three other companies having claims on the reefs, but only one of them is engaged in carrying on active operations—namely, the Southern Light Company, with a subscribed capital of £13,600, of which £809 10s. 2d. is paid up. The other two are the Mokihinui Company, with a subscribed capital of £2,650, of which £2,418 19s. 9d. is paid up; and the Guiding Star Company, with a subscribed capital of £2,400, of which £2,291 15s. 6d. is paid up. None of these companies ever paid any dividends.

Kumara, Westland.—This is the most extensive field in the colony where hydraulic operations are carried on, and a field where the miners are earning good wages. The great difficulty that will shortly have to be met is the dump for tailings. The limited area where tailings can be deposited is getting rapidly filled up, and depending to a great extent on floods in the Teremakau River to wash them away. This will soon raise the bed of the river to such an extent that the tailings difficulty will become in a short time a serious question for the miners to contend with. The No. 2 Sludge-channel, that was constructed to relieve the No. 1 Channel, has been a great boon to the miners, inasmuch that it has enabled all the claims on the flat to be worked, and it has taken away that chronic grievance that miners had against the department for years past in connection with the sludge-channel.

Ross United Company, Ross, Westland.—This company's property consists of 260 acres of leasehold on Ross Flat and 40 acres of freehold in the immediate vicinity, together with one of the most complete hydraulic pumping-plants in the colony, and two sets of hydraulic elevators for working the ground in the upper levels, as well as good winding-machinery for working the deep levels. They also hold the principal water-rights and water-races in importance that are fully constructed in the vicinity of Ross. During the last year this company, in prospecting the deep levels, discovered what was generally believed to be the layer of auriferous drift which proved so rich in Cassius's, the Morning Star, and Excelsior claims before they suspended operations, caused by the stoppage of the drainage-appliances in 1872, and which were finally wound up. This layer was opened out on and was worked until the beginning of this year, when the quantity of water there was to contend with was more than the pumping-machinery was able to lift. It is believed that the extra supply of water came from the old workings on the flat, which are known to be full of water down to the 300ft. level from 90ft. below the level of the surface, where the underground tail-race carries off the surface-water to this depth. There is no other goldfield in the colony which resembles the formation of Ross Flat. The number of different layers of auriferous drifts that underlie each other, that have been worked and proved to contain rich deposits of gold, points to it as a place well worthy of continuing gold-mining operations. The company sank a shaft to a depth of 392ft., when they went through nine gold-bearing layers of gravel-wash. Annexed is a section of this shaft, showing the nature of the ground gone through.

The amount of gold obtained from the Morning Star, Excelsior, and Cassius's claims previous to the present company's formation, and the time engaged in actually working the auriferous drifts, are as follows:—

Name of Claim.	Number of Weeks engaged in working Auriferous Drifts.	Amount of Gold obtained.
		Oz. dwt. gr.
Morning Star	34	4,094 6 23
Excelsior	28	2,726 11 5
Cassius's	36	4,722 11 17
Total	...	11,543 10 21

It will be seen from this that on an average of thirty-three weeks' work in these three claims gold was obtained to the value of £43,865 10s. During the six months the present company has been working on the deep levels, gold to the value of £8,415 16s. 9d. has been obtained, which, added to the former, make a total of £52,281 6s. 9d.

Only three of the principal claims on the flat that existed previous to the present company's formation have been taken into account. The returns from the Old Whim, Royal Standard, Ballarat, Scotia, and other claims were very considerable, and amounted to far more than what was obtained from the three companies mentioned, but there is no way of getting at accurate returns from private claims.

The Ross United Company are also the proprietors of the mining lease formerly held by the Prince of Wales Company, at Donohue's. The returns for the year from this mining lease and from the company's lease on Ross Flat have been, for gold, tributes, and water sold, £8,970 8s. 3d.; and the expenditure in connection with carrying on the company's operations, £11,826 1s. 10d. Of the latter amount, £1,740 0s. 10d. was expended in additional plant.

The expenditure in connection with opening out a mine in the deep levels of Ross Flat, in the construction of main levels, uprises, chambers, and opening out the ground to get a number of men at work on the layer of wash-drift, is very considerable, and only can be grasped by those who are well acquainted with such undertakings. The surface-expenditure is always about the same, whether there are only five men underground on a shift or a hundred. The expenditure, therefore, that has to be incurred in opening out a mine to get a sufficient number of men advantageously employed underground, especially where the surface-expenditure is large, is always very great, and should be equally distributed over the number of years' work on the particular layer of wash-drift, and not on the first year's operations. The capital of this company is £150,000, in 150,000 shares, of which £44,148 15s. is paid up, and £103,500 was given to the shareholders in paid-up scrip. Some of the shares have been forfeited, which leaves the available capital of the company for the prosecution of further works to be only £2,298 15s. Before further operations can be carried on at the deep levels additional pumping-machinery will be required, and the company's mining manager and engineer suggests also a new shaft, not only for ventilation, but also for the more economical working of the mine, and recommends one pair of jet condensing steam-engines of not less than 150-horse power, with boilers of sufficient capacity to generate steam also for a winding-engine, two 18in. plungers, and one 15in. draw-lift, with necessary gearing, which he estimates will cost £7,614. He also proposes to clean out and widen the Cassius shaft, to utilize it for the additional pumping and winding. This, together with constructing chamber, main level, and opening out the ground, to cost £7,370; thus making the total expenditure necessary to the future development of the mine to be, in round numbers, about £15,000. This amount is proposed to be raised by the issue of new shares or debentures, and, failing either these courses, the re-formation of the company is inevitable.

Mont d'Or Company, Ross, Westland.—The Mont d'Or and Greenland hydraulic-sluicing companies hold ground adjoining each other. The depth of the auriferous drift is from 250ft. to 300ft. This depth of bank prevented one company from working the ground to their boundary unless such ground near the boundary was worked conjointly. The Mont d'Or Company have leased the Greenland Company's ground for a certain time to admit of the boundary being worked. The whole of this ground lies at a considerable elevation above the flat between Donohue's and Ross, and consequently there is plenty of fall for the tailings. Nevertheless, the large amount of tailings that have come from the Mont d'Or claim is now covering the flat to such an extent that they have to construct wing-dams to prevent the water and sludge from encroaching on the freehold land near the ocean-beach. The capital of this company is £12,000, in 12,000 shares, of which £10,779 14s. is paid up. During the time the company has been carrying on operations, which is since the end of 1882, dividends to the amount of £5,400 have been paid to the shareholders.

Humphrey's Gully Company, Arahura, Westland.—This company has been engaged in carrying on hydraulic-sluicing operations for about eighteen months, but the supply of water they have had up to the present time is insufficient for the purpose of carrying on their operations on a large scale. The depth of ground this company is working, about 300ft., contains a little gold distributed throughout; but, in order to make it pay to the best advantage, it will have to be worked in a far more wholesale manner than has hitherto been done. It has always been the opinion of those who understand the principle of measuring the quantity of water flowing in streams that this company would never be able to get a sufficient supply until they extended their head-race to the Arahura River. Indeed, it did not require a scientific mind to arrive at this conclusion when the area of the watershed of the creeks that have been tapped for their water-supply was known. However, the company now find that this work will have to be undertaken before the ground can be worked to advantage, and propose making arrangements to carry out the work at once, which is estimated to cost £20,670. It is generally considered that this company's property, when worked on a large and systematic basis, will prove a profitable investment, but it is a question whether it will ever pay a large percentage on the capital of the company, which is £150,000. But this capital is only a nominal one, as £77,000 was declared paid up—or, in other words, £77,000 was given to the shareholders as partially-paid-up scrip. The real capital is only £73,000, and the profits on the workings should only show the percentage on this actual capital expended, and not on a fictitious one. The original company who previously held this property spent £10,125 on works connected with the head-race, and opening out the ground: this, added to the actual capital of the present company, which is only a re-formation of the original one, makes the capital £83,125, of which £79,976 is actually paid up, leaving a balance of £3,149 available for the prosecution of further works.

During the year ending the 9th of February last the head-race was extended for 2 miles 44½ chains, which takes up the water from Johnston's, Stoney, and Mount Brown Creeks. The construction of this portion cost £6,003 16s. 2d. The value of plant also added amounts to £1,834 19s. 1d., making

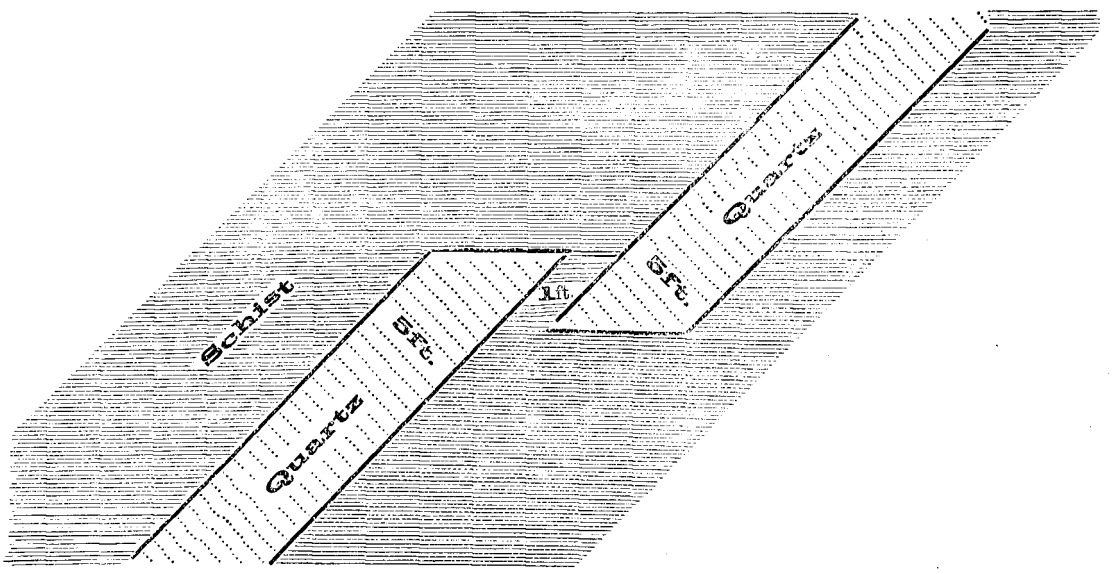
the expenditure on head-race and plant during the year, £7,837 15s. 3d. The amount of capital paid up during the year was £7,098 4s., in six calls. 300 shares have been forfeited during the year; so that at the present time the number of shares on which calls can be made is 62,984. This will reduce the available capital by the difference between the 73,000 contributing-shares and the 62,984 shares which are now held.

The value of gold obtained during last year was £3,720 11s. 6d., and working-expenses connected with the working of the claim, together with the ordinary expenses of management, were £3,157 18s. 5d., leaving a profit on working the claim of £562 13s. 1d. This does not appear a large amount when the capital of the company is taken into consideration; but it must be borne in mind that the successful working of all hydraulic claims depends to a great extent on the amount of water available, as the same number of men that is now employed can do a far greater proportion of work if a plentiful supply of water was obtained.

The length of the main head-race is now 10 miles 67 chains, and a tunnel is constructed for 30 chains for a branch supply; but before this branch supply can be made available it requires 1 mile 76 chains of open ditching to be constructed. The length that the head-race will require to be constructed before it reaches the Arahura River is 4 miles 63½ chains. Surveys of the incompleted portions have been made, and the company's engineer estimates the cost at £22,516. When these works are completed he estimates from the present returns that the annual yield of gold from the claim will be 5,634oz., representing a value of £21,409 4s., and the expenditure in connection with carrying on the company's operations, £9,169 11s. 9d. If this estimate is based on reliable data, the annual profits of the company would be increased to about £12,240, which would be about 12 per cent. on actual capital invested. Whether this is realized or not, sufficient work is done to show that the auriferous character of the ground is payable if worked systematically. There may be additional expenditure which is not at present calculated on in connection with outlet for tailings. This is almost certain to be the case, as the tailings, even from the limited amount of ground that has been sluiced away, have necessitated an expenditure of £430 to protect the adjoining farms on the Native Reserve from sludge and water from the claim.

Skipper's.

Phœnix Company.—This company's mine is looking better than it did on my previous visit. The workings are more fully opened out, and the character of the lodes better determined. The principal workings at the time of my visit were on the middle lode, which averages 5ft. in thickness. This lode is stoped out for 500ft. in length, 30ft. in height at the one end and 90ft. high at the other, where the lode breaks off. It was formerly considered that this was the top of the lode, and that the difference in the level at each end showed the exact strike, but recently it has been proved that the lode at this level is only broken across and the top portion pressed backwards, as shown in the following sketch. At the same time the bottom of the lode appears to have been pressed upwards.



Where the lode overlaps to a depth of about 6ft. there is about 1ft. thick of soft decomposed schist between the two portions of the lode. This is a new feature in quartz reefs in the Middle Island. In many instances a break in reefs is found, and the lode again found some distance on one side; but I have not seen anything like so complete a break in a quartz lode as that which occurs in this particular one: the bottom of the one portion and the top of the other exactly correspond with each other, only the bottom portion of the lode has been apparently pressed upwards since the break took place. The company has commenced stoping out the upper portion of this lode, but are still in ignorance as to what height it may still go.

Workings are carried on in the Scandinavian, or main lode, on the third level, where good payable gold has recently been struck in a lode of a peculiar-looking mullocky kind of finely-laminated schist intermixed with very thin quartz veins. Judging from the appearance of the stuff, no one unacquainted with it would think of obtaining payable gold in such material. Indeed, Mr. Evans,

the manager, stated that he was agreeably surprised when he discovered gold in this material while using it for ballast on the outside roads. This, together with the discovery of gold in decomposed schist in Green's Reef, at Ophir, upsets the old notion previously formed that quartz was the only matrix of gold. The gold is not only found in this lode in the thin quartz seams, but also disseminated throughout the foliations of the schist, which is highly charged with iron and arsenical pyrites. This discovery leads the company to hope that fresh lodes of this material may yet be opened out in the old abandoned workings. At the lower levels this lode has been opened, but its character there is altered into quartz which averages about 1oz. to the ton, the average width of the lode being 6ft.

On the Promised Land Lode, so far as yet known, the gold extends for about 200ft. in length. It has been stoped out for 40ft. below water-level, but no work has yet been done above this. The portion of it that has been worked shows that it is not nearly so rich as the other lodes—the average yield has not exceeded 16dwt. of gold per ton.

The north lode has been stoped out as far as can be done for water. No further workings can be proceeded with on this lode until the shaft is sunk and new level opened out. Taking the mine as a whole, it is a valuable property, opened out in a systematic manner, with every means of working it to advantage. Prospecting is constantly carried on, and the result of the same has been the discovery of a larger amount of payable lodes in the upper levels than was heretofore anticipated.

A new inclined shaft is being sunk on the main lode from the No. 6 or Water Level. It is now down 80ft.; its dimensions are 12ft. long and 4ft. 6in. wide. It is to be divided into four compartments—viz., two for winding, one for pumping, and one ladder-compartment for the men to use in getting to and from their work. A Tangye pump with a 9in.-cylinder engine is fixed at the bottom of the shaft to lift the water, and a 12in.-cylinder Tangye engine is also being erected, with winding-gear, in a chamber near the top, to do the haulage. This engine and pumping-engine is to be driven by compressed air.

The air-compressing machinery was constructed by Messrs. Kincaid and McQueen, of Dunedin, and is erected at the back of the battery-house, having gas-pipes conveyed from the air-receiver into the mine, where a second receiver is fixed, and from this last-mentioned receiver the air is supplied for working the engines. This plant is very compact and effective, and forms a pleasing contrast with the underground winding-plant of the Welcome Company, at Boatman's, in the Reefton District, who have a steam-engine, boiler, and air-compressor all erected in a chamber in the underground workings, about 700ft. below the surface, and over 2,000ft. into the hill from the mouth of the tunnel. The exhaustion of air from machinery in the Phœnix Mine will always tend to produce good ventilation and keep the workings cool near the top of the shaft; whereas in the Welcome Mine the chamber is almost stifling, the temperature being always at about 90° Fahr.

Crushing-battery.—The crushing-battery consists of thirty heads of revolving stamps and one stone-breaker. The latter is only newly erected, and was not in use at the time of my visit. The stone is taken from the mine and tipped out of the trucks on to a screen set at an inclination that the quartz will run down. Below this screen is a large paddock for stacking the broken and screened quartz. At the lower end of the screen the stone-breaker is erected, so that anything that does not pass through the bars of the screen has to pass through the stone-breaker, where the quartz is reduced to a maximum size of not more than 1½in. in diameter. From the paddock into which the quartz falls from the stone-breaker there is a tramway laid to the self-feeding hoppers of the crushing-battery, where the reduced material is conveyed by trucks. At the time of my previous visit the crushing-battery only consisted of twenty heads of stamps, which was driven for a few months in spring and summer by a turbine water-wheel; but the water was so uncertain that the mine could not be worked advantageously in this manner. The extremely rough and broken nature of the country prevented a larger supply of water being obtained unless at an enormous expense. Steam-power was also out of the question, owing to the prohibitory cost of fuel.

This led to the question of whether electricity could not be advantageously employed as a motive-power. Mr. Evans discussed this subject with Mr. Prince, of Fletcher and Co., electrical engineers, Dunedin, which firm finally undertook to erect electrical machinery to drive the crushing-battery, guaranteeing at the same time its success. This machinery is now erected on the left branch of Skipper's Creek, about a mile and three-quarters from the crushing-battery, where a good supply of water is obtained as a motive-power to generate the electricity. As this is the first time in the history of electricity that it has been employed as a motive-power to drive extensive crushing- machinery, a full description of the mode in which it has been applied will not be out of place.

The power employed to generate the electricity is obtained from two of Pelton's hurdy-gurdy water-wheels, constructed by Messrs. Price and Sons, of the Thames. These wheels are 6ft. in diameter and 10in. width on the face. They are erected at the foot of almost a perpendicular cliff, 165ft. in height, where the water is brought on the top by means of an open cutting from Skipper's Creek, and thence taken down the cliff in two wrought-iron pipes on to the water-wheels. These pipes are 22in. in diameter at the top, and gradually tapering down to 6in. in diameter at the bottom, where a nozzle is fixed of 2½in. in diameter to discharge the water into the buckets of the wheel. The quantity of water used at the time of my visit was from five to six sluice-heads. Taking the less number of heads, this quantity of water, with a pressure of 165ft. on the wheels, is capable of transmitting about seventy-horse power. Each wheel works separately, and is connected by a belt to an intermediate shaft, which in turn is connected by a belt to the dynamo. Separate wheels and intermediate shafts are used for each dynamo.

The dynamos used to generate the electricity are two of the Brush pattern, of the largest size yet manufactured. Each machine has four large electro-magnets, forming two horse-shoe magnets. Between these magnets the armature-ring revolves, at a speed of 750 revolutions per minute. The armature-ring is 26in. in diameter, and is bound with twelve coils of fine copper wire wound at

equal distances round the ring, having a large number of convolutions in each coil. The wire is carefully covered, to insulate one convolution from the other. These twelve coils on the armature-ring are joined in pairs, and the end of each positive coil is connected with a negative one, and the whole connected with the commutator which is fixed on one end of the shaft of the dynamo—the same as that used for lighting-purposes. As soon as the armature begins to revolve, currents of electricity are generated in the armature-coils; these currents pass to the commutator, next to the brushes, afterwards passing through the electro or field magnets. The current thence goes to one of the terminals of the machine, where it passes out to the circuit and to a Victorian motor at the battery-house, returning thence to the remaining terminal of the generator, and back again to the armature-coils. From the generators the electric current is carried by a copper wire $\frac{1}{8}$in. in thickness, a mile and three-quarters in length, passing over a range between the generators and the crushing-battery of 800ft. in height. Each generating dynamo is capable of generating a current of ten ampères when worked singly, but when the two generators are connected they generate a current of about fifteen ampères. This shows that one dynamo must to a great extent work against the other. The electro-motive force transmitted from the generators is supposed to be 2,000 volts, but, having no volt-meter attached, this may only be an approximation.

The Victorian motor that is fixed at the crushing-battery for driving the stamps is different in appearance from the other dynamos, but it is really essentially the same as far as generating electricity is concerned, when it is used for such. It has one armature, one commutator, one set of brushes, and, instead of having two horse-shoe magnets, as the other dynamo has, it has six, and has ninety coils of copper wire on the armature, instead of twelve coils, which is on the armature of the generating dynamos. The current from the generators, passing through the field-magnets of the motor, makes them powerfully magnetic, and also the coils on the armature, causing a great attraction between the two, resulting in the armature being pulled round, or towards the magnets, as each coil on the armature approaches the magnet as near as can be got. The action of the commutator reverses the direction of the current in that particular coil, causing the magnet and it to repel one another, which results that each coil on the armature, on approaching the magnet, receives a pull, and on leaving is pushed away from it. Such is the principle of the power that is obtained. The motor is driven at a speed of 350 revolutions per minute. When the motor is stopped for any purpose for a few minutes, without stopping the generators, the current is switched or cut off from the motor and sent through a long series of spiral coils of iron wire, which absorbs its energy by heating the wire instead of driving the motor. The electro-motive force given off by the motor is not over twenty-horse power, while it requires about seventy-horse power to generate a sufficient current of electricity. The loss in power is something enormous when it is considered that not one-third of the power required to drive the generators is transmitted to the crushing-battery. Yet it can truly be said the end justifies the means, as there is an immense amount of power in many places going to waste because it cannot be utilized; but, now that it has been successfully proved that electricity can be conveyed for a long distance, and used as a motor wherever water-power can be obtained to drive the dynamos, the loss in power is of little consequence, especially in New Zealand, where water is plentiful, and the streams and rivers flow at high velocities.

Very little is yet really known about electricity. The experiments that have been made at Skipper's go to prove that it is a difficult matter to work two dynamos in conjunctiou with each other to obtain the full amount of power from each. This may be partially accounted for by the machines not being exactly alike: although they are to all appearance an exact *facsimile* of one another, yet the one is more powerful than the other when both are driven at the same speed. To obviate this, one dynamo is driven faster than the other, so that the current from each may be of the same force. This necessitates separate intermediate shafts for each dynamo. The electro-motive force is only capable of driving twenty heads of stamps, so that to work the full battery the turbine water-wheel is likewise used in conjunction with electricity to drive the battery.

Judging from what I have witnessed of the application of the electro-motive force, used as a motive-power, there seems little doubt but that one large dynamo would be far more economical and give a higher percentage of power than two working in conjunction with each other; but, so far as the actual working is concerned, there can be no fault found: they go like clockwork, and require very little attention beyond keeping the bearings oiled and the commutators clean.

The belting used for driving the generators is of a peculiar construction. I have not seen it in use in any other place in New Zealand. It is a series of links made of leather, about 1$\frac{1}{2}$in. long and $\frac{5}{8}$in. in width, the leather being from $\frac{3}{16}$in. to $\frac{1}{4}$in. in thickness. All the links are of the same dimensions. There are 548 links in every superficial foot of the belt. There is an iron wire passes through all the links for the whole width of the belt, and when the belt requires to be shortened, one of the wires is pulled out, a set or so of the links taken out, and the wire again put through. This belting is about 1ft. in width, and is apparently very substantial. The generators and the crushing-battery are connected by telephone, so that the attendants at either end can communicate with each other.

This company have also erected at their own expense a telephone from the reefs to Skipper's Point, to connect with the Government telephone from Queenstown. The distance of this line constructed by this company is five miles, and the manager informed me the total cost was £27, the wire used being a No. 16 gauge copper wire. The contract price for the electrical machinery (exclusive of the cost of water-wheels) was £2,190; but to take the whole of the expenditure in connection with plant, it may be said to have cost the company fully £5,000. Mr. Evans, however, assured me that if he had to erect another plant of similar character it would not cost him above half of that amount.

Maori Point, Shotover, Otago.—A reef was discovered between Deep Creek and Maori Point about seven months ago, and at the time of my visit to this district a winze was being sunk down to test it. The stone from this winze looked very promising. After sinking down for some distance the

water proved too much to contend with, which has since led to a tunnel being driven from the face of the hill, to cut the reef at a lower level. A Melbourne company has lately purchased the ground, and constructed another level about 120ft. deeper. From the appearance of the reef and the trial-crushings made, it is likely to prove a valuable find. A crushing-battery of ten heads of stamps is in course of erection near the mine.

ANTIMONY-MINING.

Endeavour Inlet Antimony Company, Queen Charlotte Sound, Nelson.

This company holds a mineral lease of 812 acres at the head of Endeavour Inlet, Queen Charlotte Sound. Antimony was discovered here several years ago in loose detached blocks in the sides of the range and in the beds of the watercourses. Of late years the ore has been found *in situ*, and the lode worked in the range between the head of the Inlet and Port Gore. At the time of my visit, which was on the 23rd December last, the company had suspended mining operations for the holidays, and the manager informed me that the principal workings were blocked up, so that I could not see anything; but he explained to me the character and dimensions of the lode, and from what I saw of a portion of the workings there is no reason to suppose but what the information I received was correct.

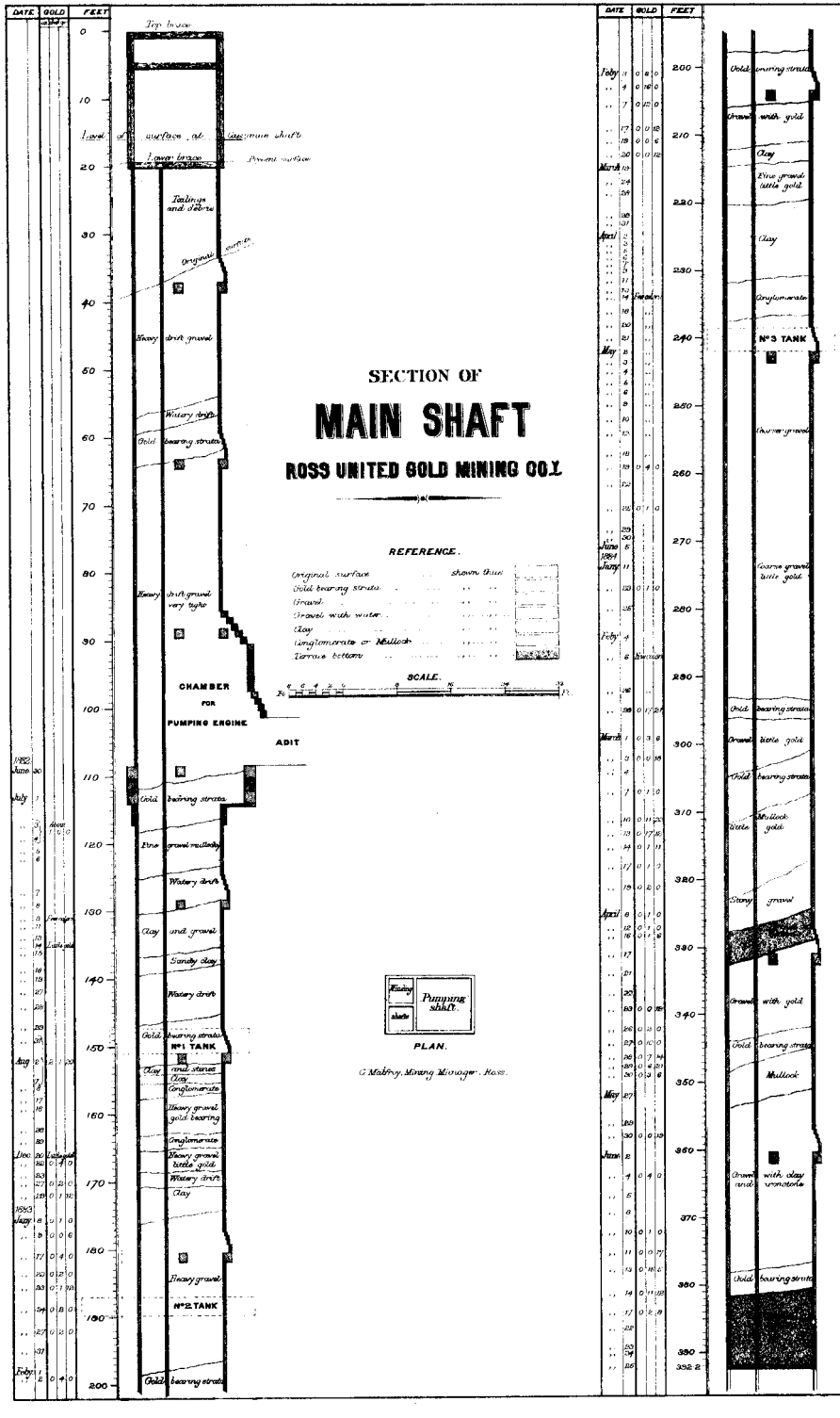
The range through which the lode goes through is about 1,600ft. above the level of the sea. On the top, where the lode crops out, the ore occurs in the form of valentinite, but in getting deeper it changes into stibnite. Where the white oxide occurs the country is generally soft and broken, but where the rock gets compact the lode changes into sulphide of antimony. A tunnel has been driven through the range at 275ft. under the crown, and 1,000ft. of the lode driven upon. On each side of the range for some distance the lode is broken and partially decomposed, with a mixture of stibnite and valentinite; but for about 300ft. under the centre of the range, and for 100ft. in height above the floor of the tunnel, the lode is compact and contains nothing but sulphide. The lode varies in width, getting narrow in places, then widening out into bunches; but, taking the average, it would be about from 18in. to 2ft. wide. It runs in a northerly and southerly direction, having a slight underlie to the eastward. The lode has been stoped out from the tunnel to near the surface. The manager expects to have the whole of this level stoped out by the end of March.

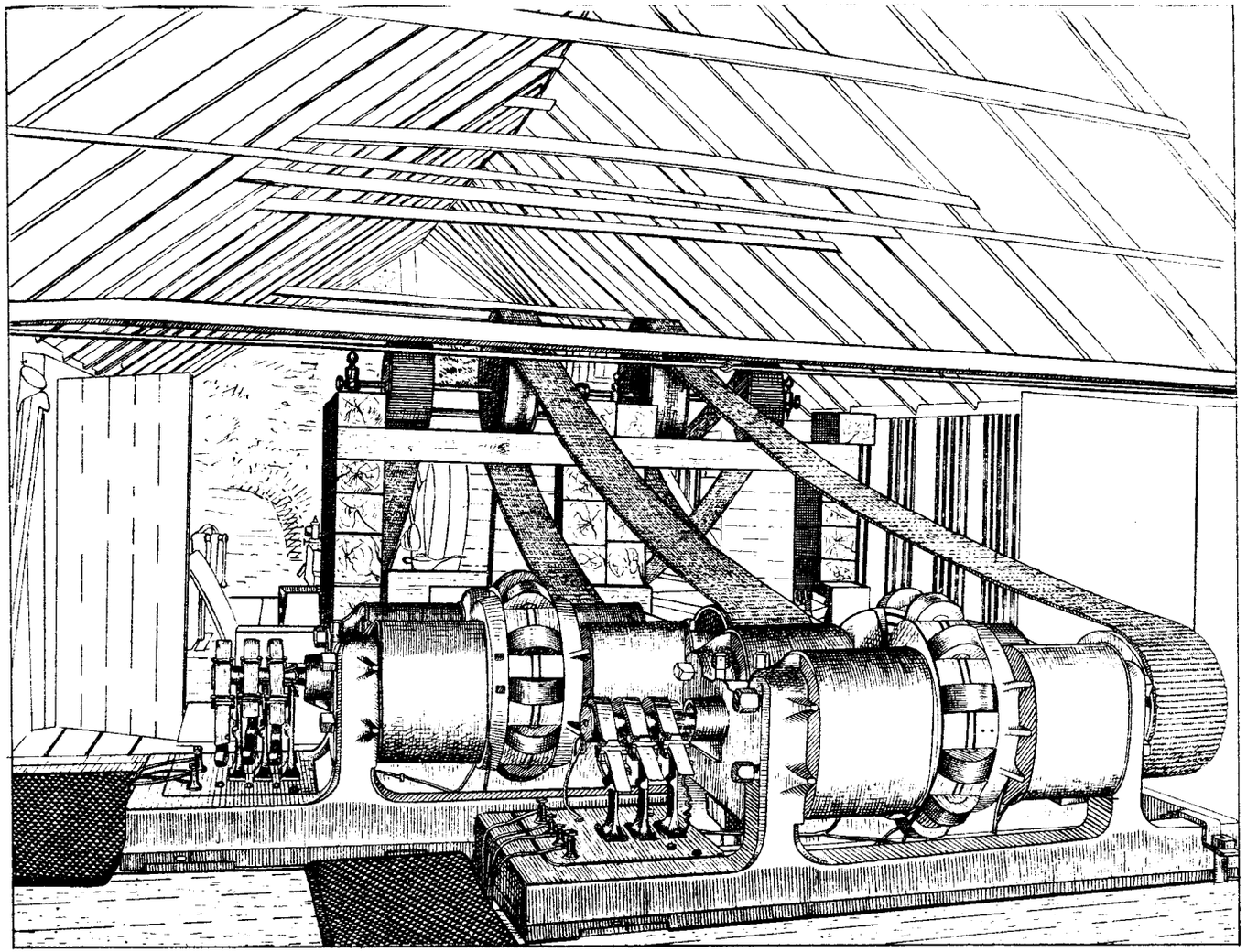
The company have commenced to construct another tunnel about 250ft. under the level they are working on. This tunnel is only in 40ft., and they expect to cut the lode at about 20ft. further. I have since learned that the lode has been cut at the point where it was expected to be intersected, and contains very rich ore. From this tunnel downward the whole face of the range facing Endeavour Inlet appears to have been a slip. The surface is broken, and large loose blocks of almost pure sulphide of antimony are mixed among the soil and loose disjointed rock. In some places these loose blocks form a continuous flat seam up the face of the range. It is evident from the appearance of this slip that there is a large lode of good ore not far distant. Whether these loose blocks have come from the lode the company is at present working on is a question that has yet to be solved; but the large quantity of this loose ore on the face of the range, about 450ft. above sea-level, will pay for working. The company propose to work this ore by sluicing away the soil.

A head-race has been cut from some of the creeks that fall into Endeavour Inlet, so as to get water on the ground to accomplish this object as soon as the rainy season sets in; which seems to be the best thing the company could do, as it will be the cheapest method of getting the ore, and it will also be the best way of tracing the ore up to the source where it came from.

The ore is taken from the mine to the reduction-works by a tramway of about a mile in length. There are three different grades in the tramway on the face of the range, each of which is worked by a brake. These brakes are very efficient, easily worked, and cheaply constructed. There are two vertical pulleys, with a groove for a steel-wire rope thereon, 4ft. 6in. in diameter, having a flat rim on the one side of the groove for the brake-band to clutch. The pulleys are placed 4ft. 6in. apart, and under these there is another pulley of same dimensions fixed horizontally. The wire-rope goes round the horizontal pulley and over the pulleys which stand vertically. One end of the rope is coupled to the empty truck, and the other end is coupled to the full truck. This method allows the rope to work very smoothly on the pulleys, and is a great improvement on the rope working round a drum, as there is no jerking of the rope by coiling or uncoiling, as is the case at the Westport Colliery Company's inclines. The brake-bands on each of the vertical pulleys are coupled together by a rocking-shaft and cranks, and worked by one man, who can easily lower by this means a truck containing 25cwt. of ore. These are, without exception, the best designs of brakes that I have seen used in the colony in connection with mining.

Dressing-works.—The ore, on arriving at the reduction-works, is hand-sorted and put through the stone-breaker, after which it is taken direct to the smelting-works, and smelted in crucibles with the necessary fluxes; but poor ore has to undergo a different treatment. The whole of the ore is run down from the mine on a tramway, and dumped out of the trucks on to the sorting-floor. The rich ore is first taken out as previously stated, and the remainder is put through the stone-breaker, and from this goes on to an assorting inclined shaking-table, which has a perforated bottom with holes of three different sizes, the finest holes being next to the upper end near the head, and the largest at the lower end. The table has a lateral shaking motion of 6in. throw, and goes at 250 strokes per minute. The stuff coming from this table is caught in three different chutes, which run under the table crosswise. By this means the ore is assorted into three different degrees of fineness, the largest being what would pass through a half-inch mesh. From this it goes through a pulverizer, which reduces it fine enough to pass through a mesh of sixty holes to the inch. On leaving the pulverizer the ore passes over two sets of jigs, each about 5ft. long and 2ft. wide, after which the gangue is carried away in a chute, and again put through another jig, which is 10ft. long by 2ft. wide. After passing through this process, the gangue and slimes leave this jig and are stacked for future treatment.


DATE
GOLD
FEET
Top brace
Level of surface at Cleminson Shaft
Lower brace
Present surface
Tailings and debris
Original surface
Heavy drift gravel
Watery drift
Gold bearing strata
Heavy drift gravel very tight
CHAMBER FOR PUMPING ENGINE
ADIT
Gold bearing strata
Fine gravel rather dry
Watery drift
Clay and gravel
Sandy clay
Watery drift
Gold bearing strata
No1 TANK
Clay and stones
Clay
Conglomerate
Heavy gravel gold bearing
Conglomerate
Heavy gravel little gold
Watery drift
Clay
Heavy gravel
No2 TANK
Gold bearing strata
SECTION OF
MAIN SHAFT
ROSS UNITED GOLD MINING CO.Y
REFERENCE.
Original surface ... shown thus
Gold bearing strata ... " "
Gravel ... " "
Gravel with water ... " "
Clay ... " "
Conglomerate or Mullock ... " "
Terrace bottom ... " "
SCALE.
Existing shafts
Pumping shaft.
PLAN.
C. Maltby, Mining Manager. Ross.
Gold bearing strata
Gravel with gold
Clay
Fine gravel little gold
Clay
Conglomerate
No3 TANK
Coarse gravel
Coarse gravel little gold
Gold bearing strata
Gravel little gold
Gold bearing strata
Mullock little gold
Stony gravel
Gravel with gold
Gold bearing strata
Mullock
Gravel with clay and conglomerate
Gold bearing strata



PHŒNIX COMPANY, SKIPPERS'.

Dynamo for generating Electricity, for driving Stamping Battery.

The stone-breaker used is one of Blake and Marsden's, which gives every satisfaction. It crushes five tons of ore per hour, reducing the ore so that the largest will pass through a half-inch mesh.

The pulverizer is one of Lucop's, which is a good pulverizer, but the wear and tear on the gudgeons and small roller are very great, and consequently very expensive to keep in repair. This pulverizer is capable of reducing the material that comes from the stone-breaker at the rate of 1½ tons per hour fine enough to pass through a mesh of sixty holes to the square inch.

The jigs are entirely of a different construction from that commonly in use. They were designed by Mr. Warren, the mine-manager. Instead of a plunger forcing the water up from below through the bed of coarse ore on the sieve, the sieves move up and down in a tank of water. The tanks are made in three compartments, so that the ore can be deposited in three different grades. There is about 4ft. 6in. in depth of water in the tank, and the sieve that forms the jigger is made 2ft. wide, with the sides standing up 6in. above the bottom. There are cross-bars of iron placed on the upper side of the sieve crosswise, at intervals of about 8in., to keep the bedding or ragging of coarse ore in its place. In the spaces between these cross-bars there is a ragging of the heaviest ore, broke into pieces of 1½in. in diameter. The crushed material is carried from the pulverizer in a chute on to this sieve, to go through the operation of jigging. This is accomplished by means of cranks and two rocking-shafts, which give the sieve a plunging motion and also a jerking motion, throwing the gangue towards the lower end of the sieve, while the particles of greatest density pass through the first portion of the ragging and sieve into the first compartment of the tank. The next greatest density goes into the second compartment and into the third, while the gangue and slimes go over the end of the sieve into a chute, and are carried off. This description of jigs works very well, but there is still a great waste of material after leaving the jigs, as a large portion of the ore is bound to be carried away with the slimes. The manager is aware of this, and wishes to have other concentrating-machinery placed at the end of jigs to treat this material.

The same class of machinery that is used for dressing tin-ore is applicable to dressing antimonial ore, and a Rittinger shaking-table would be a suitable machine to treat these slimes. These tables are about 9ft. in length and about 3ft. in width. The material enters these inclined tables 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 material into the current of water. The heaviest parts advance most, and when the material arrives at the lower end the current is divided, and the material passes into different receivers. The action of these tables can be regulated, according to the character of the material under operation, 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, requiring no manual labour.

After leaving this shaking-table the finer slimes are treated on convex rotating buddles, which are from 12ft. to 16ft. in diameter. All the slimes are fed into a receiver at the centre. The buddles, revolving slowly, are supplied with jets of clean water at different points, so as to insure perfect concentration. The lighter particles are washed off and become waste, while the heavier particles remain on the convex surface until washed off into a receiver.

The whole of the machinery is driven by a Pelton hurdy-gurdy water-wheel, with 2¼in. nozzle, under 75ft. of a head.

Smelting-works.—The smelting-works consist of three furnaces—one furnace for treating the crude ore and two furnaces for smelting the ore in crucibles. One of the smelting-furnaces is made with a large firebox, for using firewood. The flames pass over a bridge into a furnace about 4ft. in width and 20in. in height to the centre of the crown of the arch. On the crown there are two rows of circular openings, seven openings in each row, which are provided with firebrick covers bound with a strap of iron. Into each of these openings a crucible, containing from 30lb. to 40lb. of ore and flux, is placed, and allowed to stand there until melted, which takes from one to two hours, according to the quality of the ore under treatment. When it is melted the crucible is lifted out by means of a tongs, and the contents run into conical moulds, and is known as the

Singling Process.—When the ore is rich it is broken up to about 1in. in diameter, and put into a red-hot crucible with flux obtained from the slag of the second or doubling process, and also a certain quantity of scrap-iron, being generally the waste clippings of tin plates and old tinware. The amount of iron required for flux depends on the quality of the ore to be smelted. If the ore contained from 50 to 55 per cent. of antimony, 40lb. of ore would require from 16lb. to 18lb. of iron. The richer the ore the more iron it requires. The quantity of ore usually in each charge in the crucible is 35lb. This will give on an average, with the ore that is now being smelted, from 12lb. to 15lb. of metal. When the metal and slag which was poured into the conical mould is sufficiently cool it is emptied out and a little water used to cool it; then a blow from a hammer will break the slag clean off from the metal. The metal being heavier than the slag, it settles at the bottom of the mould, leaving the refuse on the top.

Doubling Process.—The singles, or metal from the first process, is sorted, so that the singles that contain an excess of sulphur may be melted with those having an excess of iron. This is put into a crucible, with a little salt-cake (crude sulphate of soda) and slag from the Frenching or refining process for flux. In the furnace where this process is conducted, each opening where the crucible is set into has a fire-grate of its own. These openings are about 16in. in diameter, and about 3ft. deep to the fire-grate. There is a flue near the top of the opening, which connects with a main flue running along the side of a number of small furnaces. The metal is broken up and mixed with very rich ore, if there is any, and for every 60lb. of metal about 2lb. of salt-cake is used and 4lb. of slag from the refining or Frenching process. The crucible is set on a coke fire, after which there is a cover, in shape of an inverted bowl, set over the top of the crucible, and afterwards filled round with coke. This is subjected to a strong heat for an hour or an hour and a quarter. When it is melted the crucible is then taken out and the molten mass poured into cast-iron moulds; hence the metal gets the name of bowl-metal.

Frenching or Refining Process.—The metal from the doubles is broken up into pieces and placed in a red-hot crucible in charges of 70lb. and 80lb., which requires 10lb. of the slag from the previous refining process and about 3lb. of pearlash (American potash). When melted the mass is stirred with an iron bar, and the character of the slag adhering to the stirrer enables the workmen to judge whether the refining is complete or not. This process requires the most skilled workmen, so as to produce good star-metal. When it is deemed sufficiently refined the crucible is lifted out, and the contents poured into a mould, where it slowly cools, and acquires, if properly treated, a crystalline structure characteristic of this metal. To favour the crystallization, the metal, when cooling, is covered with slag, and should be left quite undisturbed.

Furnace for smelting Crude Ore.—There is a furnace built for desulphuring the ore; but it had not been used at the time of my visit. It is built in the form of a reverberatory furnace, with the hearth sloping towards the centre and to one side. The furnace is charged with broken ore, and the sulphides are melted, and when in that state a plug-hole, on a level with the bottom of the furnace, is opened and the molten mass run out, which, when cool, is broken up and treated as before described; but, judging from its construction, I am afraid it will be a failure.

There is one grave defect that I observed at these works, and that is the length of the flues between the furnaces and the stack, and the absence of plenty of condensing-chambers. Antimony, when melted and subjected to a great heat, is very volatile, and a large percentage goes into the flues and up the chimney. The workmen informed me, on inquiry about this, that for five months' work in the singling process between three and four tons of oxides were taken out of the flues, which are about 150ft. in length. There is no doubt but that a large percentage of antimony is at present carried up the chimney in fumes. These fumes require a very long, serpentine flue to get condensed.

It may be interesting to those engaged in working antimonial ores to give a description of a blast-furnace that is in use at Pribram, in Bohemia, where both oxides and sulphides, with a considerable quantity of siliceous waste, are melted for crude star regulus. A description of this furnace was given by C. M. A. Balling, in a paper read before the Institution of Civil Engineers, London, from which the following particulars have been taken. The composition of the materials forming the blast-furnace charge is as follows:—

Materials.	Dressed Ores.		Oxidized Ores.	Liquation Residue.		Fine Stuff.	Refining-slag.
	Raw.	Calcined.		Raw.	Calcined.		
Antimony	43·3	48·9	46·4	21·4	23·1	56·1	25·7
Iron	14·4	...	...	12·9	...	...	...
Sulphur	25·3	0·7	3·6	15·1	2·4	...	...
Ferric oxide	...	23·4	2·4	...	17·3	6·9	...
Silica	11·7	23·3	26·6	41·6	49·2	10·8	5·9
Alumina	0·3	4·0	...	0·5	2·4	...	...
Carbonate of lime	3·3	...	7·0	4·0	...	...	...
Lime	...	1·0	...	4·0	0·7	...	...
Sulphide of antimony	...	...	...	...	...	...	2·4
Sulphide of iron	...	...	...	...	...	...	53·4
Sulphide of sodium	...	...	...	...	...	...	9·0
Carbon	...	...	...	...	...	5·1	...

The furnace has a cylindrical stack, 20ft. in height, 4ft. 7in. in diameter at the throat, and 3ft. 3in. in the hearth, which is closed, and has five water-tuyeres and three outlets for the molten products—an upper one for the slag, and two at the hearth-bottom. Of these latter, one communicates with the exterior by a passage having a slight rise, and forms the ordinary tap-hole for the metal, while the other has a horizontal outlet, and is only used for blowing out the furnace. The blast, supplied by a Krigar screw-blower, amounts to 540 cubic feet per minute, under a certain amount of water-pressure. The gases are collected by a tube leading from the side of the furnace a short distance below the throat. The furnace is kept in blast three weeks continuously, and smelts 19·2 tons of materials daily.

The smelting-mixtures are of two kinds, whose composition is as follows:—

	Lb. (*a*.)	Lb. (*b*.)
Calcined dressed ore	1,213	1,323
Liquation residues	1,654	1,323
Ores balled with lime	440	...
Fine stuff	220	...
Raw ore	...	220
Oxidized ore	...	220
Raw liquation residues	...	220
Limestone	1,323	1,764
Foul furnace-slags	882	882
Refining-slags	...	441
Crude-antimony metal	...	220

The most favourable result is obtained when these mixtures are used alternately, two charges of (*a*) being followed by one of (*b*). Lime is used, to the extent of 10 per cent., to ball up part of

the washed ore to a compact mass; and some of the fine stuff is similarly treated, but with only 7 per cent. This, however, is only necessary at starting, as it is found that when the furnace has been blowing for eight or ten days the materials may be charged in powder without in any way injuring the working of the furnace. The products of the blast-furnace are crude-antimony metal, slag, and fine stuff. The first is divided into three classes, of the following composition :—

	No. 1.	No. 2.	No. 3.
Antimony	90·02	73·80	65·04
Iron	6·23	16·16	23·80
Sulphur	2·85	8·42	10·46

The first two qualities are sent to the refining-furnace, while No. 3 goes back to the blast-furnace. The relative proportions are—No. 1 82·5, No. 2 9, and No. 3 8·5 per cent. of the total output of the furnace. The slags produced in the blast-furnace vary slightly in comparison with the smelting-mixtures. Thus :—

	No. 1.	No. 2.
Silica	46·9	45·9
Lime	34·6	31·4
Ferrous oxide	15·1	19·9
Antimony	0·5	0·9

The first is produced from mixture (*a*), and the second from (*b*). There is very little flue-dust produced in the blast-furnace, the bulk of the product being derived from the preliminary operation of calcining the dressed ores. This is done in a single-bedded reverberatory furnace 26ft. 6in. long, and 6ft. 6in. wide, with five working-doors on one side. It is heated with brown coal, which is burned on a step-grate. The produce is about 24cwt. per day. The ore, which is charged in quantities of 4cwt. at a time, clots and softens, giving off a large quantity of sulphurous acid as soon as it attains a low red heat, but subsequently becomes dry again, and when finished is in a state of powder. The average time that the ore remains in the furnace is twenty hours. The liquated residues are roasted in stalls upon a bed of old mine-timber, the heap being allowed to burn for five or six weeks. The refining of the crude blast-furnace metal is conducted in a reverberatory furnace with an iron bed, 13ft. long by 5ft. 7in. wide, covered with a layer of fireclay 28in. thick. Brown coal is used on an ordinary grate in the fireplace. The working-door is on one side, and the tapping at the end of the bed. The gases on their way to the chimney pass under an iron plate below the furnace, and upon which the moulds for the refined metal are placed in order to warm them. The charge consists of 9cwt. of No. 1 metal, 1cwt. of No. 2 (the first being coarsely broken, while the second is in powder), to which are added 92½lb. of sulphate of soda, 11lb. of charcoal-dust, and 330lb. of unroasted ore. The operation lasts ten hours, and a final slag is made by the addition of 7lb. of carbonate of potash, 5½lb. of carbonate of soda, 2¼lb. of raw, and 13¼lb. of calcined crude antimony regulus (liquated sulphide of antimony), and 26½lb. of the same slag from previous operations.

Mr. Logan, managing director of the Endeavour Inlet Antimony Company, deserves great credit for the systematic manner in which the company have gone to work, and the way in which they have conducted their operations. In starting a comparatively new industry in the colony they have had a great deal to contend with, as they have had to import several workmen from England to conduct their smelting operations. Very few in the colony are aware of antimony-mining being conducted on so large a scale as this company is carrying on. They have about fifty workmen employed, and in order to get the best class of miners and smelters they have built cottages for all their workmen, and supply them with goods at Picton prices. The miners receive 9s. and the smelters 10s. per day. There has been 3,000 tons of ore taken from the mine, some of which was sent Home for treatment—some of it realizing £10 per ton—and the rest was treated at the works. The star antimony turned out from their works is equal in quality to that from the smelting- and refining-works in London.

The capital of this company is £50,000, in 50,000 shares, on which 11s. 9d. a share has been paid. Some of this money went to the shareholders in the old company for their interest in the property, but I am informed that £25,000 has been spent on their mine and works. The company consist of only fifteen shareholders, ten of whom hold the most of the shares. These are all local men, which shows that they have every confidence in the undertaking; and, if the same class of ore continues to be got in large quantities, there is little doubt but that it will prove a profitable investment. When the company first started the value of antimony in the English market was £40 per ton, but the present price is only £31; still, with the present low value, they expect to make good returns. The deadwork is now almost completed, and the company will begin to get the benefit of their labour early in this year.

Copper-mining.

Champion Company, Nelson.

This company has been in operation for about three years, but after having contended with a series of difficulties they now find that, after spending some £34,000, they have done very little towards prospecting the mine beyond a few feet from the surface. Steps are being taken to wind up the present company, with the view of re-forming it into another company with larger capital. A stranger visiting the mine really sees very little done for the amount of money there has been expended. To trace the history of this company, they have in a certain respect followed in the footsteps of a company that was formed many years ago to work copper in the Dun Mountain, which is on the same mineral belt of country, about five miles further northwards, and which resulted in a failure. The ground was first taken up by Messrs. Irvine and Johnston, who, after merely finding a lode on the surface, would not spend any money in prospecting, but tried to form a company with a capital of £30,000 to work the mine, a certain proportion of

which was to be paid in cash, and a certain proportion, in paid-up shares, to be given to the original proprietors; but the value the original owners placed on their interest was such that they were unsuccessful in forming a company.

After this scheme fell through, an arrangement was entered into between the proprietors of the ground and a few private individuals, whereby the latter were to get three-quarters of the ground on condition of paying a small amount of cash to the proprietors, and also spending £1,000 in prospecting the ground. The result of this was, after driving into the hill for a short distance on as low a level as the creek would permit, large blocks of native copper, and also a considerable amount of ore containing carbonates and oxides, were met with, which had the effect of raising the price of shares to a higher value. Several tons of the ore were forwarded to Newcastle, in New South Wales, to be treated at the smelting-works, which gave a high percentage of copper. The present company was then formed, with a capital of £60,000, of which £20,000 was paid to the former shareholders. Smelting-works, tramways, and roads were constructed to treat the ore and produce marketable copper. Subsequent to the formation of the company an adjoining lease, belonging to the United Company, was purchased, which gives a large area of ground, or a length on the belt of country in which the copper is found, between the Roding and Minor Rivers.

The company, in prospecting on the Champion Lode, found another lode almost parallel with the Champion, about 120ft. further to the eastward: this is termed the Doctor's Lode. They also constructed six different levels on what is termed the United Lode, which is in the lease that the company purchased, extending from the Roding River to Copper Creek.

To enable the company to bring their machinery and plant on the ground, and to assist in the development of the mineral belt that runs through this district, the Government subsidized the construction of a dray-road up the Aniseed Valley to the company's mine, which is a distance of twelve miles, to the extent of £4,117. The Government also subsidized a horse-track over the range to the extent of £209, making a total of £4,326 that was given by the Government towards the construction of roads and tracks to assist in the development of the minerals in this part of the country.

The work done in connection with this company's mine is as follows: A block of ore in what what is termed the Champion Lode has been worked. It proved to be in the shape of a spherical triangle, having the respective bases of 200ft., 160ft., and 80ft. This block contained green carbonate, red oxides, and native copper. A level is constructed for some distance into the hill; but the copper ore appeared to be completely cut out. There is also a level driven on the Doctor's Lode, and a winze sunk in the bottom of the tunnel for some 50ft. This winze carried the ore for a certain distance, and then cut out. The shoot of ore in the Doctor's Lode is dipping southerly at an inclination of 1 in 2, and has also a slight inclination to the westward. The width of the ore varies considerably: in places the bunches would widen out to 15ft., and in other places the ore is very thin; but it would average from 2ft. 6in. to 3ft. wide, and from 20ft. to 60ft. across at right angles to the southern strike or dip. The level on the Doctor's Lode is constructed for 360ft., at the end of which there is a shaft leading to the surface: this shaft is also sunk down to a depth of 20ft. below the bottom of the level to cut the lode, which is partially worked above this level, and which indicates by its southern dip that it will be cut in this shaft in another 10ft. or 15ft. In the level which has been driven on the Champion Lode two winzes have been sunk—one 20ft. in from the mouth of the level, which went through rich ore for 30ft., and then cut out; and the other is in 100ft. from the mouth of the level, and down to a depth of 100ft. without striking any ore. A shaft has also been sunk on the opposite side of Copper Creek to a depth of 157ft., and a level driven from near the bottom of this shaft for 410ft. in a southerly direction and 160ft. in a northerly without any ore being found.

The workings on what is termed the United Lode are about one mile northwards from the Champion, in the face of the range fronting the Roding River. Six different levels have been driven into the face of the hill about 50ft. to 60ft. apart, and large blocks of ore got in the whole of them. The lowest level is about 500ft. above the level of the river. It is in this portion of the mine where ore is likely to be more permanent, and where the bunches are of greater extent. The ore is of poorer quality than found in the Champion and Doctor's Lodes; but the blocks being larger will more than compensate for this. The mine is now opened up to such an extent on the United Lode that a large quantity of ore can be easily obtained—sufficient to keep the smelting-work in full operation for two or three years if the quality of the ore is sufficiently rich to pay for working. That is a question which there are doubts, and one on which the company by this time ought to be able to solve.

Character of the Country.—Although the workings in this company's mine have been termed lodes there is no defined lode yet found in their ground. The ore is found in a belt of serpentine rock, which is from three to four chains in width, and occurs in bunches here and there without having the walls clearly defined. The serpentine and ore are intimately mixed together, and when native copper occurs it is generally mixed up with rock. On the western side of the serpentine belt there is a dike of diorite, which joins on to a belt of gneiss and syenite, after which there is a belt of crystalline limestone, and thence slate rock. On the eastern side of the serpentine there is diorite dike, with belts of gneiss and syenite; on the eastern side of these serpentine again is found, and chrome-ore.

It has generally been considered by geologists that whenever copper is found in serpentine rocks it is not worth working, on account of it always occurring in bunches, here and there, without having any defined lode; but at the recent discussion on a lecture delivered by Sir Julius von Haast, under the auspices of the Geological Association, in the conference-room of the Indian and Colonial Exhibition, when the character of the country in which copper found in the Champion Company's ground was described, Mr. Warrington Smythe, F.R.S., made the following remarks: "There was one point that interested him more particularly, and that had reference to

the occurrence of certain classes of rock, and in connection with them certain classes of minerals. They had had an account of certain serpentinous rocks, which were amongst the questionable rocks, and had excited the closest attention of mineralogists and geologists. It was extraordinary that in New Zealand they should find a recurrence of the old phenomena of native copper disseminated throughout the rock. Whether copper was in payable quantities he did not know, but the fact was a singular one, especially if it were considered in connection with what might be seen at Lizard Point, in Cornwall, where one of the most interesting exposures of this rock was to be met with, and which was daily studied by geologists. It had escaped the recollection of a good many people that at the time of the Great Exhibition of 1851 a very permanent and successful copper-mine was in operation there in the midst of serpentine. Not only was this native copper disseminated through the rock, but there were certain portions of it which were so large and promised so well for the future, that a mining company was kept up, and worked to a considerable depth." This shows that, although serpentinous rocks are considered questionable for payable lodes of copper to be found, there are exceptions to this rule, and that copper-mining has been carried on successfully in this character of country. Whether the bunches of copper that are found in the Champion Mine can be made to pay for working is a question yet to be solved. There are blocks of copper found throughout the serpentine belt, some of the pieces of native copper found being over 3cwt.

Smelting-works.—The smelting-works are erected on the Roding River, about a mile below the workings in the United Lode and about two miles from the workings in the Champion and Doctor's Lodes. The former workings are connected with the smelting-works by a dray-road, and the latter by a narrow-gauge tramway. This tramway is very flimsily constructed, and if ever the mine comes to be worked on a large scale a more permanent structure will have to be made. The smelting-works consist of roasting-stalls, ore-crusher, pulverizer, and a cupola smelting-furnace.

The process of treatment that the ore undergoes is as follows: The ore on arrival at the works is dumped into hoppers. The large pieces are put through one of Blake and Marsden's stone-breakers, which reduces them to about ½in. in diameter; thence it is taken and roasted in stalls. These stalls are constructed of brickwork, in two rows, seven stalls in each row, having a main flue between the rows, which leads into a brick chimney at the end of the stalls. Each stall is about 7ft. by 6ft., and 6ft. in height, and between each stall there is a small flue leading into the main flue. There are small openings left in the sides of the stalls to allow the smoke, the sulphureous and arsenious fumes, to escape into the flue. A pile of firewood is first placed in the bottom of the stall, and afterwards the ore is put on until the stall is completely full, after which there is a coating of clay-mortar placed on the top of the ore to prevent the smoke and fumes ascending into the building which covers these stalls. When this is completed a fire is kindled, and each stall is allowed to burn from fourteen to twenty days before it is considered sufficiently roasted. This process roasts the ore in the centre of the stalls to a black cinder, but the ore which is round the sides of the stall are very imperfectly roasted. After the roasting process the ore is taken to the mixing-floor, where a certain proportion of limestone is added, and it is then put into the cupola for smelting. This cupola is similar in shape and dimensions to a cupola for melting cast-iron, only that it has two openings near the bottom, one a little higher up than the other, for drawing off the slags. The cupola, or furnace, has a short chimney on the top, but there are no flues or means of condensing the fumes from the molten mass; hence a certain proportion of the copper volatilizes and is entirely lost. From the appearance of the slag that is lying about the works, there has been a difficulty in getting the silica with which the ore is mixed to smelt freely, as quantities of copper can be seen mixed amongst the slag. The furnace is heated with coke, and the blast is supplied by one of Baker's blowers, which is driven, as well as the stone-breaker and pulverizer, with a turbine water-wheel of American construction. The water is supplied to the wheel by two wrought-iron pipes, which lead from a tank at a higher level. The company smelted about three hundred tons of ore, being principally from the United Lode, which is composed of copper-pyrites; and they estimate the cost of mining and smelting by the process they have adopted as follows—the cupola being capable of treating 30 tons of ore per day:—

Daily Expenditure.	£	s.	d.
One stableman, 8s.; three ore-haulers, £1 4s.; two foremen, £1 8s. ...	3	0	0
Four horses, 8s.; one lead-smelter, 12s.; two furnace-men, £1 ...	2	0	0
Three furnace-helpers, £1 7s.; six charge-men, £3	4	7	0
Four men crushing and roasting, £1 12s; one firewood-boy, 5s. ...	1	17	0
One night-watchman, 6s.; two dump-men, 6s.; two boys, 10s. ...	1	12	0
Three labourers, £1 4s.; one blacksmith, 10s.; two machinists, £1 4s.	2	13	0
	£15	14	0

Monthly Expenditure (four weeks).	£	s.	d.
Smelting-works, four weeks at £15 14s.	439	12	0
Working-expenses of mine	709	12	0
Supplies	40	16	0
Superintendent and clerk	91	14	8
Eighty-five tons of coke, at £3 15s.	318	15	0
Incidental expenses and repairs	100	0	0
	£1,700	9	8

On the assumption that the furnace is capable of smelting 30 tons per day, this would amount to 720 tons in four weeks; but, as there are always some stoppages and repairs wanted, it is but fair to make a deduction for stoppages, which may be set down at 10 per cent. deduction from the esti-

mated quantity smelted. This would reduce the amount of ore treated in four weeks to 648 tons, which would make the cost of mining and smelting to be about £2 12s. 6d. per ton of ore. From what I could learn, the ore from the United Lode, which was the principal ore treated, averaged 7½ per cent. of pure copper; therefore 648 tons of ore would yield 48·6 tons of pure copper. This brings up the cost for every ton of copper at the works to about £35. It has to be carted for fifteen miles to Richmond and then sent by rail to the Port of Nelson. Taking cost of carriage, railway-freight, wharfage, freight, and insurance, the cost of obtaining the copper may be set down at £40 per ton. This leaves but very little margin of profit at the present price of copper in the English market.

The company have suspended operations at their smelting-works, and have only two men engaged in prospecting the mine. It seems a country where a continuous lode is not likely to be found. They will have to depend on bunches of ore here and there throughout the serpentine. Whether these bunches will be found to sufficient extent to pay a company is a question that has yet to be solved.

The great mistake that the majority of mining companies fall into is in spending large sums of money in erecting machinery and plant before the mine is thoroughly proved: this absorbs the available capital, and leaves them not sufficient money to thoroughly prospect the ground. It cannot be said that the ground here is anything like prospected, nor is there sufficient known about the bunches of copper that have been got, with the exception of the one that was first found in the Champion Lode. The others, apparently, are going down, but to what depth it is not known. The only thing proved in the mine is, that the lodes do not run continuously, but are merely bunches of ore standing on slightly-inclined angles here and there throughout the serpentine belt. Large bunches have been proved on the United Lode, and still continue to go down. The serpentine rock here is of a much harder nature than it is in the Champion and Doctor's Lodes.

Ores and their Formation.

The character of the rock in which gold- and silver-ores are found differs considerably in different parts of the world. Indeed, this applies to no place more so than in this colony. In the Middle Island the ore is found in slates and schistose rocks, and in the North Island, about the Thames and Coromandel Peninsula, it occurs in a tufaceous rock. In the Eureka Mining District, which is situated on the western side of the Diamond Range, in the eastern part of the State of Nevada, the gold- and silver-ores occur in limestone and quartz-porphyry, in bunches, bonanzas, or pockets, and not in what may be termed continuous lodes. From a geological description of the country in the Eureka Mining District, written lately by Mr. Joseph Storey Curtis for the Department of the Interior in the United States of America, the character of the country where the rich finds have been got resembles in a certain measure the formation of the Thames District; and the theory as to the deposition and source of ores apply with force to the formation and deposition of the gold- and silver-lodes in the mining districts of the North Island. Mr. Curtis states that the ores in the Eureka Mining District are not accurately classified by the miners, but received names indicative of their most striking characteristics, and the popular idea of the corresponding composition.

It may be well to describe some of the more important varieties. Most of the ore has a reddish or yellowish colour, due to the presence of oxide of iron, chloro-arsenate, or molybdate of lead. The shades of colour vary according to predominance of one or the other of these minerals and the quantity of earthy matter mixed with them. One of the principal kinds of ore is composed of a hydrated oxide of iron mixed with some sulphate and carbonate of lead, and containing intermingled grains and lumps of undecomposed galena. This ore is often called "red carbonate." It usually carries about equal values of gold and silver, from £5 to £10 of each per ton, though sometimes the gold is considerably in excess. Another variety is the "yellow carbonate." This term is applied by the miners to any ore of a yellow colour which contains lead. It belongs, however, to a very characteristic ore, which is a mixture of the hydrated oxide of iron with the sulphate and chloro-arsenate of lead in varying proportions. The ratio of silver to the gold in this ore is not at all uniform, sometimes one metal and sometimes the other being in excess. Another variety of yellow carbonate is that which owes its colour to the molybdate of lead mixed through it. As the molybdate of lead usually carries but little silver and less gold, this ore is not very rich, unless it contains other minerals bearing the precious metals. The so-called "sulphuret ore" of the miners is an almost pure crystallized carbonate of lead. It is greyish in colour, and consists of aggregated crystals of cerussite. It is sometimes quite rich in silver, assaying as high as £26 per ton, but, like all the lead-ores proper, is poor in gold. There are several varieties of red ore, consisting principally of the hydrated oxide of iron with a little lead and silver, which are tolerably rich in gold. There is usually nothing in their appearance to indicate their value, and it is only by constant assaying that it is possible to determine what they are worth.

Ore-deposits.—With regard to the ore-deposits in Leadville, Colorado, Mr. S. F. Emmons, in a report on the geology and mining industry in these districts, states that the investigations made have proved the following facts as regards their origin, mode of formation, and distribution:—

(1.) That they have been derived from aqueous solutions.

(2.) That these solutions came from above.

(3.) That they derive their metallic contents from the neighbouring eruptive rock.

(4.) That in their original form they were deposited not later than the Cretaceous period.

(5.) That the metals were deposited from their solutions mainly as sulphides.

(6.) That the process of deposition of the vein-material was a chemical interchange or an actual replacement of rock-mass in which they were deposited.

(7.) That the mineral solutions or ore-currents concentrated along the natural water-channels, and followed by preference the bedded planes at a certain geological horizon; but that they also penetrated the mass of the adjoining rocks through cross-joints and cleavage planes.

(8.) That the main mass of argentiferous lead-ores is found in calcareo-magnesian rocks.

(9.) That the siliceous rocks, porphyries, and crystalline rocks contain proportionately more gold than copper.

On this subject Mr. Curtis states that the ore-deposits in the Eureka Mining District do not differ from the Leadville (Colorado) District, except that their metal-bearing solutions came from below, and that their connection with the eruptive rocks is not plainly shown.

The Shape of Deposits.—The deposits sometimes spread out into an immense chamber that measures more than 50ft. in each direction, and which is completely filled with ore, with the exception of an occasional limestone pillar. From the sides of these chambers, which scarcely ever present smooth walls, there are branches, and auxiliary pipes lead up or down or in a horizontal direction to the other bodies. The ore-bodies do not seem to follow any particular direction either as regards dip or strike, and at the first sight they appear to be disturbed throughout the ore-bearing formation without any regularity. This is not wholly the case, and, although no well-defined law can be found governing their occurrence, this is connected with that of certain phenomena in the country rock, such as fissures, caves, and broken limestone.

Deposition of the Ore in Chambers.—The ore in the upper part of the larger chambers is mostly in a loose state, sometimes in layers, and is usually covered by beds of sand, gravel, and boulders of variable thickness. It is difficult to believe that this mass owes its structure to any other cause than rearrangement by subterranean water-currents, though it is not likely that the original position of the material was remote from that which it now occupies. There is, of course, every reason to suppose that the waters either from the surface or from below have flowed through these rocks in notable quantities ever since they were intersected by fissures; but the floods which have left the traces just described in the upper portions of the chambers must be comparatively recent, since the stratified ore has been rearranged since its oxidation. In the lower part of the chambers, on the other hand, the ore is more compact, and usually appears as if it occupied its original position.

Connection of Ore-bodies with Quartzite.—In many of the mines in the Eureka Mining District the ore is usually found in the limestone at or near its contact with the quartzite, except close to the surface, where it is generally at some distance from that formation. Although a complete connection has not been established between all these ore-bodies and the quartzite, or between all the ore-bodies themselves, yet their location and the relation that they bear to the secondary or contact fissure between the quartzite and the limestone indicate that the fissure has often served as an ore-channel.

The same thing occurs in the North Island with relation to what are called buck reefs, and the lodes in which gold has been found. On the Tokatea Range, at Coromandel, there is a connection of all the gold-bearing leaders with the main Buck Reef that goes through the range. Again, in the Waiotahi Mines, at the Thames, the large or main reef does not appear to carry a great deal of gold; nevertheless there is a connection between this and the lodes and leaders that have been worked and found to have been rich in precious metals. In this mine there are fissures in every direction, the most of which contain rich auriferous deposits. This tends to show that the fissure in which the large body of quartz is now found was a channel through which the subterranean waters flowed, carrying the mineral solution, and from which they found their way into the joints, crevices, and fissures of the rock in the vicinity. Whether the solution of these minerals came from below or from the surface, or percolated through the adjoining rock into these fissures, is a problematical question which has not been solved. It is nevertheless a question of considerable importance to the miner to ascertain the source of the ore, and how the different minerals were deposited, in order to carry on prospecting mining operations on a scientific and intelligible basis.

Far more attention has been directed to this subject of late years in America than in other gold- and silver-producing countries. This is not to be wondered at, seeing the magnitude on which mining operations are carried on, and the enormous annual yields of gold and silver compared with that of any other country. Mr. Curtis attributes solfataric action to have acted a prominent part in decomposition and in the formation of minerals.

With regard to the source of the ore in the Eureka Mining District, Mr. Curtis states that there is a strong probability, if it is not absolutely certain, that the eruption of rhyolite preceded the deposition of the ore. Extensive eruptions of this rock took place at no great distance from the mines, and, as has been described, a dike of it follows one of the chief fissures of the mineral zone. The decomposition of this dike, and of other rocks accompanying it, especially the quartz-porphyry, is such as is characteristic of volcanic regions, and its occurrence must almost inevitably be ascribed either to the rhyolite eruption or to the still more recent outburst of basalt. There is no basalt, however, in or near the mines, and therefore nothing to indicate a connection between its ejection and the deposition of the ore. The solfataric action traceable in the mines is therefore most naturally referred to the rhyolite eruption. It is, of course, no objection to this hypothesis that the rhyolite is itself decomposed, since the decomposition of lavas within a few days after their ejection, by the gases and solutions of the same eruption has frequently been observed, while the period of the rhyolite eruptions near Eureka may have covered centuries. The character of the decomposition of the rhyolite is familiar, and consists largely in the extraction of the heavy bases and alkalies, leaving siliceous clay as a residue. Sulphuretted hydrogen is almost invariably an accompaniment of volcanic action, and the alkalies in solution were in part converted into sulphides. As most of the sulphides of metals are soluble in solutions of the alkaline sulphides, a vehicle was thus formed for the transportation of any metallic sulphides which might be present. Those sulphides, or compounds which would yield them, might have formed constituents of the rhyolite, but, as a matter of fact, there is no rhyolite in the vicinity of the ore which contains sufficient gold, silver, or lead to admit of its being regarded as the source of these minerals in the ore.

The rhyolite, however, is not the only eruptive rock met with in the mines—quartz-porphyry also occurs. This rock, however, contains considerable quantities relatively of gold

and silver, particularly of the former. The explorations in the mines in which it is found are not sufficient to give any definite idea of its extent, but it is possible that it is much more extensive than its croppings suggest. The result of the assays made of this porphyry indicates that the rock contained silver and gold, and perhaps lead, after it solidified, and before any solfataric action could have affected it. Though the age of quartz-porphyry cannot be proved from this district, there can be no doubt, from its lithological character and its mode of occurrence in innumerable other localities, that it is pre-Tertiary, and far older than the rhyolite. That the solfataric action incident to this eruption had an effect upon this porphyry is extremely probable: at any rate, changes of a solfataric character were brought about in it, such as the formation of iron-pyrites and the concentration of gold and silver in that mineral from the porphyritic mass. Although it is not certain that the gold and silver in the mines of its immediate neighbourhood were derived from this rock, yet the amount of gold and silver it contains, and the transformation it has undergone, render it a possible source of those metals in the ores of the mines in the vicinity of quartz-porphyry rock. Assays from this rock showed that it contained silver to the value of 3½d. and gold to the value of 1s. 0½d. per ton. The nearer the body of ore the higher the percentage of assay, and the further away from such body the percentage was less.

Manner of Deposition of the Ore.—Mr. Curtis, in summing up the different probable theories as to the manner in which the ores were deposited in the Eureka Mining District, states as follows: "The solution containing the ore penetrated the limestone, passing through fissures and interstices in the broken rock, and deposited the ore when conditions of temperature and chemical activity were favourable to its precipitation. It is impossible to determine what may have been the chemical composition of the solutions which carried the ore, but it is not improbable that they consisted in a great part of metallic sulphides dissolved in alkaline sulphides. These solutions were necessarily formed under the influence of heat and pressure. Rising into the shattered limestone at a diminishing pressure and temperature, the liquids lost much of their solvent power, and many of the metals that they contained were precipitated. This precipitation could have occurred in only two ways—either through deposition in pre-existing large cavities, or through a substitution of ore for country rock. The manner in which the deposition took place has a very important bearing upon the probabilities of finding ore at any considerable distance below water-level."

There is no doubt the mining operations are conducted on a far larger scale in America than they are in this colony; but the mines here are only in their infancy, and those engaged or interested in mining pursuits require to direct their attention more to the formation of lodes and source of the ore. It is only by close investigation that this can be done, if ever it be absolutely determined. But there are always indications where bodies of ore are likely to be found if prospecting is conducted on an intelligent basis.

Mr. Pond, Colonial Analytical Chemist, Auckland, read a paper on the minerals of Cape Colville Peninsula some twelve months ago, before the Auckland Institute, giving an interesting description of those minerals and their value. The following is an extract:—

"*Gold.*—This metal is by far the greatest in value of any deposits hitherto found in the district. To the present time it has been discovered in the native state only, alloyed with more or less silver The average percentage is about 64 of gold and 36 of silver. The probability, on further exploration, of finding gold in another form, is, I think, very great. But, at the present time, though we have it accompanying and attached to arsenic, antimony, and tellurium, it is only in the free state, and uncombined. The energy, however, which is now being displayed may make us acquainted with it in some other form than that with which we are familiar. When we bear in mind the wealth that has already been recovered from the district since 1854, and the extent of ground that has been proved auriferous, it can but be a matter of energy and time to still further enhance this total.

"*Silver.*—As I have already intimated, this metal has always been alloyed with the gold found in the reefs in this district, occasionally to a very large extent, but generally closely observing the ratios already given. The presence of silver in the form of pyrargyrite, or ruby-silver, has also been known for a considerable time. In this form it almost always accompanies the gold when found in rich deposits, and I have found it in specimen-stone to the extent of 200oz. and 300oz. to the ton. This is, of course, invariably lost in the ordinary process of crushing, owing to its not amalgamating readily with mercury. Another form in which it exists here, and, at present, gives promise of moderately large riches, is in the form of a telluride. This combination I first found in the Moa claim, at Te Aroha, and have since discovered it at Karangahake and Waihi, and anticipate that it will be probably found also at Waitekauri. It occurs in the reefs, very unevenly distributed through the stone, and invariably accompanied by magnetic pyrites in minute grains and crystals, in the same manner as the free gold at Te Aroha. Both tellurium and antimony occur combined with the silver at Karangahake, and on this account the profitable working of these ores will be a problem not easily solved. At Waihi the silver so far mined is almost entirely an antimonide, and it will be interesting to note the difference in the constituents of rich portions of ores taken from the Crown, at Karangahake, the Rosemont, at Waihi, and the Champion, at Te Aroha, showing the relative value of antimony and tellurium to each other in these ores, though the varying richness of the ores prevents an accurate deduction without complete analyses of each, which has only been carried out with the Waihi ore.

Waihi, Rosemont Gold-mining Company—

Silica ...	... 89·3	per cent.	
Alumina ...	... 1·5	"	
Protoxide of iron	... 5·94	"	
Lime ...	... ·49	"	
Sulphide of lead	... ·05	"	
Sulphide of copper	... ·06	"	
Sulphide of antimony...	·302	per cent.	
Gold ...	... ·021	"	
Silver ...	... 1·149	"	
Tellurium ...	... A trace		
	98·812	"	

Te Aroha, Champion Gold-mining Company—Tellurium	0·30	per cent.
Sulphide of antimony	0·16	"
Karangahake, Crown Gold-mining Company—Tellurium	3·4	"
Sulphide of antimony	1·6	"

"As the profitable working of these complex silver-ores depends upon a knowledge of their composition, there is much useful work in these districts for the analyst. The amount of riches which have been lost in the Karangahake District alone by the attempt to save the gold and silver in the ordinary battery-process must have been considerable, and any mode of treatment must be based upon a knowledge of the chemistry of the subject before any real success can be obtained. With a desire to obtain as much practical knowledge as possible on these ores, I have, in conjunction with Mr. E. H. Whitaker, made a large number of experiments with ore from the Silverton at Waihi. A portion of the ore was taken and reduced to a size that passed through a wire mesh-sieve of sixteen-hundred holes to the inch. From this powdered ore portions of 5lb. each were treated in a berdan with chained revolving ball, giving in the pasty mass a thorough amalgamation with a sufficient quantity of mercury; and the parcels were treated for from three to four hours. Taking first a parcel of raw ore treated in the manner specified, the results were 16·36 gr., or 15oz. 5dwt. 19gr. to the ton. The residual matter is worthy of note as showing how large a portion of the value can be lost in running water. After washing the fine sandy portion of the ore the sludge was left to precipitate, but after two days' rest the water, still being thick and charged with clayey matter, was poured off from the sludge and the whole of the water evaporated, leaving a large quantity of an impalpable powder. These three portions of the tailings were then assayed, with the following results:—

	Sand. Oz. dwt. gr.	Sludge. Oz. dwt. gr.	Slimes. Oz. dwt. gr.
Silver	37 17 21	32 0 6	16 16 11
Gold	12 1 17	11 2 3	3 8 14

"These results give some idea of the loss which must take place where battery- or pan-treatment is concerned with the raw ore. In addition to this loss it was found that on wetting the dry powdered ore a black scum rose to the surface in every instance, on examination of which it was found to contain principally the finely-divided silver-ore, with magnetic pyrites and gold, entangled with fine globules of air. So difficult to cause separation of these particles with the air was it, that frequent stirring for several days was insufficient to precipitate the major portion. The same loss was noticeable in all the Waihi and Karangahake ores, as well as that from the Champion at Te Aroha. After many experiments with the same-size parcels—5lb.—of the same richness and degree of fineness, it was found that the best results were obtained by a careful chloridizing roasting, and treatment with sulphate of iron and common salt for four hours in an almost pasty condition with excess of quicksilver. By this means a return of 84 per cent. was obtainable of the total value present, as against 40 per cent. saved in the treatment of the raw ore as detailed above. In these experiments I need hardly say that the bullion from the Silverton ore, being so largely composed of gold, would be more favourable for amalgamation than many of the true silver-lodes already alluded to.

"*Copper.*—This metal is found in small quantities throughout the peninsula, in the form of copper-pyrites (chalcopyrites), accompanying most of the rich gold-deposits. I have also found it present in this form in several of the mixed lodes, which will be considered when dealing with the galenas—notably in the Manukau Mine in one of these veins, which yielded 12·63 per cent. of sulphide of copper; and, again, in the Little Agnes, at Tararu, which yielded from 3 to 9·7 per cent. From Coromandel also I obtained in a similar lode 15·49 per cent. of sulphide of copper, and at Port Charles to the extent of 6·4 per cent. Captain Hutton also, in 1867, reported the presence of copper in veins between the Thames and Tapu; but in no instance on the peninsula am I aware of its existence in payable proportions.

"*Lead.*—This metal we have present in a good many places in the district in the form of galena. At Port Charles is a vein carrying also copper and iron-pyrites, and yielding 25 per cent. of metallic lead. At Coromandel, in the Driving Creek, is a narrow vein containing a good clean sample of galena, but irregular in size and quantity. At Waiomo and at Cabbage Bay are similar veins; but very much intermixed with other sulphides—notably zinc, antimony, and iron. In the Tararu Creek are several veins of the same character, also containing a large amount of zinc and antimony. So large are the percentages of these metals as to make it valueless as a lead-ore. In the Manukau Mine a well-defined vein of this character was also worked, but not with any payable result. I know of no lead-ores south of Grahamstown until we reach Te Aroha; but here we have several at the Tui Creek and at Waiorongomai. In the latter district are several compact well-defined veins carrying a fair sample of galena. At several places in this locality I have found lead in the shape of chromate in small quantities. The galena in these mines can only be worked to advantage when containing sufficient gold or silver to make it valuable on this account, and it will be of interest to note the extent to which the precious metals are present in these lodes. The following are the assay returns which I have obtained from samples most of which I have taken from the lodes myself:—

	Silver. Oz. dwt. gr.	Gold. Oz. dwt. gr.
Port Charles	2 8 17	0 0 7
Coromandel	5 12 17	0 1 15
Coromandel	3 8 14	0 4 21
Waiomo	4 16 6	0 1 18
Little Agnes, Tararu	6 12 0	0 9 19
Manukau, Thames	2 15 12	Nil
Waiorongomai (galena)	3 8 14	0 9 19
Waiorongomai (quartz and galena) ...	4 18 0	2 5 17

"From the results of these assays it will be seen how small an amount of the precious metals are present in the lead-ores. In no instance have I obtained in picked samples of galena more than 9oz. silver or ½oz. gold to the ton. The assays of the Waiorongomai sample are interesting, as they were both from one piece of ore. The sample of galena picked free from stone gave at the rate of 9dwt. 19gr. gold per ton, while the sample to which quartz was attached yielded the precious metal at the rate of 2oz. 5dwt. 17gr. per ton. This result is not surprising, as I have also examined samples taken from the Lucky Hit claim at Waiorongomai, where two veins of galena enclose a vein of quartz in which gold is plainly visible, making very pretty specimens; yet the galena itself is very poor in gold. The same circumstances apply to the Manukau sample, which, though in the vicinity of rich gold-bearing leaders, is very poor in silver, and contains no gold.

"*Zinc.*—I have already alluded to this metal as accompanying many of the galenas. It also occurs in the Tararu District in the shape of blende in the absence of lead; but only in small quantities in a few of the lodes. It is rather significant that in the presence of these baser metals the richer ones seem to disappear. I have already alluded to the absence of gold in the Manukau galena, though in the immediate vicinity of rich gold-deposits. The same peculiarity occurred in the Little Agnes claim at Tararu, where rich gold was found in the upper workings; but when the galena and blende came in the precious metals were apparently cut off; and, though the gold in the Lucky Hit claim occurred so closely adjacent to the galena, yet it was entirely distinct from it, and only accompanied it a short distance.

"*Antimony.*—In all parts of the peninsula we have this metal present in the form of stibnite. At times beautiful branching crystals are found in the vughs of the lodes: especially is this the case in the Tararu and Karaka districts. When so situated these crystals are not auriferous, but frequently have beautiful attachments of gold either interlaced through the needles of stibnite or studding the facets. In only one place am I aware of the massive variety of stibnite being found, and that was in the Hape Creek. In this instance the precious metals were absent, and the vein from 3in. to 6in. in width. In combination with silver I have already dealt with this metal.

"*Arsenic.*—This metal has been found in large quantities in the native state at Coromandel, in the Kapanga and Bismarck Mines. It is obtained in the vughs in the lodes in a reniform shape and foliated character. In almost every instance these masses contain gold, very often visible. The following assay shows the value of some obtained in the Kapanga Mine: Arsenic, containing—gold, 135oz. per ton; silver, 97oz. per ton. In the form of mispickel or arsenical pyrites we are best acquainted with it throughout the whole of the districts. Particularly is this the case at Coromandel, although the Moanataiari and Karaka also produce it in most of their lodes.

"*Mercury,* in the form of cinnabar, is occasionally met with in various parts of the field. From the Crown Princess Mine, at Grahamstown, I obtained several specimens, and from the Hape Creek some water-worn stones showing the presence of cinnabar. I have also received some from Te Aroha, Owharoa, and Coromandel, but in no instance is it present in large or defined quantities.

"*Platinum.*—The presence of this metal in the lodes is a matter of great interest, and, though of no practical value at present on account of its sparsity and the difficulty of recovery, still, it may occur in larger quantities, and prove of intrinsic value. To the present I have obtained it only in two places—the first in the Queen of Beauty Mine, where I met with it varying from 1¼oz. to 10oz. per ton (Trans. N.Z. Inst., Vol. XV., p. 420), and again in a massive pyrites at Coromandel, where it assayed 16dwt. 8gr. per ton.

"*Manganese.*—This I have found at Karangahake, occurring under very peculiar circumstances in the form of wad in spherical nodules in hyalite. No seam or vein connecting them, they form very conspicuous objects in the white soft silica. When the City of Dunedin Reef, at Tararu, was being worked some years since it was well known as the Black Reef, owing this distinction to the presence of peroxide of manganese. At Cabbage Bay there is a large deposit of manganite having quartz-crystals interspersed throughout, and the same form is mentioned by Mr. Skey as occurring in small quantities at Tararu.

"*Nickel.*—I have found this metal in small quantities as a silicate in a foliated serpentine at Coromandel.

"*Iron.*—The presence of this metal in combination with sulphur is very general throughout the peninsula. In a few instances it occurs in a massive form, though not to a large extent. Again, it is occasionally found in a radiated form as marcasite, but generally throughout the reefs and the enclosing tufaceous rocks it occurs in small, well-formed, isolated crystals. To a slight extent it is also present as magnetite, which is obtainable in any of the streams through the disintegration of the rocks. In the form of hæmatite it is also found in several parts of the field, but not, so far as I am aware, in extensive deposits. In this state it has been used to a limited extent in the manufacture of hæmatite paint.

"*Carbon.*—In the form of graphite several small deposits occur at Coromandel, but they are all too small and impure to be of any practical value. It occurs also as a hydrous brown coal in several places at Cabbage Bay, where there is a large deposit, interspersed with bituminous shale in alternating narrow seams, thus making it valueless for commercial purposes. Again, in the Mata Creek, at a long distance back, there is another outcrop of coal, more compact and less charged with earthy impurities. Again, at the head of the Kauaeranga River, to the west of Table Mountain, is a larger deposit of the same class of coal outcropping in several of the creeks. At Paeroa is a still larger deposit of the same character, upon which a good deal of work has been done, proving it to extend over a considerable area. In this locality there are two seams overlying the main one, which has a thickness of about 4ft. Analyses which I have made of the coal I append:—

	No. 1. From Shaft.	No. 2. From Outcrop.	No. 3. From Drive.
Fixed carbon	45·03	34·55	34·4
Hydro-carbon	30·57	37·15	28·4
Water	17·30	18·50	28·2
Ash	7·10	9·80	9·0
	100·00	100·00	100·0

"*Lime.*—Though this mineral is found occurring in a large number of the lodes in the form of calcite, it is only in very small proportion to these lodes. At the Big Pump, at Grahamstown, this mineral, in the shape of a carbonate, was at one time a serious inconvenience, through its incrusting around the working portions of the pump at a very rapid rate; and, though the incrustation still continues, I believe it is to a much less extent. In the district I am aware of only two places where calcite forms part of a regular lode. These are both at Tararu—one near the Bluff, and the other in the land owned by Mr. Carran.

"*Silica.*—The very general distribution of quartz throughout the peninsula places this mineral in the foremost place. The varieties are also great. From Coromandel and Tapu fine samples of chalcedony and agate are obtainable. From the same districts, and from Tararu, rose and amethyst quartz is obtained; while from the Kauaeranga River I have secured fine specimens of red jasper with opalescent veins. Some of the reefs at Waihi are also very pretty, and filled with chalcedonic quartz. I have already mentioned the presence of hyalite at Karangahake, and may add, of common opal. So excellent are some of these specimens that it would be well worth searching diligently for the purpose of deciding whether the precious opal may not be present. Through the whole peninsula very fine samples of rock-crystal are also to be obtained. Some of these, found in veins in the reefs, have filamentous gold attached, and intertwined amid the crystals, forming beautiful specimens. In many of the rich specimen-reefs a white powder was found to accompany the gold: in fact, in some of the lodes—notably at the Union Beach, Coromandel—this was the indication most welcome to the miners as denoting the presence of rich stone. This powder, very frequently quite dry, was found in the veins and holes in the lodes, and sometimes filaments of gold were found dotting the surface or lying amongst the powdery material. An examination of a sample obtained from the Union Beach showed it to contain—silica, 72; alumina, 28; magnesia, trace: total, 100. Most probably this material was a decomposed feldspar. Other varieties of silica, in the form of chert, flint, and silicified wood, are occasionally met with in various parts of the peninsula, but do not call for any special remarks.

"[Since writing these remarks, further development has taken place of the lead-lodes at the Tui. In the Champion a compact galena lode containing a good deal of iron-pyrites has been opened out by a road being cut through it, and samples of the galena obtained from the lode I have assayed, and give herewith. In the adjoining mine, the Surprise, a carbonate-of-lead lode has been uncovered, and, though small and irregular, contains some very pure ore. This lode has been cut in a low-level tunnel, and the lead here is no longer a carbonate, but a sulphate, with a few crystals of galena enclosed. Assays of this lode I append.

	Silver. Oz. dwt. gr.	Gold. Dwt. gr.
Champion (galena)—Tui (Te Aroha)	9 2 22	A trace
Surprise (carbonate)—Tui (Te Aroha)	7 7 0	3 6
Surprise (crystallized), homogeneous at base of crystals)—Tui (Te Aroha)	26 12 11	3 6
Surprise (sulphate)—Tui (Te Aroha)	19 12 0	A trace

The same results are thus apparent here in the poverty of these lead-ores in silver and gold. The probability of the lode in the Surprise making again is great; but in sinking or opening at a lower level, and driving on it, I think it will be found as a galena lode. Accompanying this lead are a good many patches of cinnabar—too small, however, to be of any practical value. The country in the vicinity is well worthy of prospecting, many fine reefs outcropping from which stones may be picked giving very fair assay-value; and the same remark applies to a great deal of loose stone lying on the surface for a long way down the mountain. The low level of the Surprise is 2,050ft. above sea-level."]

Treatment of Gold and Silver Ores.

The treatment of gold-bearing quartz has for several years been carefully considered, and different methods from time to time adopted to extract the gold from the stone; but, where gold is finely disseminated in the quartz that is generally found on the northern goldfields, giving it the appearance of finitesimal atoms of gold, silver, silica, sulphur, and iron being all blended together, —which in point of fact they are—it has not yet been definitely determined which is the most successful and economical method of extracting the metals. The amount of silver in the gold gives it a light-yellowish appearance, which to the uneducated eye presents very little attraction. In crushing this character of auriferous stone it has to be ground up to a pulp before the gold can be separated from the silica, and in doing this has so far baffled the proprietors of stamping-batteries to get anything like a fair percentage of the gold from the stone by this process of treatment. While the contention of the gold-saving process was going on, another new feature was discovered about two years ago—that a great deal of the stone was, in addition to gold, rich in silver, which occurred in the form of sulphides, chlorides, and tellurides. Attention is now being directed to get some process of treatment whereby both gold and silver can be saved, and several plants are being devised, some of which are erected, to cope with this important question.

The first plant erected to extract the whole of the metals from the stone was the La Monte smelting-furnace at the Thames, which was expected by a few to quite revolutionize the system of

treating ores; but, alas! it did not come up to expectations, as the character of the ore was not suitable to this process of treatment, owing to the large expense of procuring flux, and also the large amount of flux required to conduct the operations. This mode of treatment is suitable to the class of ore there is at Sunny Corner, and for many of the mines in the Silverton district in New South Wales, where gossan and galena are abundant in the stone, which are the principal fluxes required; and where the stone is poor in galena, copper also is said to serve the same purpose. At Sunny Corner the ore contains copper, galena, and a very large percentage of gossan, along with gold and silver; so that the expense of smelting is almost reduced to a minimum, there being nothing but lime to purchase to mix with the ore, which is delivered at the works at a cheap rate. At the time of my visit to the mines in the Sunny Corner district, one of the La Monte furnaces was in operation, and was giving satisfaction as far as extracting the metals from the ore was concerned. The only thing that the company complained against was that the furnace did not smelt the quantity of ore that the patentees guaranteed it to do; and when in Sydney, one of the patentees, Mr. Kahlo, showed me the different monthly sheets of expenditure in connection with the amount of ore smelted, which ranged from £2 3s. to nearly £4 per ton. The average cost of treating 4,950 tons was £3 4s. 2¼d. per ton. It will therefore be seen that if it costs this amount to treat ores which do not contain a large percentage of silica, but contain the principal fluxes, the cost of treating the class of ore there is on the northern fields must be considerable, when the ore contains over 90 per cent. of silica, and does not contain the fluxes required. The La Monte furnaces are suitable for galena ores; but for the form in which silver occurs in the Karangahake and Waihi districts, being principally as sulphides, chlorides, and tellurides, with at least 90 per cent. of silica, these furnaces are not suitable, because the large amount of flux required to make the slag run freely prohibits this class of treatment from being adopted. Two of the La Monte furnaces are erected, one at Grahamstown, and the other at Karangahake. The former was worked for several months, and the latter only made a small trial-smelting.

Another new plant has been recently erected at Karangahake, and only started operations on the day of my visit to the district. As this plant is quite different from any there is in the colony, and great expectations are entertained as to its success, a description of it will not be out of place. Mr. Railey, the owner, kindly gave me the use of the plans, so that I could make myself acquainted with the design, and he also explained to me the mode of treatment at the different stages.

Railey's Plant.—This is a combined stamping- and grinding-plant, but still quite different from any that has heretofore been erected in the colony. The machinery is driven by a Pelton water-wheel 6ft. in diameter and 18in. in breast, working under a head of water equal to 44ft., and is calculated, when driving the machinery at full speed, to make ninety revolutions per minute, which appears to me to be driven at too high a speed to give the greatest percentage of power. According to the experiments made with this wheel in California, the most efficient effect was obtained when the periphery of the bucket-line of the wheel was travelling at about half the velocity of the water. The velocity due to 44ft. head, taking fractions into account, is about 50ft. per second, and, the diameter of wheel being 6ft., the velocity of the periphery would be 25ft. per second if based on the experiments mentioned, or eighty revolutions per minute. This water-wheel is placed at the side of the Waitawheta Creek, at as low a level as can be got for floods not to interfere with its working. It is geared with bevel-wheels to a vertical shaft, about 60ft. in length, which in its turn is geared to a horizontal shaft with bevelled gearing, on which shaft pulleys are fixed for belts to work to drive the whole of the machinery.

In order to lift the water out of the Waitawheta Creek for the purpose of driving the machinery, Mr. Railey constructed a timber weir across Waitawheta Creek, which raises the level of the water 9ft. This weir is on a similar principle to the timber dams that are constructed in cañons in the mining districts of America. It is made of frames of squared timber of 12in. by 10in. and 12in. by 13in., set about 5ft. apart, and standing edgewise up the stream. The up-stream side has a slope of 1 to 1, and the uprights, which are three in number, are standing at right angles to this slope. The ends of the sloped beams, as well as the bottom of the upright pieces, are well stepped into the bed-rock. There are longitudinal beams bolted on the face of the frames about 3ft. apart, the ends of these beams being let into the rock on the sides of the creek; and on to these beams are spiked two thicknesses of 2in. planking, to make the dam or breast of the weir water-tight. There is no puddle or concrete used to make it watertight, but simply some loose stuff thrown in on the bottom end and at the side of the planking where it butts on to the rock.

At one side of this weir there is a sluice-gate constructed to regulate the flow of water into the flume which conveys it to the battery. The width of the weir on top is 130ft., and since its construction there has been as much as 4ft. deep of water flowing over this width, and the structure shows no signs of weakness. This is a cheaply-constructed weir where there is solid rock to be got in the bottom and sides, but it is not suitable when there is only a loosely-cemented gravel bottom and similar sides.

The stamping-battery consists of ten heads of stamps of the same description as that ordinarily used; but, instead of quicksilver and blanket-tables being used, the tailings are discharged through the gratings into a small chute, and are carried into a series of settling-vats. No attempt, so far, is made to save any of the metals. These settling-vats are twelve in number, each 6ft. by 5ft., and 3ft. deep, placed in two rows alongside each other, and have openings at the top which allow the muddy water to flow out of one into another until it has passed through eleven of these vats. By this means, the metals having a higher specific gravity than the slime, they are supposed to all settle in the vats. When one of the vats is full, the tailings are taken out of it on to a platform ready to be treated in the grinding- and amalgamating-pans. Having twelve of these vats, it always allows eleven of them to be used for settlers while the other is being cleaned out.

The tailings that were taken out of the settling-vat are now put into the grinding-pans,

which are four in number, in certain charges. These grinding-pans are a combination of the Spanish arastras and Wheeler's pans, and are similar in construction to those used by Mr. J. Brown, of Tararu, only the muller is differently constructed. The annexed plans of these pans and separators will enable any one to see the principle on which the ore is dealt with. There is a false bottom cast in one piece, and held to the bottom of the pan by bolts. The inside diameter of the pans at the bottom is 4ft. 2in. and at the top 4ft. 8in., and they are 18in. in depth. There are twelve cast-iron shoes of hæmatite iron, held to the bottom of the muller with one rivet in the centre, and cast-iron catches, which go into clutches in the bottom of the muller to keep each shoe in its place, and prevent it from swinging on the single rivet with which it is held. These shoes are placed about 1in. apart, and are also placed so that there is a space of about 4in. between them and the outside of the pan, and there is also the same space left between the outer edge of the false bottom and the outside of the pan, while the space between the inner edge of the false bottom and the inner side of the pan is filled up with wood, the space left on the outer side being for quicksilver. On the top of the muller three curved guides are placed to regulate the grinding of the tailings.

Before starting these pans they are first charged with quicksilver in the recess between the edge of the false bottom and the outside of the pan. The charge of tailings is then put in with water, and also a little salt and sulphate of copper, and a wooden cover is bolted on the top, after which the pans are set in motion. A jet of steam passes through the cover into the pan, and the temperature is maintained up to about 210°. After each pan has been working for about three-quarters of an hour more quicksilver is added, and the grinding continued, the pans being driven at sixty-five revolutions per minute, until the whole is in a pulp. The stuff is then run out of the pans from a cock at the bottom into small chutes, which carries the stuff into the separator. The pan is then charged as before and grinding continued, the principle being to grind each charge separate, and not to be continually grinding and continually running off the slimes.

There is a separator to each two grinding-pans. These separators are 6ft. 6in. in diameter and 2ft. 6in. in depth. The bottom and flange round the bottom are made of cast-iron, but the sides are made of wrought-iron plates. There is no grinding done in this pan. On the bottom of the muller there are fixed curved wooden slips, 2in. in depth. The muller, revolving at the rate of twelve revolutions per minute, with these curved wooden slips, causes a contracting influence to the centrifugal motion of the water, and tends to collect all the fine particles of quicksilver and amalgam which come from the grinding-pan. This process is carried on for some time with a plentiful supply of clean water, until the whole of the quicksilver is separated from the slime. A cock is then opened, and the slime run off into a chute and over a ripple-box before allowing the tailings to run to waste. The quicksilver and amalgam are then run off into bags and filtered, after which the amalgam is ready for retorting.

In erecting this plant there is provision made for erecting a dry crushing-plant for rich ores, which Mr. Railey contemplates doing as soon as the plant comes to hand. Mr. Railey states that he was for several years employed at a plant of this description in Mexico, and there the company guaranteed the owners of the ore 80 per cent. of the metals it contained by assay; and if he suceeeds in giving the same percentage on this field—which I question—he will have accomplished far more than has heretofore been done, and be the means of making many of the mines in this district remunerative for working.

The following process is described in a late copy of the *Mining and Scientific Press*, of California, which is almost similar to the plant that Mr. Railey has erected:—"The process of working gold- and silver-ores varies more or less with the character of the ore, but where they are free-milling and do not require roasting or previous preparation the process is very much the same all over the Coast. To those not familiar with the process of milling gold-ore or silver-ore the following brief description will be of interest: In gold-mills the ore coming from the mine is dumped upon the grizzly, where it is screened. That portion which is less than a two-inch cube passes into the ore-bin, from which it passes by gravity into the hoppers of the ore-feeders, and is fed automatically into the mortars as required. The size of the screen generally used on the mortar is a forty-mesh or a No. 9 to 10 slot-punched screen. The ore, after passing through the screen, falls directly upon the plates: if the ore contains free gold only, it is allowed to run to waste as tailings, but if the ore contains sulpherets it is conducted from the plates to concentrators, where the sulphurets are collected and taken out. The style of mortar generally used is of single discharge, with copper plate at the back, which can be removed for cleaning. Each mortar (five stamps) weighs about 5,000lb. The stamps weigh about 750lb. to 800lb. each, and are usually run at about ninety drops per minute. In silver-mills ore from the mine is dumped upon the grizzly, which screens that portion small enough to go into the mortars. The balance is passed through the crusher, which falls into the ore-bins, from which it passes by gravitation into the hoppers of the feeders, from whence it is fed automatically into the batteries. These mortars are generally single-discharge, and are provided with a forty-mesh steel-wire or brass screen, or a No. 9 or No. 10 slot-punched Russia-iron screen.

The ore from the batteries is conducted into settling-tanks, from which it is shovelled into the pans. Quicksilver is introduced (200lb. to the pan), and the process of amalgamation goes on. After remaining in the pans from five to eight hours (according to the character of the ore) it is drawn off into settlers, when by gentle agitation the amalgam and quicksilver is settled and drawn off into canvas straining-sacks, the amalgam remaining in the sack while the quicksilver passes to a tank, from which it is elevated to the pan-floor, to be used again in the same manner as before. The amalgam is taken from the sacks and placed in retorts, where, after being heated for from five to six hours, all the quicksilver it contains has been drawn off and condensed for use again. The retort is then allowed to cool, when it is opened and the silver taken out, which is in the form of a porous spongy mass, usually called by millmen crude bullion. This is broken up and placed in black-lead crucibles, and melted with borax and other fluxes to collect the impurities contained, and cast into ingots or 'bricks,' weighing about 1,200oz. troy. It is then ready for mar-

ket, being usually about 990 to 997 fine. If the ore contain gold it will be found in the brick with the silver.

This process, if proper care be taken in manipulation, will save 90 per cent. of the assay-value. Great care requires to be taken to keep the quicksilver in proper condition: it should be kept perfectly clean, in order to utilize its full amalgamating properties and prevent flouring. 'Flouring' is a term used by millmen, and signifies that quicksilver has segregated or divided itself into myriads of small particles, so fine that they may be held in suspension in almost still water. When quicksilver is in this condition great loss occurs, not only in quicksilver itself, but in silver, as each particle contains more or less. In mills where the greatest care and attention are bestowed the loss in quicksilver from various causes is considerable—generally from $\frac{3}{4}$lb. to 1lb. for every ton of ore crushed. This, however, has been reduced of late by allowing the tailings to run into one or more Duncan concentrators, or a machine equally as effective, when a large percentage of the quicksilver and amalgam escaping the settlers is caught, as well as the sulphurets, if any are contained in the ore."

From what I have seen of the ore in the Ohinemuri District, it is especially adapted for chloridizing, and either amalgamating or lixiviating. In amalgamation the bullion will contain both gold and silver, and also a portion of the base metals, which can afterwards be separated by refining; while by the lixiviation process the metals can be extracted separately. The experiments made by Mr. Skey at the Colonial Laboratory on some of the stone from Waihi show that even by roasting and amalgamating with cyanide of potassium about 9 to 10 per cent. of the gold is lost, and 40 per cent. of silver. If this loss is made in making an analysis, where every care is taken to get out as much as possible, when the operation has to be conducted on a large scale the loss will be almost certain to be greater; whereas, by the lixiviation process nearly the whole of the metals can be obtained. This question is attracting considerable attention at the present time in America, and able papers have been written on the subject in the *Mining and Engineering Journal*, of New York. From these, and also from private information of the mode of treatment in America, the following process would be suitable for the ores that have to be dealt with here:—

Crushing the Ore.—The ore, on being brought to the place of treatment, is put through a pulverizer, or stone-breaker, which reduces it to a maximum size of about 1½in. in diameter; afterward this is crushed dry with either steel rolls or stamps, so as to pass through a grating not finer than a hundred holes to the square inch. The coarser the crushed material is, consistent with the fineness of the metallic gold in the ore, the better—it is better adapted for the roasting process. Crushing with two sets of steel rolls, the same as those used by the Bertrand Company, in America, will be found to be far more economical than a stamping-battery, as the wear and tear is far less, and they do not require the same amount of power to drive them as a stamping-battery. There is no class of crushing-machinery that requires more power to work it than stamps, as they have always to be lifted from a state of repose; but with rolls, they are always in a state of momentum. The Bertrand Company, Nevada, finds that two sets of rolls can crush as much ore as a fifty-head stamping-battery.

Roasting Process.—The crushed material is now taken to a reverberatory furnace, which is constructed with three hearths, each from 10ft. to 12ft. square, with the corners cut off, so that the ore can be better handled in the furnace with rakes, slices, or hoes. The upper and lower hearths have each a man-hole on the top to charge them as required. The crushed material is put in on the upper hearth, and exposed to a gentle heat with an abundant excess of air. The sulphide takes fire and burns, and the metal and sulphur is thus oxidized with the abundance of oxygen from the air. This oxidized part of the sulphur goes off into the flues and up the chimney, while the remaining portion of the sulphur combines with portion of the oxidized metal, forming metal sulphate. The other portion of the metal, with the exception of silver, is formed into oxide; but the silver remains as a sulphate or becomes metallic, and gold remains in a metallic state. Antimony and arsenic are oxidized, and partly go off in fumes and partly combine with metal oxides, forming antimonates and arsenates. Silver is left either in a metallic state or in the form of sulphates, and the base metals are converted into either oxides or sulphates. When the charge is sufficiently oxidized on the upper hearth, it is raked down to the next, or middle hearth, where it is subjected to a greater heat, which causes some of the metal sulphates that were formed on the upper hearth to decompose: the sulphur oxide flies off, and the metal oxide remains, while a small portion of them is volatilized to some extent; but any lead-sulphate is not decomposed. Iron- and copper-sulphates are decomposed before silver, the latter requiring a greater amount of heat; the principle being to allow the stuff to remain on this hearth until all the iron- and copper-sulphates are decomposed.

Chloridizing Process.—The material is now raked down to the lower hearth and mixed with a certain proportion of salt, depending on the character and richness of the ore, varying from 1 to 20 per cent. of the weight of the ore. Some mix the salt with the ore before putting it into the furnace; but it is better and more economical to mix with salt in the last process by mixing it thoroughly with the ore in the furnace. During the whole of the roasting and chloridizing process the ore requires to be constantly stirred with slices and hoes, and only kept in thin layers on each hearth. As soon as one hearth is cleared a fresh charge is again made. The salt, being a compound of sodium with chlorine, is the cheapest method of producing chlorine. The chlorine of the salt, under the action of heat, is transferred to other metals by different agencies, but chiefly by means of sulphur and oxygen, for which sodium has a great affinity. When the metal sulphate is heated in conjunction with sodium chloride the sulphur and oxygen form sodium sulphate, and the other metals take the chlorine, forming chlorides. Sulphur is therefore necessary in the chloridizing process, as without it sulphates cannot exist. The higher sulphur-oxide or sulphuric anhydride produces a decomposition of the salt and the liberation of chlorine. The latter acts upon the remaining sulphides, and to a certain extent on oxides and metallic silver, converting them into chlorides. As the heat increases the base-metal chlorides are decomposed, giving off the chlorine remaining, or volatilizing as chlorides of a lower degree, or by absorbing oxygen from the air become oxychlorides or oxides. Silver-chloride is, however, not decomposed by heat. Some of the iron-

perchloride which forms in the early part of the roasting goes off into the flues, while another part, giving off chlorine, is reduced to a protochloride, and this again loses the remaining chlorine by absorbing oxygen from iron-peroxide, which remains in the ore. Copper-protochloride gives off half its chlorine and forms dichloride, and volatilizes to some extent. Lead-sulphate requires a greater heat to convert it into chloride than can be used to preserve the better metals, so that it remains almost wholly unchanged: the chloride gives off some chlorine, and, absorbing oxygen, becomes oxychloride. Zinc is partly volatilized, but the oxide is quite stable. Antimony and arsenic form volatile chlorides as well as oxides, which to a great extent go into the flues and partly up the chimney. Gold at a very low heat forms a chloride, which decomposes at a higher temperature, and remains in a metallic state.

Sifting the Ore.—When the ore is sufficiently chloridised, which takes about eight hours to go through the whole process of roasting and chloridizing, the charge is raked out of the lower hearth and allowed to cool; afterwards it is put through a revolving screen with about two thousand meshes to the square inch. Any grit that passes over the screen is crushed along with the other ore, and again put through the furnace, while the dust that passes through the screen is now ready to be taken to the amalgamator.

Amalgamation.—The ore is now ground up in Wheeler's pans with quicksilver and heated water, which can be done by a jet of steam passing into the water and condensing. When the first charge is sufficiently amalgamated a cock is opened on the side of the pan, which is placed above the level of the quicksilver and amalgam, and the slime is run off into a chute and carried away to settling-basins, where the sediment, when settled, is afterwards taken out, and if proved by assay to contain either gold or silver is again passed through another Wheeler's pan and amalgamated; but if there is only a very small percentage left in the sediment it is thrown into the waste-product heap. As soon as there is a certain amount of amalgam in the pan a cock is opened at the bottom, and the quicksilver is strained through a thick canvas bag, which is made in the shape of an inverted cone. The strained quicksilver is again put into the pan, and the same process repeated, while the amalgam is now ready for retorting.

Leaching or Lixiviation Process.—Mr. G. W. Bull, at Karaka Creek, Thames, has been experimenting on the leaching of silver- and gold-bearing ores, and as far as his experiments have been conducted he has been successful in obtaining excellent results at a low cost of treatment. He first tried it on a small scale, with a common American bucket for a vat; but has now made a vat with which he can test a ton of ore, and thinks the whole cost of crushing, roasting, chloridizing, and leaching will not exceed £2 per ton, and probably will not be more than £1 10s. per ton. If this process can be carried out for the cost that Mr. Bull anticipates, and is successful in obtaining at least 90 per cent. of the metals, there is a great future for this district.

The roasting and chloridizing process have to be gone through, the same as I have before described, but when the ore is taken out of the furnace and is cool it is put into a vat with a solution of hyposulphide of calcium, or, better still, hyposulphide of sodium, which dissolves the silver and leaves the gold still remaining in a metallic state. The ore is placed in a wooden vat, made of rectangular form, having the sides sloping outwards. There is a glass or leaden tube fixed through the bottom, on which is placed an india-rubber tube. Inside the bottom there are a few strips of wood laid across to support a perforated false bottom, on which a filter is laid. The filter consists of, first, a layer of coarse pebbles, and next a layer of smaller ones, and each successive layer is finer than the other, till on the top it forms a layer of sand. This filter is in all about 5in. in depth. On the top of the filter is placed a coarse bag or cloth so as to keep the filter intact each time the vat is cleaned out; but the cloth must be of coarse open material, to allow water to pass through readily.

The vat is then filled with the chloridized ore to a depth of from 20in. to 2ft., and the solution of hyposulphide of calcium is put through the india-rubber tube fixed on the glass or leaden pipe which passes outwards through the bottom. The india-rubber is bent up to such a height that the solution passes through the filter on the false bottom, and upwards through the material to be operated on until the whole of the material is thoroughly saturated It is then allowed to stand from five to eight hours, when all the silver will be dissolved. Afterwards water is put on top of the material in the vat, and the whole of the liquid is drained off into another vat, where the precipitating process takes place. The material in the vat is washed until the liquid shows no signs of silver being left. This is tested by using the precipitant for silver as the draining process is going on. When leaching of the silver is completed, the ore is removed from the vat and allowed to dry while a fresh charge is being manipulated and the same process gone through.

When the ore that was previously removed from the vat is sufficiently dry, it is again placed in the vat, and the chlorine-generator set at work. The gas is passed from the generator through a wash-bottle into the spaces between the false and main bottom of the vat. The lid which covers the top of the vat is now put on and made air-tight by having the joint luted with linseed-meal dough. There is a hole in the centre of the lid which is left open until the chlorine-gas has made its appearance on the surface of the ore. This can be easily ascertained by taking the cork out of an ammonia bottle, or dipping a glass rod in ammonia and holding it over the hole, when dense white fumes will arise if chlorine is present. As soon as its presence is detected the hole is closed up, and the ore is allowed to stand from thirty to forty hours in the vat to get properly chlorinated. Before removing the lid of the vat after the time allowed for chlorination the plug in the top of the cover should be taken out again, tested with a glass rod dipped in ammonia to see if chlorine is still present; if not, the chances are that a poor result will be obtained in leaching unless chlorination is repeated.

At this stage of the process the workmen employed have to be careful not to get suffocated with the chlorine gas. When the cover is taken off it will appear as a green vapour above the ore. They will have to retreat as fast as possible until this disappears. After the cover has been removed a stream of water should be admitted in the form of a fine spray. This is done by a revolving arm made of 1in. gas-pipe, with fine holes perforated on the side, which causes the arm of the pipe to

revolve when the water is turned on, distributing a fine spray of water all over the chlorinated material. The liquid from the vat is drained off into large earthenware tanks or jars, ready for precipitating the gold. The liquid is not allowed to run quickly out of the vat, but to keep draining off slowly. If the ore in the vat contains no copper and has been properly roasted the lixivium will be of an amber colour; a green hue indicates copper, and a dark, almost black, appearance is produced by iron-perchloride, showing that the ore has been improperly roasted.

Leaching is now carried on to a great extent in California, and whenever this treatment is adopted good results have been obtained. Some persons are under the impression if rich auriferous silver-ores in which the percentage of gold is high—almost equal to that of silver—are subjected to roasting and chloridizing, the impregnating with chlorine gas, and leaching with water to extract the gold, and finally leaching with the hyposulphite of lime for the purpose of extracting the silver, that not more than 50 per cent. of the gold can be obtained; but experience shows this to be a fallacy, for not only is there a high percentage of gold obtained, but also almost the whole of the silver can be extracted from the ore.

The general system adopted in California is as follows: The roasted ore is sifted through a coarse sieve to separate the lumps that have been formed in roasting, and also to separate any nails or pieces of iron that may have got mixed with the ore. The lumps in the roasted ore show generally that they have not been sufficiently roasted, and therefore they are laid on one side, and again put through the furnace. If any of the sulphate of iron is left in the ore (which occurs from imperfect roasting) it would precipitate the gold in the vat as soon as the water was turned on, and consequently would be entirely lost. After sifting the ore it is damped with a fine spray of water, just to be moist enough so that no dust will fly about. This is done for two reasons—the slightly-moist ore does not lie so close in the vats as it does being entirely dry, and the chlorine also acts far more vigorously on the moist ore; the great object being to get the ore in as porous a condition as possible. The vats where the ore is chlorinated is made circular. The bottom is made of planks 3in. thick, grooved and held together with tongues. The sides are made of 2in. planks or staves with plain joints, and bound together with iron hoops the same as a tub. There is a false bottom made of 1in. boards, with perforated holes about 1in. in diameter. This bottom is supported about 1in. above the main bottom with thin slips of wood; and on the top of the false bottom there is a filter-bed made of quartz pebbles in layers, every layer being finer than another, until on the top it is only coarse sand. This filter-bed is about 5in. in thickness, and on the top of the bed is spread old gunny-bags or loose porous cloth, to keep the ore separate from the sand on the top of the filter-bed. These bags are generally drawn up on the side for about 2in., and held in their place by a ring of moist ore gently pressed against the side of the vat. The size of these vats varies in different places from 6ft. to 20ft. in diameter, according to the amount of ore to be treated at the works. In some places a filter of pebbles is dispensed with, and only a couple or three layers of gunny-bags placed on the top of the false bottom. The vats used in chlorination works are coated inside and out with three coats of asphaltum varnish; but this is not required where there is only silver-ore to be operated on, or where the silver is first extracted from the ore by hyposulphite of lime, or hyposulphide of sodium, and the ore containing the gold is taken out of the vat and put through the amalgamation process. The ore is put into the vat to within about 3in. of the top, and the chlorine-generator set to work. The generators are in some instances glazed earthenware jars, and sometimes of lead, cylindrical in shape, about 22in. in diameter. They are placed either in a tub with water, into which a jet of steam is inserted to raise the temperature of the water in case the evolution of the chlorine is too slow, or they may rest in a pan containing water, under which a fire is placed to heat the water for the same purpose. When steam is not used, the pans are generally set in brickwork, having a stove-pipe to carry off the smoke. Where large vats are used four of these generators are set to work. Each generator is charged with 9lb. of black oxide of manganese and 11lb. of common salt. If they be made of earthenware there is one large opening in the top, and smaller ones for pipes to be inserted; but when the generator is made of lead the cover has two openings on the top. As soon as the salt and manganese are put in the cover is put on and luted with flour-dough to prevent any gas escaping. Sulphuric acid is now put in. Sixteen quarts of acid, 66° Beaume, are diluted with three quarts of water, and one-half of this solution is used for each generator. The acid is charged into a lead vessel above the generator, and by means of a faucet is allowed to pass slowly through a trapped lead pipe into same. Towards the end of the evolution the the gas is assisted by the water that is around the generators being made hot. In this way the chlorine is slowly evolved at about the same rate that it can be absorbed by the ore in the vat. When the gas leaves the generator, it is first passed through a wash-bottle for the purpose of holding back the small quantity of muriatic acid carried along with the chlorine, and it also indicates, by the more or less lively bubbling, the right degree of absorption and evolution of gas. From the wash-bottle the chlorine passes through a flexible tube, which at the other end is attached to a lead nipple under the false bottom of the vat. The generators can be set to work as soon as the vat is half filled with the ore; and when the chlorine gas rises within a couple of inches of the surface of the ore the cover is put on and luted with either flour or linseed-meal dough, and the space between the surface of the ore and the cover must be well filled with gas to insure good chlorination. Care has to be taken that no gas escapes round the cover, which can be easily detected by a glass rod dipped in ammonia. In six hours the gas generally comes to the top of the ore; but the gas continues to pass into the vat for about ten hours after this, when the generators are disconnected, cleared, and charged again ready for the next operation. The gas is now left in the ore for another twenty-four hours before the water is introduced to leach out the gold. When the liquid is all drawn off until no traces of gold can be got by testing the solution, the vat is charged with a solution of the hyposulphite of lime to dissolve the silver, the same as previously stated.

C. H. Aaron states: "If the ore contains lead-chloride it is treated with cold water until the greater part of the copper- and iron-chlorides and salt are removed. It is then treated with hot water

as long as any metal can be extracted, after which it may be necessary again to apply cold water to cool the ore before admitting the hyposulphide of calcium, so that too much base metal may not be extracted with the silver. Hot water, if applied at first, increases the solubility of the silver-chloride in the solution of base chlorides and salt; but after these are in the main removed by means of cold water, it may be used with advantage. If, however, it were immediately followed by the hypo., more base metal would be extracted than would be the case if the ore were cooled, for, as before remarked, there are base-metal compounds in the roasted ore which are insoluble in both hot and cold water, but which are soluble in the hypo., especially if it is warm. Lead-chloride is almost insoluble in cold water, but dissolves readily by the aid of heat. The sulphate is not dissolved by water, hot or cold. Hence it is better that lead should be chloridized in the roasting, because it can then be removed by washing. If lead is extracted in silver-leaching it cannot, like copper, be retained in *matte* when melting, but inevitably goes into the bullion, because its sulphide is easily reduced by iron at a red heat, while copper-sulphide is not."

Precipitation of Metals.

Silver.—The liquid containing the silver-solution that was drawn from the vat containing hyposulphide of calcium, is now in another vat ready for precipitation, which is effected by a strong solution of sulphide or polysulphide of calcium. It throws down silver and other metals as sulphides in the form of dark-brown or greyish-black mud, which soon turns black. At the same time it restores the hyposulphide of calcium which was altered in dissolving metals, so that it can be used again. The greatest care has to be exercised not to use more of the calcium-sulphide than is necessary to precipitate the metals, because if too much be used the excess remains unchanged, and, being mixed with the leaching solution for re-use, it converts some of the silver-chloride in the ore into sulphide, which cannot be leached out.

In precipitating the silver the solution containing the silver should be quickly stirred before the calcium-sulphide is poured in. The calcium is then allowed to run in as long as it is seen to cause a distinct precipitation. The solution is then stirred vigorously for a few minutes with a circular motion, and afterwards the motion reversed and a short time allowed for partial settling. A sample is then taken out in a glass, and a little more calcium-sulphide added. If a considerable precipitant is produced more calcium-sulphide is added to the solution, and the same stirring and testing repeated. When the calcium only produces a slight precipitation the solution is left in the vat undisturbed for a few hours.

If in the test calcium-sulphide produces no precipitate, too much may have been used; therefore another sample is tested by adding a few drops of sulphate-of-iron solution, which instantly gives a black precipitate if there is the least excess of calcium-sulphide. If neither of these tests gives a precipitate the quantity of the precipitant is right; but if it is found that an excess of calcium-sulphide has been used, it must be counteracted by an addition of silver-solution, or some sulphate of iron may be used instead. However, experience shows that as soon as enough calcium-sulphide has been added a white cloudiness appears in the silver-solution. After the solution has stood for a few hours the liquid is siphoned off, and the silver-sulphide, along with any base-metal sulphides, is removed, and washed with hot water, and dried.

The dried precipitate is then roasted in a reverberatory furnace to burn off the sulphur, beginning with a sufficient heat to set the sulphur on fire, and gradually increasing this temperature to such a degree that the metal will stand without melting. During this roasting process it must be continually stirred and kept in as long as any trace of sulphur remains. Afterwards it is taken out and is ready for melting.

Mr. C. H. Aaron describes the process of melting the silver which is usually adopted in America, as follows: "This is done in black-lead crucibles in a wind-furnace, with coke or charcoal for fuel. If the precipitate, before roasting, contained but little base-metal sulphide, the silver is seen in form of threads traversing the roasted mass, which, however, still contains a considerable quantity of sulphur. The crucible, containing some scrap-iron, is filled and placed on the fire, standing on a piece of brickwork; for, as the melting occupies a considerable time, even a thick layer of the best coke does not last long enough to prevent the crucible from settling down to the grate. A little borax is added, and the whole is heated until there is no room in the pot for more material, when it is refilled by means of a scoop and funnel. As in the case of the gold, the refilling is done before the mass in the crucible has become fluid, in order to avoid loss by projection. As fast as the scrap-iron disappears more is put in; but if such addition is made after the full fusion, the iron is first heated.

If the roasted precipitate contains much copper or iron more borax is required, and a little clean sand is useful, especially if the roasting has been excessive. Some charcoal is also added. When the pot is full of thoroughly melted matter and pieces of iron, a test is made by placing the red-hot end of an iron rod in it. If, after a few minutes, on withdrawing the rod, it is found that part of it is melted, more time must be allowed. When iron is no longer consumed, the melting of that quantity of precipitate is finished, and slag and *matte* are dipped out by means of a red-hot assay-crucible, held with crooked tongs, and poured into a mould or iron pan. The pot is now again filled with roasted precipitate, taking the precaution to add it slowly, until the melted mass is somewhat chilled. When all the precipitate has been worked up, or the pot contains a sufficient quantity of metal, a part of the slag and *matte* is removed as before, and the remainder is poured into a warmed and greased mould. The overflowing of the slag and *matte* is of no consequence if the mould is large enough to contain the silver, which will go to the bottom, in consequence of its greater specific gravity.

After removal from the mould it is usual to place the bar in a tub of water for the purpose of cooling it; but when there is *matte* upon it this must not be done until the *matte* also has solidified, otherwise an explosion will occur. If the melting has been properly conducted the *matte*

is brittle, and separates readily from the cooled bar. If it is tough, that which adheres to the metal must be beaten off, and the whole remelted in presence of iron, as it contains a great deal of silver. After cooling it is broken and examined for any large buttons of silver which may have been dipped out with it. All *matte* and slag are preserved, the latter to be sold, and the former to be crushed and reworked by roasting and leaching. If a handsome bar is desired, it must be remelted with borax, cleaned by skimming, and recast, covering the surface with powdered charcoal before solidification.

Gold.– The solution containing the gold is operated on by using the sulphate of iron as a precipitant. The best way is to put the solution of sulphate of iron into the jar before the gold-solution, especially if wooden tubs or vats are used, so as to decompose the gold, and precipitate it as soon as it enters the tub, as that lessens the loss of absorption into the wood. The solution of gold and precipitate should be well stirred, and then allowed to settle for a few minutes, when a sample can be taken out in a glass and tested by adding more sulphate of iron. If any discoloration is produced, more of the precipitant is required. It is always best to add enough sulphate of iron, as an excess does no harm. The gold settles better if stirring is repeated after an hour or two. In stirring it a circular motion is imparted to the liquid, nearly all the gold will settle near the middle of the tub or jar. It is advantageous to add a little sulphuric acid. The gold requires from twenty-four to forty-eight hours to settle. The solution is then siphoned off, and the gold, which appears as brown mud, is then collected, pressed, and washed, dried, and melted.

Calcium-sulphide.—This is made by boiling lime and sulphur together in water. This may be done in an iron pot over a fire, with frequent stirring. As soon as the water is hot fresh-slaked lime is mixed with it, and flowers of sulphur added by rubbing through a sieve. Two or three hours' boiling suffices. The proportions of lime and sulphur vary with the quality of the lime. Abou 1½lb. average lime is required for 1lb. sulphur; 75lb. lime, 50lb. sulphur, and 120 gallons of wate will produce a solution of suitable strength to precipitate from 25lb. to 50lb. silver, according to the quantity of base metal in the lixivium. In boiling the lime and sulphur over a fire, the quantity of water that evaporates will have to be replaced. The proper strength of the solution is indicated by a density of about 10° Beaume. If below 6° it will dilute the hyposulphide too much when used for precipitation.

Calcium-hyposulphide.—This is made by passing air and fumes from burning sulphur, or from sulphuric acid and charcoal heated in a retort, through a solution of calcium-sulphide until the latter is colourless. C. H. Aaron, in his work on leaching, advises that it is better to procure sodium-hyposulphide in crystals to begin leaching with. In use with calcium-sulphide as the precipitant the sodium-hyposulphide soon disappears, being replaced by calcium-hyposulphide through the chemical reactions which take place. The strength of the solution to be used in leaching depends on the composition of the ore. If this contain but little base metal the solution may be quite strong, and even used warm. But in general a strong solution would extract too much base metal. It may be made by dissolving 2lb. sodium-hyposulphide crystals in each cubic foot of water, or about 26¼lb. to 100 gallons. If it is then found to dissolve too much base metal—which may be ascertained by an examination or an assay of some of the precipitate—the strength is reduced by the addition of water. After it has been used the density cannot be relied on, as it then contains other substances besides hyposulphide. A good guide is the taste, which should be very sweet during the first stage of leaching if the ore contains much silver. The solvent power of the solution may at any time be tested thus: Dissolve 5¼gr. of silver in nitric acid. Precipitate with hydrochloric acid. Wash the precipitate three or four times with water to remove any trace of the acid. One fluid-ounce of the leaching-solution should dissolve the whole of the silver-chloride.

Production of Chlorine.—C. H. Aaron gives the quantities to produce chlorine to operate on from three to four tons of roasted ore as follows: Manganese, 30lb.; salt, 40lb.; water, 36lb.; sulphuric acid, 66° Beaume, 70lb.

Assays of Ore from Tui Creek and Waihi District.

Mr. J. Adams, manager of Messrs. Firth and Clarke's battery at Waiorongomai, who recently paid a visit to California to see the different processes connected with the extraction of gold- and silver-ores, took several samples of stone from the Tui and Waihi district to get treated there. The following are the results of the assays made and the manner of treatment, which will be interesting to those engaged in treating ore of a similar character:—

Tui Company.—Chemical Laboratory, Assay Offices, Bullion-rooms and Ore-floors, 524, Sacramento Street, San Francisco; 22nd October, 1886.—Report of working-tests of ore marked "Tui," for the Tui Company.—The ore is composed of quartz gangue, containing 2 per cent. of pyrites and a little galena. By amalgamation in the battery and on copper plates the ore will not give up any of the precious metals contained. Moreover, the ore does not concentrate to advantage, the general average of the ores being nearly as high as the concentrates. Pan-amalgamation before roasting, with the simple addition of 20lb. of salt, 10lb. of sulphate of copper, 10lb. of sulphate of iron, and 5lb. of alum per 2,000lb. of ore, effect a saving of $76 14c. per ton, which is, say, a little over 53 per cent. of the total value ($143 10c.). Pan-amalgamation, after roasting with salt, and the addition of 10lb. of sulphate of iron and 5lb. of alum per 2,000lb. of ore, effected a saving of $119 5c. per ton of ore, which is 83 per cent. of the total value ($143 10c.). The proper process by which to treat such ore is to crush dry in a stamp-mill, roast with salt in a self-acting revolving furnace, or in a reverberatory furnace, and then amalgate in pan, with the addition of chemicals in the proportion described above. The ore can also be smelted with rich lead-ores. Assay of ore as received: Gold per ton 2·2oz., gold-value $45 48c.; silver per ton 75·5oz., silver-value $97 62c. Saved by amalgamation in battery and on plates: Gold, traces; silver 4·5oz., value $5 82c. Saved by pan-amalgamation with chemicals, without roasting: Gold 1·15oz., value $23 77c.; silver 40·5oz., value $52 37c. Saved by pan-amalgamation, after roasting with salt and addition of chemicals: Gold 1·85oz., value $38 24c.; silver 62·5oz., value $80 81c.

Nevada Metallurgical Works, San Francisco; 7th October, 1886.—Lot No. 3,602, one sack marked "Tui."—The average pulp-sample showed an assay-value of—gold, 1·63oz., $33 91c. per ton; silver, 61·97oz., $80 13c. per ton: total, $114 4c. per ton of 2,000lb. The ore contains 0·2 per cent. of sulphurets (4lb. in a ton). 30lb. of the pulp was worked by common pan-mill process—*i.e.*, four hours' hot amalgamation with ¼ of 1 per cent. of sulphate of copper, and 1 per cent. of salt—and the yield was 283gr. bullion, which was 023·2 fine in gold, 837 fine in silver. This yield represents a yield of gold $18 83c. per ton, equal to 55½ per cent. of assay; silver, $42 53c. per ton, equal to 53 per cent. of assay: total yield per ton was $61 36c. To prove this working the tailings were saved, dried, and sampled; and assayed—gold 0·72oz., $15 7c. per ton; silver, 29·16oz., $37 10c. per ton: total value of tailings, $52 77c. per ton. Concentrating the tailings is out of the question.

The Rosemont.—Nevada Metallurgical Works, San Francisco; 10th October, 1886.—Lot No. 3,608, portion of lot marked "R," two sacks.—The average pulp showed an assay-value of—gold, 0·72oz., $15 7c. per ton; silver, 10·63oz., $14 14c. per ton: total, $29 21c. per ton of 2,000lb. The ore contains 0·25 per cent. of sulphurets (or, 5lb. of pure sulphurets are in a ton). 30lb. of the pulp were worked by pan process—*i.e.*, ground for one half-hour in the pan and then amalgamated hot for four hours—and the yield was 99·09gr. of bullion, 035·7 fine in gold, 531 fine in silver. This represents a yield of—gold, $10 14c. per ton, equal to a yield of 67·2 per cent. of the assay-value of the ore; silver, $9 47c. per ton, equal to a yield of 66·9 value of the ore. The total yield per ton was $19 60c. The tailings were saved, dried, and sampled, and showed an assay-value of gold 0·24oz., $5 2c. per ton: total value of tailings, $9 73c. per ton. These tailings were concentrated, and we obtained 4·32oz. of concentrations; therefore a ton of tailings would yield us 18lb. of such concentrations. These showed an assay-value of—gold, 4·98oz., $103 per ton; silver, 30·38oz., $39 28c. per ton: total value of concentrations, $142 28c. per ton. When we sum up we get from a ton of ore—(1) by free milling, at the rate of $19 63c. per ton; (2) by concentrating the tailings we get 18lb. concentrations from a ton, which have an assay-value of $1 28c.: total saving was $20 89c. per ton.

Chemical Laboratory, Assay Offices, Bullion-rooms and Ore-floors, San Francisco; 22nd October, 1886.—Report of working-tests of sample of ore marked "R," for the Rosemont Company.—This sample is an auriferous silver-ore, and does not yield sufficient gold and silver by amalgamation in the battery and on the copper plates to render it advantageous to employ this process. The best result from working this ore was obtained by subjecting the ore to a chloridizing roasting, and then amalgamating in iron pans with the addition of 5lb. of sulphate of copper, 5lb. of sulphate of iron, and 5lb. of alum, per 2,000lb. of ore. By this process I effected a saving of $32 56c. out of the total value of $39 94c., which amounts to a saving of a little over 81·8 per cent. of the total value. An additional saving of 2·5 per cent. was effected by a concentration of the tailings from the pan-amalgamation. These concentrates can be worked over by admixture with the original ore. The above is the only satisfactory process for the treatment of the ore. Assay of ore as received: Gold per ton 1·1oz., gold-value per ton $22 74c.; silver per ton 13·3oz., silver-value per ton $17 20c. Saved by amalgamation in battery and on plates: Gold 0·206 oz., value $4 26c.; silver 3·33oz., value $4 31c. Assay of concentrates (3 per cent.): Gold, ·810oz., value $16 54c.; silver 15·6oz., value $20 17c. Saved by pan-amalgamation, with chloridized roasting and addition of chemicals: Gold 0·910oz., value $18 60c.; silver 18·10oz., value $13 96c.

The Union.—Chemical Laboratory, Assay Offices, Bullion-rooms, and Ore-floors, 542, Sacramento Street, San Francisco; 22nd October, 1886.—Report of working-tests of sample of ore marked "T.M.," for the Union Company.—This sample consists of free gold disseminated through an auriferous silver-ore. Amalgamation on copper plates and in battery yields $88 26c. in gold, out of a total value of $159 17c., or nearly 55·5 per cent. of the entire gold contained in the ore, in addition to $2 13c. in silver, which is a little over 3·8 per cent. of the entire silver contained ($55 85c.). The percentage of gold saved is much larger than the saving of silver, and represents the gold existing in the ore in a free state. In addition to this there are 2 per cent. of concentrates, having an assay-value of $189 72c., which amounts to $3 71c. per ton of original ore. However, we still have the tailings, containing $122 77c. per ton. Pan-amalgamation, after a chloridizing roasting with 10lb. of salt, and the addition of 10lb. of sulphate of copper and 5lb. of sulphate of iron, and 5lb. of alum, per ton of ore, gave $171 90c. out of a total of $215 2c., which is a saving of nearly 80 per cent. of the whole. A concentration of tailings from the pan gave a still further saving of 5 per cent. of the precious metals, the concentrates so obtained assaying $189 72c., and being in such a form as to be available for treatment by mixing with the original ore. There are two methods by which this ore can be treated:—

(1.) Crush in the ordinary stamp-mill, saving the free gold by copper plates and pan-amalgamation. Collect the tailings, dry the same, and treat in iron pans with the addition of chemicals as described above. By this method the free gold is extracted at once, and fully 5 per cent. more can be saved by this process than by pan-amalgamation preceded by chloridation roasting. The disadvantage of this process will be the expense of drying the tailings.

(2.) Crush the ore dry and subject it to a chloridation roasting, and then amalgamate in iron pans with the addition of chemicals as previously described. This second process is probably the most economical, and for this reason this process is to be recommended over the first.

(3.) The ore can be smelted in blast-furnaces by admixture with lead-ores. By this process about 85 per cent. of the precious metals contained in the ore will be saved. Assay of ore as received: Gold per ton 7·7oz., gold-value per ton $159 17c.; silver per ton 43·2oz., silver-value per ton $55 85c. Saved by amalgamation in battery and on copper plates: Gold, 4·27oz., value $88 26c.; silver, 2·13oz., value $2 75c. Assay of concentrations (2 per cent.): Gold, 5·2oz., value $107 49c.; silver, 63·6oz., value $82 23c. Saved by chloridation roasting and amalgamation with chemicals: Gold, 6·25oz., value $129 20c.; silver, 33·1oz., value $42 79c.

General Remarks.—Messrs. C. A. Luckhardt and Co., of the Nevada Metallurgical Works, report:—Lot No. 3,616: The two lots of ore marked "Tui" and "T.M.," which were worked by free mill process No. 3,602 and No. 3,603, being so near alike in character, with the exception of their respective gold-values, were worked together by roasting and amalgamation as follows. The method employed as described will work the same on one as on the other. The ore "Tui" assayed—gold, 1·63oz., $33 91c. per ton; silver, 61·97oz., $80 13c. per ton: total, $114 4c. per ton, containing 0·2 per cent. of pyrites. The ore "T.M." assayed—gold, 8·26oz., $170 82c. per ton; silver, 63·19oz., $81 70c. per ton: total, $252 52c. per ton, containing 0·29 per cent. of pyrites. There were 27lb. of "Tui" and 37lb. of "T.M." mixed, and since the percentage of sulphurets in the ore was not adequate to chloridize the amount of silver, the ore was mixed with 3 per cent. of pyrites of iron (common sulphurets) and roasted, first, without salt on account of the gold, and after nearly all the sulphur was expelled 5 per cent. of salt was added, and chloridizing roasting was completed. The ore gained in weight 0·78 per cent. after roasting (we drew 64·5lb.), and this roasted ore showed an assay value of—gold, 5·2oz., $107 60c. per ton; silver, 60·76oz., $73 56c. per ton: total, $186 16c. per ton of 2,000lb.; and upon analysis 913·10 per cent. of the silver had been converted into chloride. This roasted ore was now amalgamated hot for four hours, and we obtained 2·2oz. of bullion, which was 066·1 fine in gold-value, $3·006, and 798 fine in silver-value, $2·2699. This shows that we had amalgamated 86·6 per cent. of the gold and 89·6 per cent. of the silver from the roasted ore, which is an excellent yield considering the high percentage of gold. Now, when we calculate this yield on the original ore, inclusive of the loss sustained in roasting, we have a yield of—gold, $93 93c. per ton of 2,000lb.; silver, $70 93c. per ton of 2,000lb.: making a total output by actual bullion yield of $164 86c. per ton. In other words, 83·08 per cent. of the gold and 87·5 per cent. of the silver contained in the original ore were saved. The tailings were saved and sampled, showing an assay-value of—gold, 0·6oz. $12 56c. per ton; silver, 6·07oz., $7 85c. per ton: total value of tailings, $20 31c. per ton. To recapitulate, we have from the ore, which had an assay-value of $194 9c. per ton—

1st, saved in bullion at the rate of $164 86c. per ton;
2nd, lost on roasting at the rate of $6 46c. per ton ($4 61c. in gold and $1 85c. in silver);
3rd, left in tailings at the rate of $20 31c. per ton. Total, $191 63c. per ton.

The deficiency of $2 46c. per ton apparent from $194 9c. per ton absolute value is pardonable in the manipulation, also owing to the high gold-value, owing to coarse gold in the ore, which prevents obtaining true average samples for assay. P.S.—With these ores you will have to pay some attention to the roasting, by not giving too high a heat in the first stage of roasting—*i.e.*, until nearly all the sulphur has been expelled—when you can raise it, and then only add the salt; otherwise you will sustain a loss in gold. Actual working on a larger scale will yield better results than we have herein obtained.

Extract from Luckhardt's General Report.—The ores "Tui" and "T.M." will not work raw (see Nos. 3,602 and 3,603), although "F.M." (see No. 3,608) yielded raw about 60 per cent. of its value, with bullion 841 fine: they are roasting-ores and fit for amalgamation, and not roasting and lixiviation, as might suggest itself to you. The bullion will range from 760 to 800 by amalgamation, and the yield will vary from 85 to 87 per cent. of assay-values. Trial 3,616 shows high tailings, and an apparent large loss in roasting the ores. You will find in practice that these figures will be much lower if you work steadily. We drew the ore a trifle too early from the furnace. That addition of sulphurets to this ore, "Tui" and "T.M.," is necessary whenever their percentage goes below 3 per cent. in the ore, which is easily ascertained by washing a small sample in a horn or pan. I would state here that if you work the ores marked "R" by raw or free milling, and concentrate, throw these concentrations together with these "Tui" and "F.M." ores, but do not exceed 6 per cent. sulphurets—it does not require it—that is, before roasting them mix these concentrates in: they work well owing to the copper they contain. These ores work better when crushed to 40-mesh screen than if you crush finer. I mean the ores of "R," "T. M.," and "Tui." They are apt to cinder if they are so very fine. Never grind in amalgamating. To conclude, let me state that you will find no difficulties in the beneficiation of any of these ores. The few points herein reiterated are simple to carry out. Whenever any ores carry over 2½ per cent. of lead, throw them with your concentrating- and smelting-ores. Do not try to roast and amalgamate them.

TABLE showing the RESULT of QUARTZ treated by C. A. LUCKHARDT and Co., San Francisco, from Claims at Waihi, Karangahake, and Te Aroha.

Company.	Lot No.	Assay-value per Ton of 2,000lb.			Yield per Ton, Ordinary Mill Process.			Yield per Ton, Grinding, Roasting, and Chloridizing.			Yield per Ton, Concentrating.			Total Yield.		Grand Total.	Remarks.
		Gold.	Silver.	Total.	Gold.	Silver.	Total.	Gold.	Silver.	Total.	Gold.	Silver.	Total.	Gold.	Silver.		
Galena	3610	$2·09	$2·04	$ 4·13	..	..	..	..	..	..	$1·63	$1·28	$2·91	..	..	$2·91	Concentrations, 6·13 tons to 1 ton.
		0·09oz.	1·57oz.								77·9p.c.	62·7p.c.	70·46p.c.			70·46p.c.	
	3611	$4·08	$3·14	7·22	..	..	..	..	..	..	$3·81	$2·08	$5·89	..	..	$5·89	" 5·26 " "
		0·19oz.	2·43oz.								79·3p.c.	66⅔p.c.	81·58p.c.			81·58p.c.	
	3612	$5·03	$7·85	12·88	..	..	..	..	..	..	$3·91	$5·02	$8·93	..	..	$8·93	" 5 " "
		0·24oz.	6·07oz.								77·4p.c.	64p.c.	69·⅓p.c.			69⅓p.c.	
	3601	$2·09	$2·04	4·13	$1·10	$0·30	$1·40	..	..	..	*	*	*	..	..	$1·40	Tailings assayed $2·72 per ton.
		0·09oz.	1·57oz.		52p.c.	15·5p.c.	33·9p.c.									33·9p.c.	
	3620	$4·08	$3·14	7·22	..	..	..	..	..	..	$3·55	$1·82	$5·38	..	..	$5·38	Concentrations, 5·26 tons to 1 ton.
		0·19oz.	2·43oz.								87p.c.	57·96p.c.	74·51p.c.			74·51p.c.	Loss in roasting, $0·35 per ton.
New Find	3607	$22·60	$28·28	50·88	$7·50	$7·83	$15·33	†	†	†	..	..	$17·47	..	..	$32·80	Concentrations, 1 ton to 260lb.
		1·09oz.	21·87oz.		33·1p.c.	27p.c.	30·13p.c.									64·46p.c.	Quicksilver loss, 3lb. per ton of ore.
	3617	$22·60	$28·28	50·88	..	..	..	$19·80	$21·30	$41·10	..	..	..	..	..	$41·10	Loss in roasting, $4·48 per ton.
		1·09oz.	21·87oz.					87·6p.c.	75·3p.c.	80·77p.c.						80·77p.c.	Tailings assayed $5·21 per ton.
	3613	$22·60	$28·28	50·88	..	..	..	..	..	..	$11·25	$15·83	$27·08	..	..	$27·08	
		1·09oz.	21·87oz.								49·7p.c.	58p.c.	53·22p.c.			53·22p.c.	
Tui	3602	$33·91	$80·13	114·04	$18·83‡	$42·53‡	$61·36‡	..	..	..	..	..	..	..	..	$61·36	Tailings assayed $52·77 per ton.
		1·63oz.	61·97oz.		55·5p.c.	53p.c.	53·8p.c.									53·8p.c.	
Union	3603	$170·82	$81·70	252·52	$98·81‡	$50·39‡	$149·20‡	..	..	..	..	..	$16·58	$110·37	$55·41	$165·78	Concentrations, 1 ton to 40lb. Tail-
		8·26oz.	63·19oz.		57·8p.c.	61·6p.c.	59·8p.c.						6·56p.c.	64·61p.c.	67·82p.c.	65·65p.c.	ings assayed $20·31 per ton.
Tui and Union (together)	3616	..	..	194·09	..	..	..	$93·93§	$70·93§	$164·86§	$11·56	$5·02	..	..	..	$164·86	Loss in roasting, $6·46 per ton.
								83·08p.c.	87·5p.c.	84·94p.c.	15·8p.c.	16p.c.				84·94p.c.	Left in tailings, $20·31 per ton.
Rosemont	3608	$15·07	$14·14	29·21	$10·14‡	$9·47‡	$19·61‡	..	..	..	..	..	$1·28	..	..	$20·89	Concentrations, 1 ton to 18lb.
		0·72oz.	10·93oz.		67·2p.c.	66·9p.c.	67·13p.c.						4·38p.c.			71·51p.c.	

* Roasted and smelted.
† Sulphur, 3 per cent. Last stages, 0·25 per cent. of lime added after nearly all the sulphur was expelled.
‡ Pan process.
§ Pyrites of iron, 3 per cent.; salt, 5 per cent.

The *Mining and Scientific Press*, of California, gives some very useful and interesting information regarding the cost and success of the lixiviation process at Lake Valley, New Mexico, of which the following is an abstract: "The successful treatment of these ores has always constituted one of the most difficult metallurgical problems ever met. Smelting, raw milling, and concentration have each in their turn failed to give satisfactory results; and it has remained for the leaching process alone to meet the requirements of economy and high percentage of extraction." This company's property is under the management of Dr. F. M. Endlish, a gentleman whose name is familiar as a chemist and mineralogist; and the process that he adopts for the treatment of the ore is that known as Russell's process. The unusual difficulties presented by the Lake Valley ores called for mechanical and chemical treatment of an almost extraordinary character, and the present mill-extraction of 87 per cent. has been reached only after numerous changes and the treatment of over a thousand tons of ore. The rate of increase in the percentage is now about 1 per cent. for each hundred tons treated, and in the treatment of the next 500 tons will probably reach 92 per cent., although the ore is crushed through a 16-screen and chloridized with only 7 per cent. of salt. The mill is probably the most automatically arranged of any so far constructed. With the exception of a small amount of flue-dust there is no handling of the ore from the time it enters the Blake crusher until it appears on the cooling-floor. By a contrivance of Dr. Endlish even the flue-dust from the dust-chambers of the chloridizing-furnace is delivered at the lower end of the furnace mixed with the coarse hot ore. From the cooling-floor the chloridized ore is conveyed by three elevators, starting from three different points under the cooling-floor, to the bins over the ore-tubs, each holding twenty tons. The apparatus of the leaching-department consists of six ore-tubs, each 12ft. in diameter and 5ft. deep; five precipitating-tanks, each 9ft. in diameter and 9ft. deep, and three storage-tanks of the same size; also a Johnson 15in. filter-press, and a small Knowles's pump for handling the solution. Each ore-tub is also provided with an Allen lead-lined siphon-pump. These are on the ejector principle, and serve to maintain a constant vacuum underneath the filters, and so increase the speed of leaching, and also deliver the solution at any desired point. The ore-tubs are loaded to a depth of 4½ft., which is equal to twenty tons for each tub, or 120 tons in all. By means of the bins the loading of 120 tons can be accomplished in three and a half hours. The total cost of treating the ore by the new leaching-process after it leaves the cooling-floor is 74c. (3s. 1d.) per ton for chemicals, and from 25c. to 40c. (1s. 0½d. to 1s. 8d.) per ton for labour; the last item varying according as the number of tons treated per day. The total cost of treatment, including crushing, roasting, and leaching, is $5 (£1 0s. 8d.) per ton.

Climo and Bawden Machine.

This machine was only in course of construction when I was at the Thames, and therefore nothing was known as to its capabilities. The patentees have high expectations concerning it, and in order to enable me to give a description of it they handed me plans showing the design.

The machine is a circular trough 9ft. in diameter, having a cone in the centre. The top of the cone is provided with a bush or bearings, which support a vertical shaft, while the sides of the cone have openings for the discharge of the slimes. It is similar to Railey's pans, only it is twice the diameter. The bottom, and flange round the bottom-side, are cast-iron, to which is bolted or riveted wrought-iron sides, which stand 2ft. high. The width of the trough in the bottom is 2ft., having false bottoms occupying a space of 1ft. 4in. in the centre. The false bottom fastened on in twenty-four sections, with dovetailed joints, which leaves a space of about 4in. on the outer and inner sides of the false bottom as a receptacle for quicksilver. The driver is a conical piece of cast-iron, made in two pieces corresponding to the shape of the inner cone of the pan, terminating at the bottom in a flat circular ring corresponding to the false bottom in the pan. This ring is provided with holes for the purpose of fastening and carrying the grinding-shoes. Before the grinding-shoes are put on there is a false shoe with a joint at the inner side, to which is attached a rod of iron, and which is screwed for, say, 6in. long on the upper end to allow for a nut on the under side of each flange. The end of the rod passes through a flange which projects on the side of the driver, and between the lower side of this flange and the bottom nut a strong spiral spring is placed. Underneath these false shoes the grinding-shoes are placed, and fastened together by means of dovetail catches and bolts which come up through the circular ring on the bottom of the driver; only the false shoes have a certain play between them and the circular ring of the driver to allow them to move up and down by the pressure of the spiral spring. On the top of the circular flat ring of the driver there are several guides fixed to cause the pulp to travel from the outer to the inner side of the trough, and bring the stuff underneath the grinding-surface, and on the side of the cone of the driver there are eight openings to allow the pulp to get through and down to the grinding-surface, so that the appearance of the driver is like a part of a cone with eight arms.

The grinding-shoes are twenty-four in number, and are placed about 1in. apart, so that with having a spring attached to each of them they have a uniform pressure on the false bottom, and grind independently of each other. On the top of the driver there is a strong boss, flanged and bolted to the driver, and this boss has a flat-threaded screw cut to form a nut.

The vertical shaft coming up through the central cone has a corresponding flat screw cut for some distance on the upper end to fit the screw in the boss on the top of the driver; the shaft and boss having also a keyway cut, so that when the driver is sufficiently low down a key is put in, and grinding commenced. It is not intended to grind up the quicksilver, but merely to have it in the circular well on the outer and inner sides of the trough.

The patentees intend to use an electric current among the quicksilver by having the negative pole in the quicksilver-well and the positive one in the water covering the quicksilver, for the purpose of keeping the mercury from "sickening;" but chemical amalgamation will be first used as a trial.

The machine may be termed a combination of the Spanish arastra and Wheeler's pan, on a large scale; and Messrs. Climo and Bawden, the patentees, claim that they will produce perfect amalgamation by bringing the pulp in contact with the mercury on leaving the grinding-surfaces, and a constant circuit of the pulp from the outer to the inner side of the trough. They also contend the centrifugal motion tends always to keep the heavier particles to the outer side of the trough; so that, with the addition of clean water mixed with the pulp, nothing but the light and worthless material will pass through the openings in the cone.

To examine this machine closely it will be seen that it has great grinding-power, but it is only suitable for tailings or coarse crushed material. It will, however, reduce the sand to the finest slime; but I fear that the patentees' expectations regarding the amalgamating qualities will not be realized. It is intended to save both silver and gold, but any process of crushing the ore containing sulphide of silver will necessarily carry away a large proportion of silver along with the water. However, it is a very ingenious machine, and the patentees deserve credit for turning their attention towards devising a different mode of treatment from that which is now adopted, as by the present process the loss of silver and gold is very great, and any machine that will give a higher percentage of these metals is a step in the right direction. Annexed is a plan of this machine and sectional elevation, which will enable a better idea to be obtained of its capabilities than can be formed by a mere written description.

Frue's Concentrator.

There is a company which has taken up some of the Foreshore at the Thames, and is concentrating the tailings with one of Frue's concentrators, which is giving very satisfactory results. This machine has been described in my report on the Australian goldfields; but, seeing that it is now in use in the colony and working satisfactorily, a further description may not be out of place.

The frame of the machine is 12ft. long, and in that length it has a slope or fall of 16in. towards the end where the sand is carried away. It has two principal rollers at each end, which carry the endless belt where the material is concentrated. These rollers are made of galvanized iron riveted together, 13in. in diameter and 51in. in length. A larger roller, 24in. in diameter, is placed midway 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 material 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 and uniform surface. The belt is made of vulcanized india-rubber and A1 three-ply navy canvas, and it has a rim on each side which stands up 1½in. above the surface where the concentrates are collected.

At the upper end of the belt there is a hopper fixed, into which the sand or tailings to be concentrated are placed, and at the upper side of this hopper there is a water-box placed across the belt and a short distance above it. This box has a number of small holes, which form fine jets which play on the sand in the hopper and also on the belt, which wash the sand regularly down towards the lower end. The belt has two actions, one travelling slowly lengthwise against the stream, and the other a short, quick, lateral motion of about 190 to the minute. This gives a wavy motion to the belt, and keeps the whole of the material alive, the particles of greatest density getting undermost, while the water washes off the light sand. The material being deposited on the travelling-belt, with water flowing downwards towards the lower end, also takes part in the up-hill travel and the lateral shaking motion, which keeps the material in an agitating condition: every particle is more or less suspended in water and follows the oscillation of the shaking-table. The heavier particles settle, and, clinging to the smooth surface of the belt, arrive under the water-spreader, while the light sand is carried down to the foot of the table, where it is dropped into a waste-launder.

The separation of the metallic minerals from the larger grains of sand, which have about the same absolute weight, and which were too heavy to be washed off with the fine sand, is now effected under jets of water which flow from the water-spreader: the force of the descending water takes hold of these grains of sand and carries them now also down to the foot of the table, while the revolving belt carries the heavy metallic minerals which adhere to the surface of the belt over the head of the machine, and deposits them in the concentrating-box, which is partly filled with water, through which the belt passes and consequently washes off all the concentrates.

It is an interesting and instructive experiment in working a Frue concentrator to turn off the water from the water-spreader for a few minutes. The separation of the ore and sand ceases at once, and a mixed layer of all the materials is carried over the head of the machine; but if the water is turned on again, concentration takes place immediately. The shaking-table motion of the belt, which also revolves round the rollers, brings continuously forward new portions of settled ore to be acted on by jets of water, and bright-yellow bands of clear sulphurets are produced, while the unproductive sand is carried away.

Quantity of Water in Concentrating.—It must be evident to any one using these concentrators that the quantity of water used on the belt must vary with the fineness and density of the material to be operated upon. Too much water will wash off particles of the metallic minerals, and too little would produce unclean concentrates; but this is not difficult to regulate. Diminish the uphill travel of the belt if too much sand comes over the head, and increase the speed if sulphurets are getting elongated under the water-box and the ore-spreader.

Vulcan Smelting-works, Onehunga.

This is a furnace made after a design of furnaces used in England for smelting ores, but it is quite new to the colonies. It is constructed on the principle of a reverberatory furnace; but, instead of having flat hearths or being on one incline, it is constructed with two hearths, each 4ft. 6in. long

by 3ft. 10in. wide, sloping towards each other on an inclination of 3 to 1, and having a recess between the two hearths for the purpose of holding a bath of molten lead to absorb the metals from the melted ore, the quantity of lead required being about 3in. deep across the bath. The furnace is constructed of fire-bricks, having the sides 14in. thick, and the roof or arch constructed with 9in. birch-wood, and 22in. high above the floor of the furnace. At the one end there is a fire-box, with iron gratings underneath, and between the fire and the hearth of the furnace there is a low bridge built of fire-bricks. At the other end there is a short flue, 20ft. in length, leading to a brick chimney. In this flue, near its junction with the chimney, there is a damper, made of fire-brick and bound together with iron, to regulate the draught. The furnace is bound together by heavy cast-iron plates on the sides, and bolted together.

This furnace has been constructed by Mr. H. Johnson, who is very sanguine as to its success. He intends to smelt the quartz in charges of about 6cwt., which he states takes about two hours to complete, his object being to allow the molten mass to stand in that condition, so that the gold and silver in the ore gets time to settle down in the lead-bath.

There had been no real trial made with this furnace at the time of my visit: some quartz containing a large percentage of iron only had been operated on. Mr. Johnson states that it requires one ton of ironsand and from half a ton to one ton of lime for every ton of quartz. With the experiments he has already made, he thinks that he can smelt the quartz-ore at £3 per ton. The difference between the La Monte smelter and this is, that Mr. Johnson smelts in small charges; then runs off the slag before charging the furnace again, leaving about 1in. deep of slag on the top of the lead to protect it from the flames.

I fear this will not be a success: even if the smelting is easily done, and the metals are readily absorbed by the lead, a portion of the metals will volatilize, and, the flue being straight and short, and no provision made for condensing the fumes, they will go up the chimney. Mr. Johnson has made no arrangement yet for refining the bullion after it is collected in the lead-bath.

Te Aroha.

New Era Company.—This company commenced operations to erect a public crushing-plant up Waiorongomai Creek, near the upper quartz-workings, in August, 1884, and completed their plant, roads, and tramways in April, 1886. The unusual difficulties there were to contend with in getting their machinery on the ground and connecting their battery with the mines were far more formidable than they ever anticipated. The tramway to connect the mines with the battery was estimated to cost £1,500, of which amount they were subsidized by Government to the extent of £1,000. The amount estimated would have been sufficient if the tramway had been properly laid out; but they, like many more companies with limited means, did not pay the attention to survey and plans that they deserved, which resulted in increasing the cost from £1,500 to £2,400. They had also to widen the horse-track from Waiorongomai up to their works into a dray-road, to enable their machinery to be brought on the ground. The Government also subsidized this work to the extent of £333 6s. 8d.

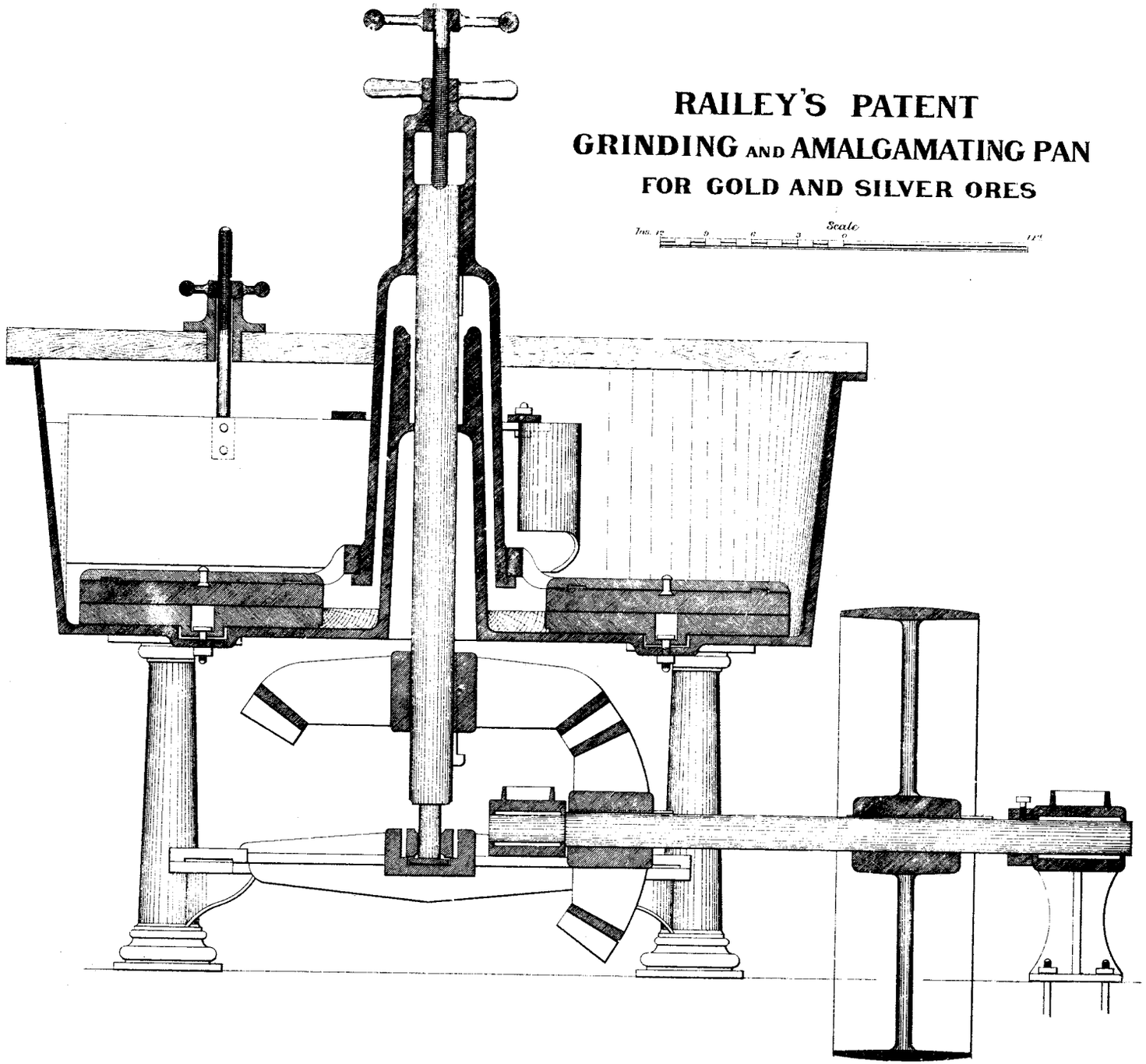
Their plant consists of a calcining-kiln, a stone-breaker, a large revolving-pan, with two heavy rollers each two and a half tons in weight, eight Mackay pans, and four amalgamating-pans. The quartz is delivered from the mines by an inclined tramway into a large hopper, from which the quartz goes down a chute and goes through the stone-breaker, thence passes through the calcining-kiln, after which the calcined ore passes through a second stone-breaker before going into the large pan to be ground by the rollers. These rollers and pan are similar to a large Chilian mill, only there is a grating on the outer diameter of the pan, which does not allow the ground material to pass through until it is in the consistency of coarsely-ground oatmeal. Up to this stage the grinding is done in a dry state.

The ground material is now fed into the Mackay pans in charges of 15cwt., each charge taking from four to five hours to reduce the ore to the consistency of a fine pulp. During the latter portion of the grinding quicksilver, chemicals, and hot water are added. The heating is done by a jet of steam from a boiler which is expressly erected for this purpose. When the amalgamation is deemed to be complete the pulp is drawn off into the settler, which has revolving-arms fitted with shoes, and these keep rubbing over the bottom surface of the settler at a speed of twelve revolutions per minute. A good supply of clean water is let into each settler after they have been working for about an hour, and the process is continued for about an hour and a half longer, when the amalgamation is deemed to be complete, and the fine particles of quicksilver which were formed by the grinding are again collected into a body at the bottom of the settler along with the amalgam. The tailings are kept in suspense until they are washed out of the settler into a concentrator with a continuous stream of clean water. This concentrator is intended to catch any of the particles of quicksilver that may escape from the settler. The amalgam and quicksilver are drawn off from the settler in the usual manner into buckets, after which the bullion is retorted. This plant is driven by a Pelton hurdy-gurdy wheel under a 300ft. head of water.

So far this plant has not proved a success. Since they commenced grinding only 140 tons of ore have been treated, which yielded 87oz. of bullion. The refractory nature of the ore in this district, which contains, as well as gold, sulphide and tellurium of silver combined with arsenic, necessitates a different process of treatment from that hitherto adopted by this company. One of the proprietors of this plant—Mr. Fraser, of Fraser and Sons' foundry, Auckland—erected a small plant in Auckland, and has been for some time past conducting experiments on the treatment of this class of ores. He finds that the ore must be first ground and then chlorinized in a furnace before it can be treated properly, in order to get clear of the sulphur and arsenic; and they now propose to alter their plant to treat the ore in this manner, which they can do at a small outlay. After the ground ore is properly roasted and chlorinized, the latter being accomplished by means of adding a small quantity of salt to the ore in the last stage of roasting, in the manner

RAILEY'S PATENT
GRINDING AND AMALGAMATING PAN
FOR GOLD AND SILVER ORES

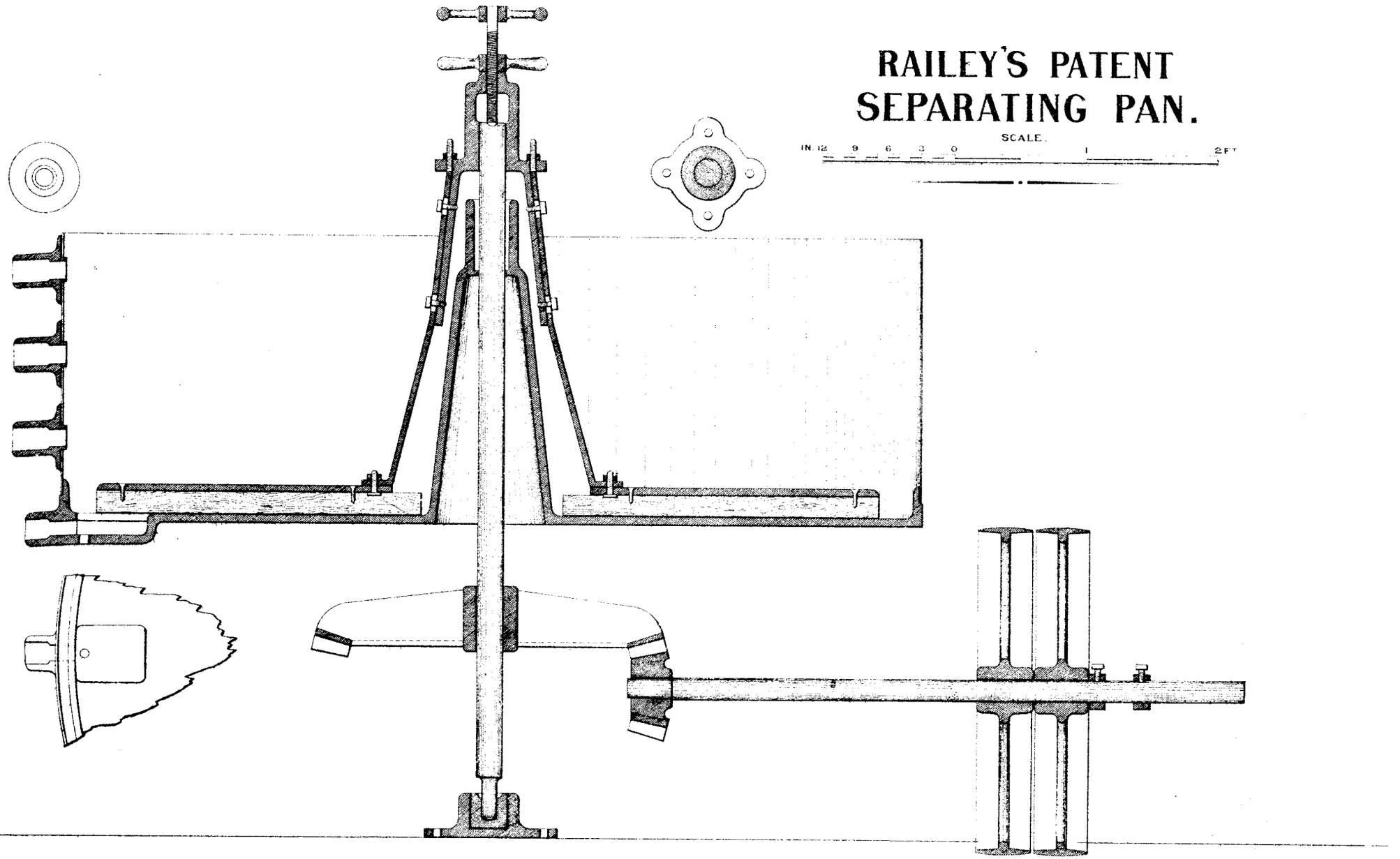
Scale
Ins. 12 9 6 3 0 12



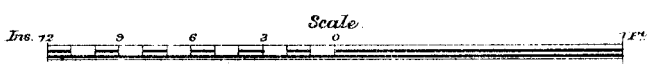
RAILEY'S PATENT SEPARATING PAN.

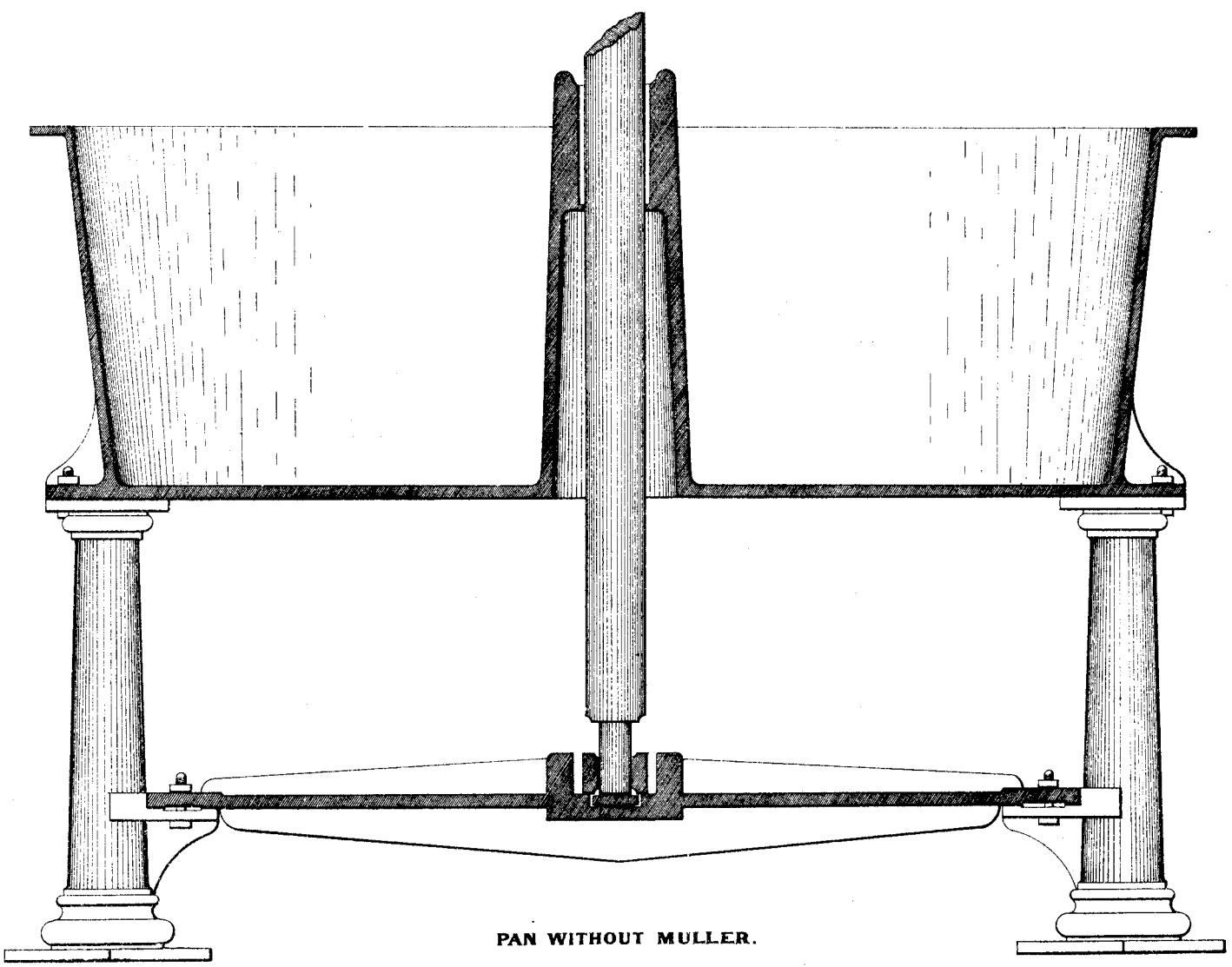
SCALE.

IN 12 9 6 3 0 1 2 FT



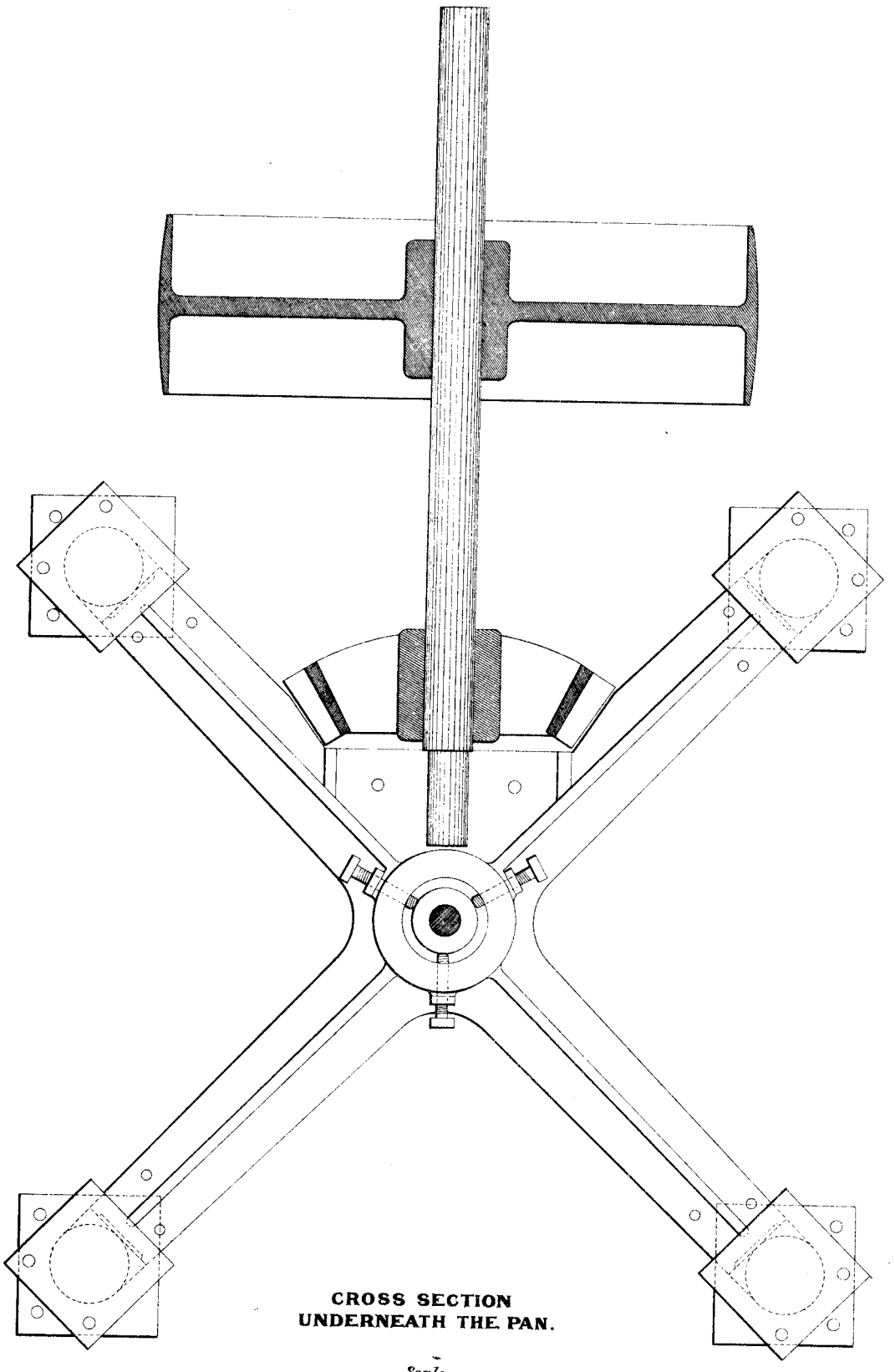
RAILEY'S PATENT
GRINDING AND AMALGAMATING PAN.
FOR GOLD AND SILVER ORES.





PAN WITHOUT MULLER.

RAILEY'S PATENT
GRINDING AND AMALGAMATING PAN,
FOR GOLD AND SILVER ORES.

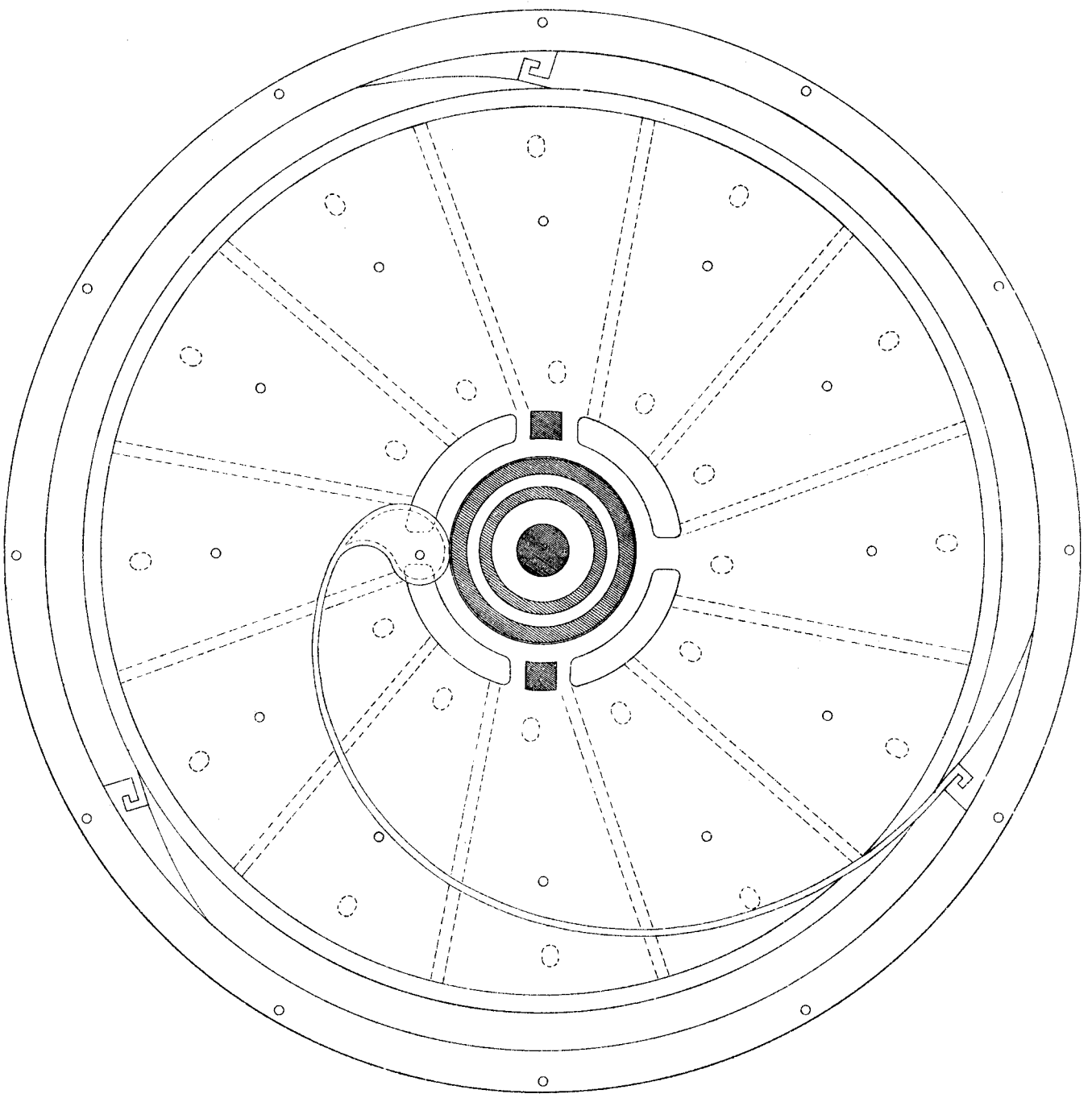


CROSS SECTION
UNDERNEATH THE PAN.

Scale.

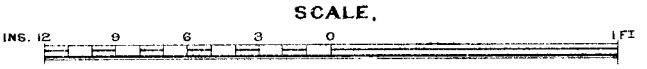
Feet. 12 9 6 3 0 1 Ft.

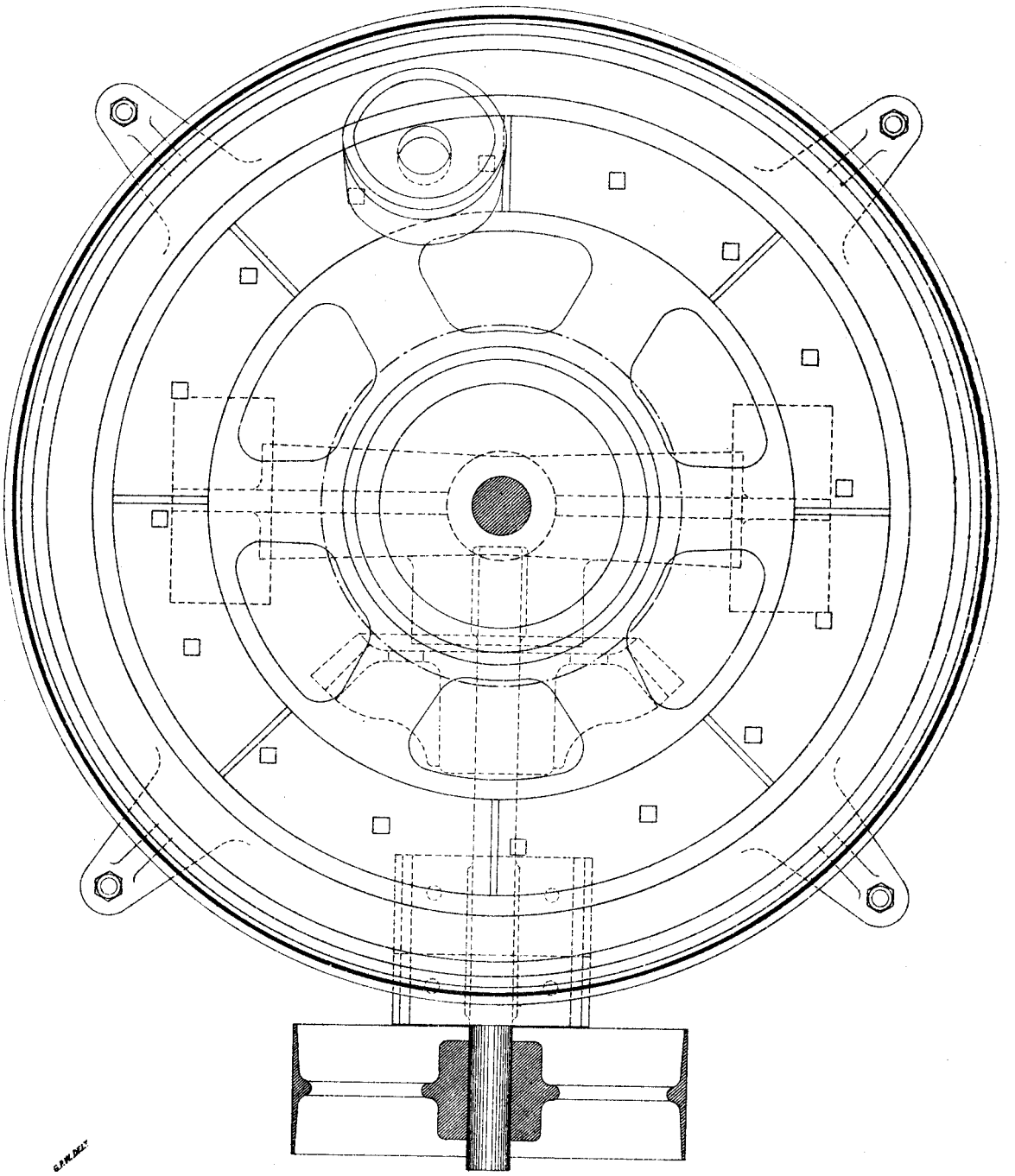
INTERIOR OF PAN.

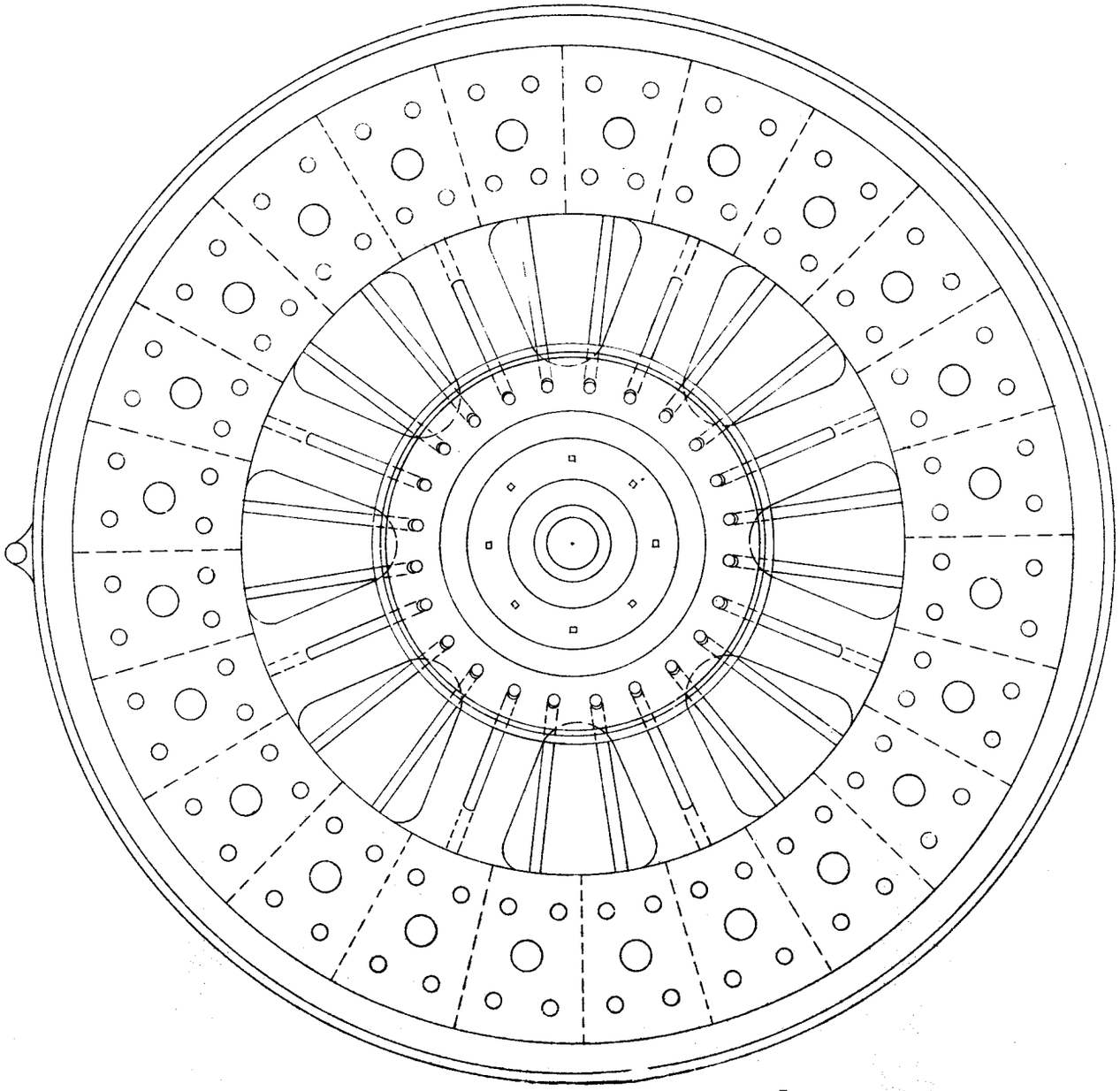


RAILEY'S PATENT
GRINDING AND AMALGAMATING PAN,
FOR GOLD AND SILVER ORES.

SCALE.







CLIMO AND BAWDEN'S GRINDING AND AMALGAMATING PAN.

Scale.

FT. 0 1 2 3 4 5 6 FT.

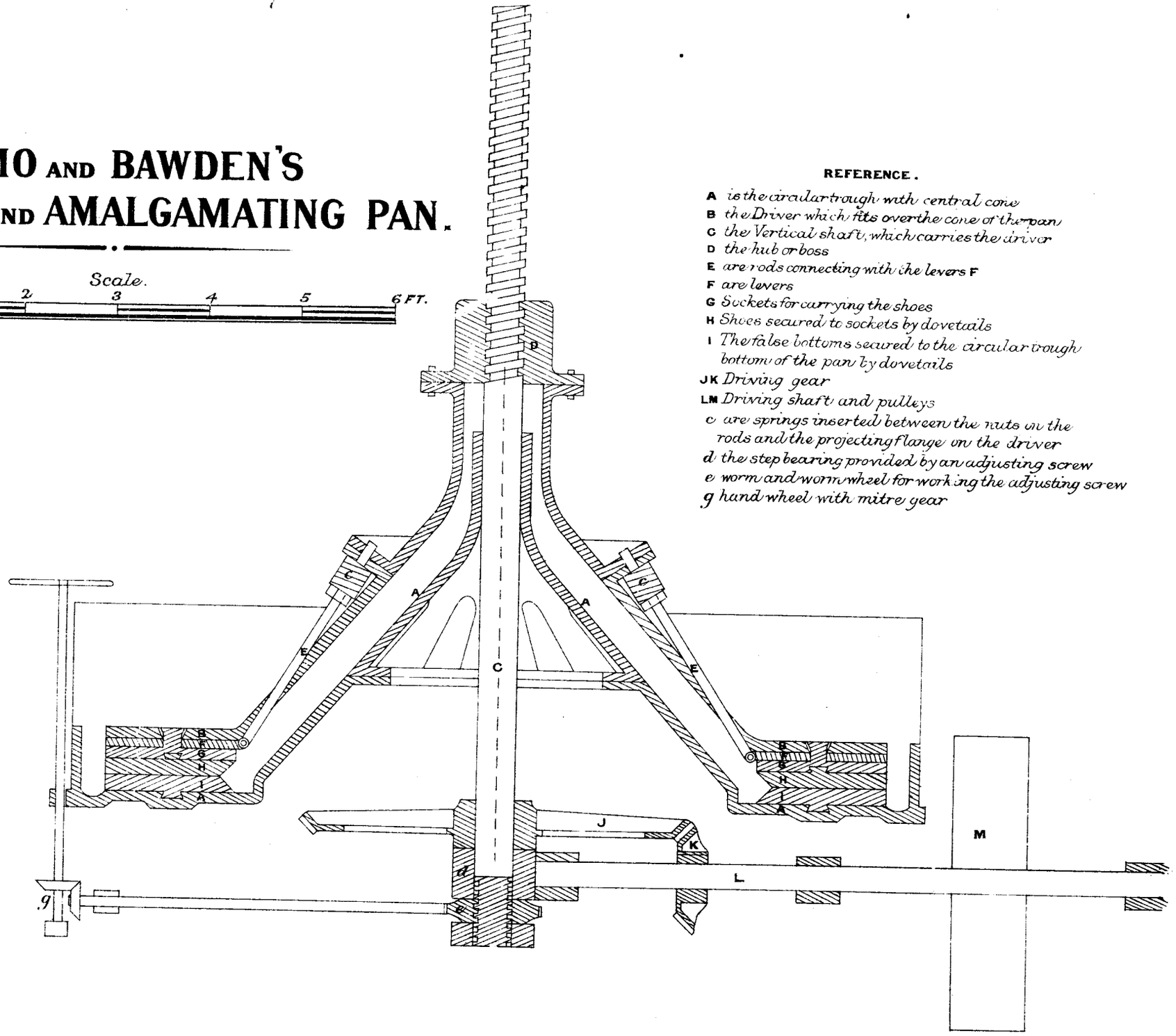
CLIMO AND BAWDEN'S GRINDING AND AMALGAMATING PAN.

Scale.

FT. 0 1 2 3 4 5 6 FT.

REFERENCE.

- **A** is the circular trough with central cone
- **B** the Driver which fits over the cone of the pan
- **C** the Vertical shaft, which carries the driver
- **D** the hub or boss
- **E** are rods connecting with the levers **F**
- **F** are levers
- **G** Sockets for carrying the shoes
- **H** Shoes secured to sockets by dovetails
- **I** The false bottoms secured to the circular trough bottom of the pan by dovetails
- **JK** Driving gear
- **LM** Driving shaft and pulleys
- *c* are springs inserted between the nuts on the rods and the projecting flange on the driver
- *d* the step bearing provided by an adjusting screw
- *e* worm and worm wheel for working the adjusting screw
- *g* hand wheel with mitre gear

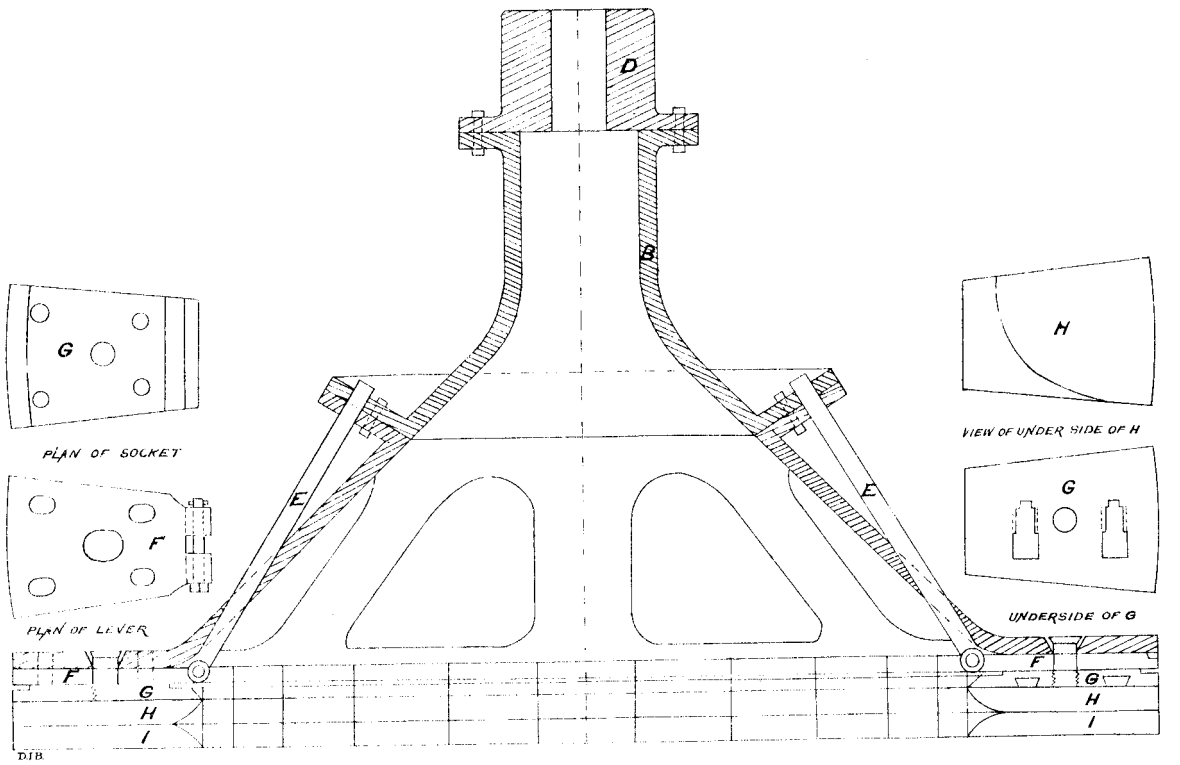


CLIMO AND BAWDEN'S GRINDING AND AMALGAMATING PAN.

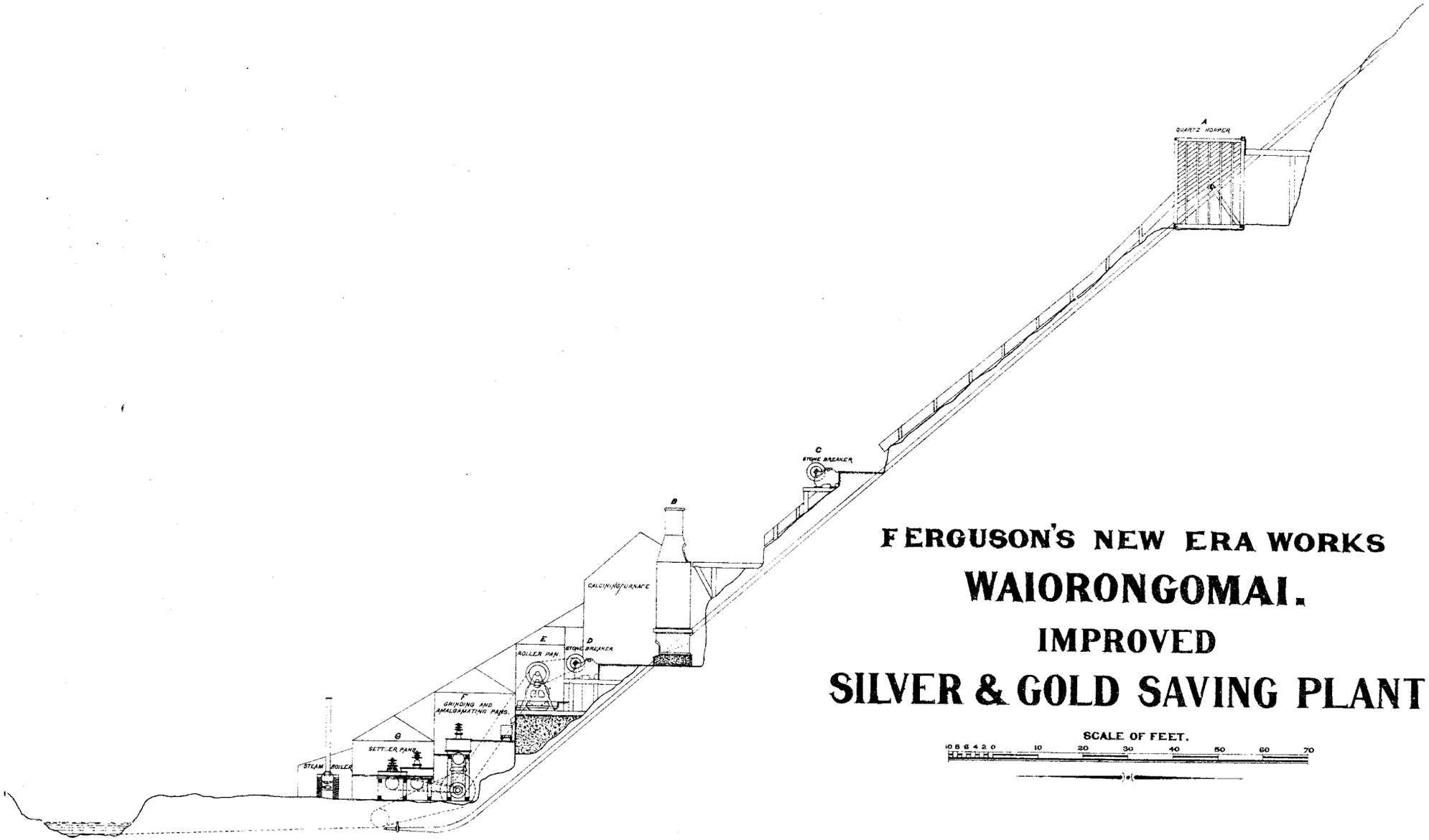
SCALE

REFERENCE.

B. Driver which fits over the cone of the pan
D. Hub or boss
E. Rods connecting with the levers F.F.
F. Levers
G. Sockets for carrying the shoes
H. Shoes secured to sockets by dovetails
I. False bottom secured to the circular trough bottom of the pan by dovetails



MULLER.



FERGUSON'S NEW ERA WORKS

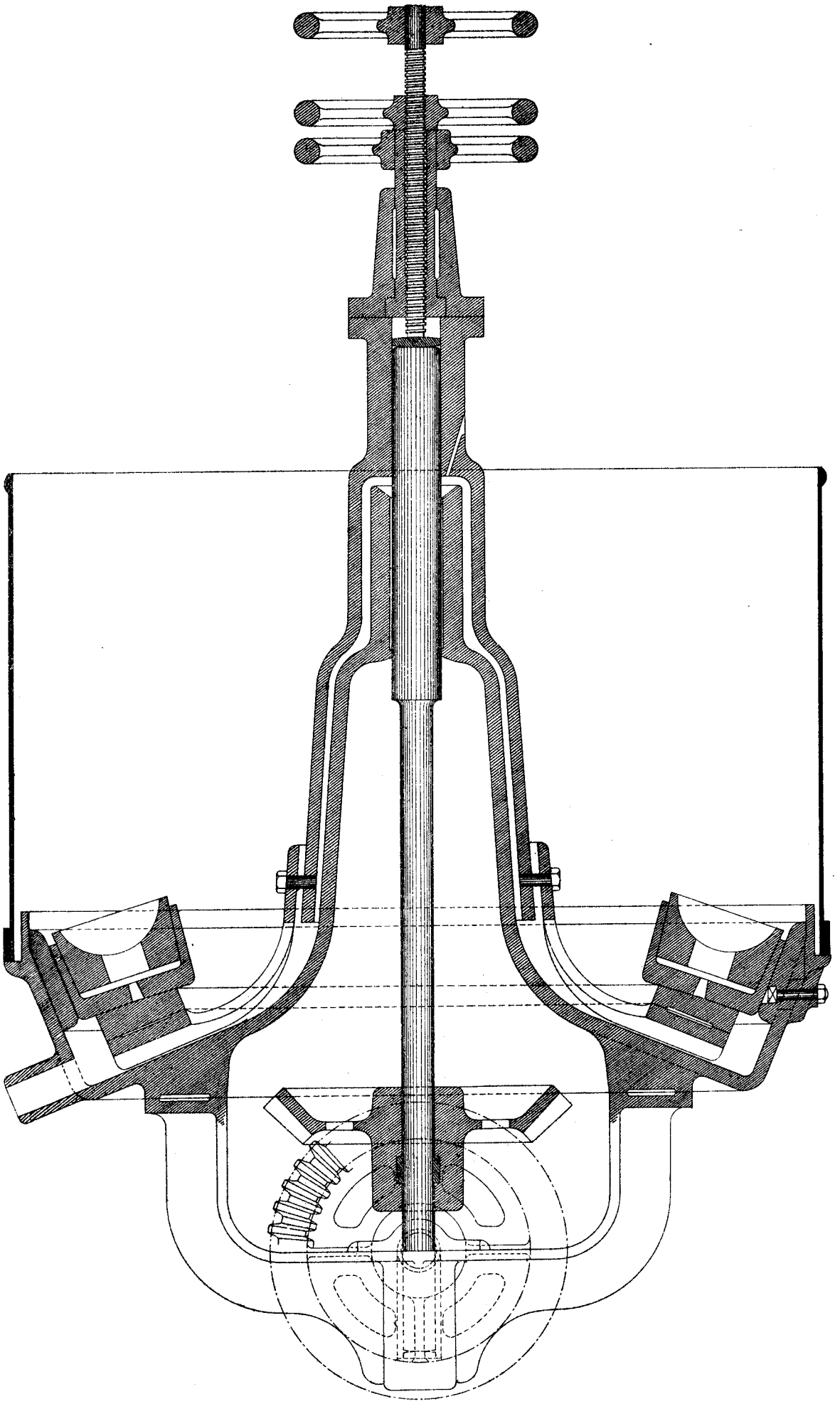
WAIORONGOMAI.

IMPROVED

SILVER & GOLD SAVING PLANT.

SCALE OF FEET.

10 8 6 4 2 0 10 20 30 40 50 60 70



Mc KAY'S AMALGAMATOR,

(LARGE PAN.)

SCALE.

INS. 12 9 6 3 0 1 2 FT

previously described in this report, the ore can then be either amalgamated or put through the leaching process, as may be deemed the most economical and effective in saving the largest percentage of the bullion.

In America great attention is paid to the roasting-process in treating this class of ore. In the *Mining and Scientific Press* of the 8th January last Mr. Carl A. Schenk writes an article on the roasting and leaching of silver-ore, stating that: "The roasting-foreman is solely guided by the time occupied in roasting in judging if a charge should be dropped: by taking samples and noting the physical changes of the ore he watches principally the progress of roasting, and gives his order to drop if the appearance of the last sample informs him that it is time. The answer to the question of what nature are these physical changes from which he can tell that a charge is done, is difficult, inasmuch as only a practised eye is quick in observing them, and a description of them is not easy. A sample of finished ore coming red-hot out of the furnace must assume throughout, in the first stage of cooling off, a lively light coffee-brown colour, so that no streaks or specks of unchanged or only partially unchanged sulphurets can be detected. The raw pulp is of a bluish colour. The use of the microscope, or, at least, a magnifying-glass, might be of service here. A sample of roasted ore coming red-hot out of the furnace, and immediately held to the nose, must give up a peculiar faint smell—sweetish, as it is termed. As crude as these tests appear, they are nevertheless valuable in practice, and the best results are obtained. Whenever these physical changes are noticed in their highest perfection the silver-loss in roasting is small, and the percentage of chlorination high."

As this plant is different in construction from any yet erected in the colony, a sketch is appended, from which a better idea can be obtained than from a mere written description.

It may be of interest to those engaged in the treatment of auriferous ores to quote the report of Professor William Crooks on gold-ores dry amalgamation process—taken from the *Industrial Review* of the 8th and 15th January last—by which 81 per cent. of the gold in sulphuret-ores can be obtained by amalgamation without having recourse to roasting. He states:—

"In the month of June last (1884) I visited the works of Messrs. Jordan, Son, and Commans, Stratford Market, and made a thorough examination of some new machinery which had been fitted up for the extraction of gold from its ores by a dry process of amalgamation, the yield with intractable pyritic ores being reported as far superior to that given by the old wet method of amalgamation."

After describing the apparatus and the method of using it, &c., the Professor goes on to say,—

"In the month of August I visited the works for this purpose, and worked upon about half a ton of ore. This, in my opinion, is a sufficiently large quantity to make the results trustworthy, and comparable with what would be obtained on a larger scale. The ore on which the operation was performed is a complex pyritic ore from the Disraeli Mine in the Charters Towers district, North Queensland. No visible gold is seen in it. The yield is said to be very uniform, and assays at different times previously have shown that the total gold varies between 4oz. 8dwt. and 4oz. 13dwt. per ton. The mean of several of my own assays gives a total quantity of 4oz. 14dwt. of gold per ton. Treated by the ordinary process of wet amalgamation this ore has yielded on an average of five years past about 1½oz. of gold to the ton, showing a loss of 67½ per cent. of the gold present, besides a considerable loss of mercury, which is always 'sickened' by the action of the sulphurets present, and carried away as flour in the stream of water. The Disraeli ore employed consisted of 473lb., in the form of large lumps, and 626lb. of the same lot, which had recently been powdered to coarse sand and stored in bags. The 473lb. of lump were first treated. 840lb. weight of mercury were first put into the amalgamator, and more was added subsequently, either fresh or from the mercury-separator, to replace that carried over into the mercurialized-ore storage-chamber.

"In the whole operation a total quantity of 1,166·5lb. of mercury was employed. As some of the original mercury had been used before samples were taken and submitted to assay, and the amount of gold obtained allowed for in the final calculations. It was at first intended to take note of the steam-power required for the various operations; but the power of the engine (ten-horse power) was so largely in excess of what was wanted that I could form no estimate of the power absorbed.

"The heaviest job—that of crushing the 473lb. of rock—was done in less than a quarter of an hour, and it was all passed through the disintegrator in about three hours. During the rest of the time only a small fraction of the available engine-power was required. The feed was at first set to deliver powdered ore at the rate of about 30lb. per hour; but it was soon increased, so that the first lot of 473lb. was passed through the amalgamator in ten hours and three-quarters, or at the rate of 44lb. per hour. As the powdered ore passed through the hopper into the amalgamator samples were drawn every five minutes during the day, so as to get a fair average of the ore. Assays showed that it contained 4oz. 14dwt. of gold per ton of 2,240lb. This agrees fairly well with previous assays by others.

"After completing the operation on the first lot of 473lb. the mercurialized ore in the storage-chamber was carefully mixed and sampled for assay. It was then passed on to the mercury-separator, and after the separation of mercury was effected it was thrown on to the tailings-heap. As already said, the temperature of the mercury rapidly rose: it was kept at about 200° Fahr. by means of the water-jacket.

"Without interfering with the mercury in the amalgamator, except to add more when the column got much below 30in., the second lot of 626lb. powdered ore was commenced. The rate of feed was a little quicker, the whole lot passing through in about thirteen hours and a half, or at the rate of 47lb. per hour. The fastest speed by actual experiment was found to be 4·15lb. in five minutes, or at the rate of 49·8lb. per hour. As before, samples were drawn every five minutes. The mercurialized ore from the second lot was well mixed, and sampled as before.

"It is evident that the whole of the ore and all the mercury, except what is left in the amalgamator, will ultimately find its way into the storage-chamber and channels leading thereto. The

weight of mercurialized ore will therefore equal that of the ore originally used, *plus* that of the mercury carried along with it, *minus* a small quantity of ore, estimated at about 10 per cent., which floats away from the chamber in finest dust, like smoke. Some of this was collected, and found to contain neither mercury nor gold.

"The total weight of mercury used was 1,166·5lb. On completing the operation the mercury left in the amalgamator was drawn off, and found to weigh 646lb.; 520·5lb. had been carried over with the 1,099lb. of ore, the 473lb. carrying over 210lb. of mercury, and the 626lb. of ore carrying over 310·5lb. of mercury. Deducting 10 per cent. (the amount estimated to float away as fine dust) from the total of 1,099lb. of ore leaves 989lb. of ore mixed with the 520·5lb. of mercury, giving a total of 1,509·5lb. of mercurialized ore, containing 34·5 per cent. of mercury. This mercurialized ore is in the form of a heavy impalpable powder. It is difficult to imagine that any particle of gold which it may contain can have escaped amalgamation after so complete a saturation with mercury.

"Knowing the remarkable effect of sodium in reducing floured mercury to a bright liquid state —an action discovered and patented by myself in its application to gold-mining twenty years ago—I prepared a 3-per-cent. sodium amalgam (with sodium which the inventors of the machinery had already provided themselves with), and added a small quantity of this to the mercury-separator when in action. The effect was instantaneous. The isolated globules of mercury at once coalesced, and the separation, which without sodium was tedious and incomplete, became with its assistance rapid and almost perfect in the reduction of mercury.

"On the large scale the mercury-separator would be placed near the amalgamator, and the mercurialized ore, instead of passing into the storage-chamber, would be carried direct with a little water into the mercury-separator, from the upper tap of which the exhausted tailings would flow away to the waste-pit, whilst from the lower tap would run a continuous stream of mercury. The apparatus could be made as purely automatic as the pulverizer and amalgamator now are, and could equally well be kept under lock and key.

"It is important to save every pound of mercury possible, for not only have we to consider the value of the mercury, but it must be borne in mind that waste of mercury in the form of flour means also loss of gold which the mercury carries away with it.

"The weight of mercury obtained in this way from the mercurialized ore was 498·5lb. To this must be added 12·5lb., which was taken away at various times in the samples required for assay, making a total of mercury from the mercurialized ore of 511lb. This, added to the 646lb. left in the amalgamator, gives a total of 1,157lb. I give this in a tabular form below:—

	Lb.
"Mercury from the mercurialized ore	498·5
Mercury left in the amalgamator	646·0
Mercury taken in samples	12·5
Total mercury recovered	1,157·0

"There will be noticed a difference of 9·5lb. between the weight of mercury originally taken and that remaining at the end of the operation. The only scales available were very rough ones, used for weighing the ore, and they would not turn within half a pound. The mercury originally taken was weighed in a few large bulks, and the weight may therefore be considered fairly accurate. The final weighings were, however, performed as the mercury was being collected and bottled, and only comparatively small quantities were weighed at a time, as the retort required to be filled. The 'turn of the scale,' therefore, required an excess of mercury over its true weight to be taken each time, and this in the aggregate would be quite sufficient to account for much of the apparent loss. Moreover, some mercury got accidentally spilt in the numerous transfers from basin to bottle and from bottle to retort, and some was lost during retorting owing to imperfect condensation. When all these sources of error are allowed for, it will be apparent that very little of the 9·5lb. deficiency can be fairly ascribed to actual loss in working the process.

"The auriferous mercury was not squeezed through chamois-leather, as is the custom in gold-amalgamation on the large scale. In the latter case squeezing through leather is advisable, because there is sufficient gold in the mercury to form a solid amalgam, which sinks to the bottom. This solid amalgam, after straining through leather, remains behind in a lump, containing from 30 to 50 per cent. of gold. The liquid mercury squeezed through the leather will still contain ¾oz. of gold per 112lb. of mercury. As the whole quantity of gold which could possibly be present in the mercury would not amount to 2½oz., it is evident that this quantity would easily remain in solution.

"Samples of each lot of mercury were taken, and submitted to assay for gold. The 646lb. of mercury from the amalgamator were found to contain 62·2gr. of gold per 112lb. of mercury, equivalent to 14dwt. 22·7gr. of gold on the whole 646lb. of mercury.

"The 210lb. of mercury from the first lot of 473lb. of ore, and the 310·5lb. of mercury from the second lot of 626lb. of ore, were mixed and sampled, and the whole lot was found to contain 145gr. of gold per 112lb. of mercury, equivalent to 27dwt. 21·2gr. on the whole 502·5lb. of mercury. The gross yield of gold from the whole 1,099lb. of ore was 2oz. 2dwt. 19·9gr. But the mercury originally used was not quite pure, as it contained 5dwt. 1gr. of gold; so this amount must be deducted from the gross yield, leaving 1oz. 17dwt. 18·9gr. as the actual yield from the ore taken, equivalent to 3oz. 17dwt. of gold per ton of 2,240lb. of ore. These results will be better seen if I arrange them in a tabular form.

	Oz.	dwt.	gr.
"Gold from mercury in amalgamator	0	14	22·7
Gold from mercury in mercurialized ore	1	7	21·2
Gross total of gold obtained	2	2	19·9
Deduct gold originally in mercury	0	5	10·0
Actual gold obtained	1	17	18·9
Equivalent to per ton of 2,240lb.	3	17	0
Gold present per ton of 2,240lb.	4	14	0
Gold left in tailings	0	17	0

"This is equivalent to a yield of 81·9 per cent. of the total gold present. Assays of the tailings run from the mercury-separator gave an average yield of 17dwt. 16gr. per ton. Deducting this from the gold actually present—namely, 4oz. 14dwt.—shows a yield of 3oz. 16dwt. 8gr. per ton, equivalent to 81·2 per cent. of the gold present. The close agreement in the results obtained by these two entirely different methods confirms their accuracy.

"The advantages of this new process of dry amalgamation over the old process of wet amalgamation may be summarized as follows: Under the new system, the ore, while in a perfectly dry condition and in the form of a powder about forty times as fine as that producible by stampers, goes through a mass of heated mercury 30in. in vertical depth, instead of being, while in a coarse state, driven by a rush of water through stamper-boxes, riffle-boxes, over surfaces of amalgamated copper, &c. In other words, the naked gold is at once handed over to the action of the only agent which is commercially capable of saving it, under circumstances which allow that agent to exert its powers in the most advantageous manner.

"The new process, from the time the ore is raised from the mine up to the moment when the amalgam is deposited in the retort, does not involve the use of either fire or water beyond whatever of these two agencies is required for motive-power and for the use of the mercury-separator.

"The advantage of dispensing, by the means under consideration, with the use of water in the principal gold-saving districts, and the disadvantages attendant on its use in connection with stampers, are apparent from the following facts: As the gold contained in the auriferous rock is for the most part fine, instead of coarse, the water in the stamper-process ordinarily carries away with it a considerable percentage of precious metal, and the loss by 'water-sweep,' added to that caused by non-amalgamation consequent on defective pulverization and want of contact, amounts frequently to between 40 and 50 per cent. of the total gold, and sometimes to considerably more.

"In many auriferous regions, particularly in the tropics and in many goldfields in Australia, water is sometimes for many months in the year almost unprocurable, and, as in the stamper-treatment large quantities of water are essential, crushing-operations have to be entirely suspended during this season, while the pay of at least some of those employed by the mill-owners still goes on.

"Apart from the expense and trouble of pumping-gear, where water is used in quartz-reduction a heavy outlay, first, in the making and maintenance of roads, and, secondly, in the cartage of the quartz, is almost invariably required, for it is generally impracticable, both on engineering and on commercial grounds, to bring the water to the quartz—the quartz must be taken to the water. In many cases the cost of cartage necessitates the abandonment of fairly rich lodes; for in mountainous districts, while the making of wheel-tracks is often impracticable, the scarcity of horse- or bullock-feed increases with that of water, and fodder has frequently to be carried in wagons for very long distances.

"The new process extracts at one operation nearly all the gold contained in the ore, and renders unnecessary the numerous and expensive minor operations attendant on and inseparable from the employment of stampers, such as the use of blanket-strakes, buddles, Wheeler's pans, berdan-pans, &c. As the iron amalgamators, storage-chambers, and mercury-separators, in which all the gold extractable from the ore is deposited, can during both active operations and the suspension of work be locked up as securely as a bank-safe, the mine-owner has neither to trust nor to pay the wages of a watchman day and night to prevent robbery of amalgam.

"The new process, being almost absolutely automatic throughout (save that a man is required to feed the stone-breaker and to attend to the level of the mercury in the amalgamator), will effect an immense economy in labour.

"The new process can be used with very great economy for the treatment of stamper-tailings, especially where much pyrites is present with the quartz. Tens of thousands of tons of pyritic tailings, containing 1oz., 2oz., and sometimes 3oz. to the ton, commercially unworkable by the ordinary process, are waiting the introduction of some such process as the present one, which could be at once employed on these tailings with the certainty of winning a large percentage of gold from them.

"In all the principal goldfields of the world the free-milling ores near the surface are practically exhausted. Much of the ore now being mined contains a large percentage of sulphurets, and is of far too complex a character to be successfully treated by appliances so mechanically rude as stampers.

"The gold in these complex ores is, in many instances, finer than flour itself; it therefore follows, as a natural consequence, that there must be a perfect disintegration and absolute contact of the powdered ore with the mercury. These requisites have never been obtained by the old method, but are fully secured by the new process. There is, moreover, a great advantage in working with hot, dry mercury. The powdered ore falls cold into the amalgamator, and is at once saturated with mercury-vapour.

"Mercury, having a greater affinity for metals than for stone, condenses in preference on the gold present, and thus amalgamates the metallic particles and renders them eminently susceptible of solution when they reach the bath of hot mercury. In the old process the mercury could not be used at a temperature above that of the water which covers it.

"The new process will treat pyrites and other intractable ores almost as effectually as it will free-milling quartz. In the present case it has saved about 82 per cent. of the total gold present in an ore from which stampers only obtained an average of 32½ per cent. of the gold."

Newbery-Vautin Process of Chlorination.

A new method of chlorination and leaching has recently been brought into use by Messrs. Cosmo Newbery and Claude Vautin, of Melbourne, for the treatment of roasted auriferous sulphurets. The process, however, has not yet been sufficiently in use to fully bear out its practical utility, which the inventors claim to have discovered, for treating auriferous and argentiferous ores in a satisfactory and economical manner; nevertheless there is a certain guarantee connected with its success when a scientist such as Mr. Newbery is connected with it. Even should the details of the plant be defective the principle is correct; and should there be any defects in any portion of its details these will soon be remedied. The greatest feature in the process is that chlorination is produced in a far shorter time than by the old process, and the cost of treatment is not one-half the former expense. The latter is the great desideratum in order to be able to manipulate poor ores. The old system requires the ore to be first damped, an operation requiring not only great care, but also skill, as it must not be too wet nor too dry if good results are to be produced. It has to be sifted into a vat, and chlorine gas has to permeate, through a filter-bottom, on which the ore rests, and also through the whole body of the ore, which requires from twenty-four to forty-eight hours to produce effective chlorination.

It is well known that chlorine gas is of a very poisonous character, and in treating under the old system the lid has to be removed, when the poisonous fumes escape into the building, and are very injurious to the workmen. The process perfected by Messrs. Newbery and Vautin is said to overcome all these obstacles.

In the new process Messrs. Newbery and Vautin claim that the improvements are of such a character that not only are the mechanical difficulties of the old method overcome, but the chemical reactions are greatly accelerated, the cost reduced from about £1 10s. to 12s. per ton, and the loss of gold practically nothing; that the old slow, costly, and cumbersome process has been converted into a rapid, economic, and effective means of extracting gold from auriferous pyrites, refractory ore, tailings, &c., from which, when necessary, antimony, sulphur, arsenic, &c., have been removed by proper calcination.

The plan herewith annexed will enable any one more readily to understand the principle of this process from the following description: The material to be treated is taken from the calcining-furnace in trucks, which are hoisted up for a certain distance to allow the ore to pass through the various processes of treatment with the minimum amount of hand-labour. The ore is deposited in the hopper A, immediately over the chlorinator B, which is a rotating-barrel constructed of such material and in such a manner that chlorine has little or no effect on it, and strong enough to withstand an internal pressure of 60lb. to the square inch. The chlorinator B is charged with from 20cwt. to 30cwt. of ore from the hopper A by a chute from the hopper to the man-hole; a given quantity of water, chlorine, or chlorine-producing chemicals is then added; the man-hole is then securely placed in position, and the vessel is then perfectly air-tight.

A pipe leading from the air-pump C is connected with a valve on the chlorinator, which is opened, and an air-pressure produced as required or found necessary, depending on the coarseness of the gold. The effect of this air-pressure will be explained further on. The valve is then closed, and the connection with the air-pump broken. The vessel, with its contents, under pressure, is caused to revolve for one hour, when it is stopped, and a pipe connected with the valve which leads into a closed vessel or vessels D, in which there is lime or soda-water; the vessels D are connected with a vacuum-pump of special construction, so that when the valve on the chlorinator A is opened, any chlorine that may exist in the form of gas is drawn into the lime or soda-water in D and absorbed. By this means the workmen are prevented from inhaling any chlorine gas, which would be the case if the surplus gas was not withdrawn before the chlorinator was opened. After a few minutes the man-hole door is removed and the vessel again put in motion, when the contents are discharged into the vessel E, called the solution-separator or filter, which consists of a lead-lined iron vat with false bottom, and connected with the vacuum-pump G by the pipe F. Immediately the contents of the chlorinator are deposited in the solution-separator, the communication between the vacuum-pump and filter is opened, and the solution of gold-chloride rapidly withdrawn from the ore and deposited in the holder H. Water is continually added to the surface of the ore in the filter, and the solution from it tested from time to time; and when free from gold the connection with the vacuum-pump is broken, and the filter tipped up, causing the waste ore or tailings to fall into the truck, when they are run out on to the tailings-heap. The removal of the gold-solution and washing of the ore occupies, with ordinary sands, about one hour, no matter how fine. When large quantities of slime are to be treated extra filters must be provided.

The solution of gold in the holder H is then allowed to flow through charcoal in vessel J, during which passage the chloride of gold is decomposed, and the gold deposited on and in the charcoal, which, when fully charged, is burnt, and the ashes fused with borax in a crucible, and the gold obtained. In places where water is scarce the liquid from J can be used over and over again with economy, as it becomes charged with hydrochloric acid, which assists in liberating chlorine in the chlorinator. It can be pumped up to the cistern K for further use. The lime or soda-water in the vessels D can also be used to produce chlorine for fresh charges of ore after it

has combined with the chlorine drawn into it just before opening the chlorinator, as before described.

The patentees claim for this new process the following advantages:—

(1.) That the material for treatment falls by gravitation into the chlorinator, and is not damped or sifted by hand as in the old method, for it does not matter how wet it is: thus a great saving of time and labour is effected at the very beginning of the operation.

(2.) That the vessels in which the chlorination takes place do not occupy much space, say 4ft. by 5ft., instead of 10ft. and 12ft. in diameter, as required by the old process.

(3.) That the ore under treatment is kept in motion during the time that it is exposed to the action of chlorine under pressure. The great advantage of combined motion and pressure are, that the combination of the chlorine with the gold under high pressure is far more rapid that when only under the normal atmospheric pressure, and, no matter how large or coarse the grains of gold may be, they are rapidly dissolved. There is no obstruction to the action of the chlorine on the grains of gold by being surrounded with a solution of gold-chloride, or coated with silver-chloride, in many instances the source of failure by the old process. In cases where the silver alloyed with gold is worth recovering, or if there is any present in the chloride, it can be obtained by adding salt to the charge; when, as is well known, it will go into solution.

This is a point of great importance, and will make the process of value, especially in the North Island districts, where a very large percentage of silver exists in the auriferous ores.

A great point of value, and to which the patentees direct special attention in the improved process, is the introduction of compressed air; for by such means any chlorine that would otherwise exist over the surface of the ore in the form of gas is forced into the water with which the ore is mixed in the chlorinator. By this means there is not only a great saving of chlorine, but the chemical action is greatly accelerated, and the gold in the ore converted into chloride in one hour or so, instead of twenty-four to forty-eight hours by the old process.

(4.) The time saved in separating the solution of gold from the material is one of the principal features of the mechanical improvements of the new process; for heretofore the difficulty of leaching or washing the ore, and thereby removing the solution of gold-chloride, has been one of the great drawbacks to chlorination. The rapid filtration is brought about by means of a vacuum produced under the filtering-medium in the solution-separator by a specially-constructed pump, the action of which prevents the material, however fine, from settling down on or into the filter-bed in a compact mass; but, on the contrary, keeps the same lively and open.

(5.) The advantages of decomposing the gold-solution by passing it through charcoal or some other insoluble reagents are numerous, and will be fully appreciated by those who have experienced the never-ending and uncertain method of precipitation by sulphate of iron; and, moreover, such means of recovering the gold is practically automatic. When small quantities—say, 50 tons or less per week—of ore are to be treated, the process can be worked in one barrel or chlorinator; but greater economy will be experienced by using them in sets, as the pumping-power for exhaust and pressure with the smallest effective pump for one chlorinator or barrel is the same as required for four or more. The capacity of each barrel or chlorinator is from fifty to sixty tons of ore per week.

(6.) The plant can be made to treat small or large quantities of ore, and the cost is within the means of working miners. No great skill is required to work the new process, as all details have been so arranged that any person of ordinary ability can master the working of the process in a few days. The cost of chlorination proper is said to be from 10s. to 12s. per ton, including labour and wear and tear. The chemicals required amount to 2 per cent. of the ore treated, and can be so packed that no trouble or risk need be experienced in transit, and the acid necessary may be obtained dry in wooden casks.

This process is said to be in full work at the Mount Morgan Mine, in Queensland, and it has been of such marked success that the loss in the tailings is not 1dwt. of gold per ton. The patentees have also erected an experimental plant at Langland's Foundry, Melbourne, which has so far proved to be a great success. The production of chlorine at this plant is from equal quantities of sulphuric acid and chloride of lime.

Although this process is only now causing attention in the Australian Colonies on account of its introduction by Messrs. Newbery and Vautin, there is nothing original in the idea, neither is it a new one.

Since writing the above, further communication has been received by Mr. A. Saunders, of Auckland, from Mr. J. Cosmo Newbery, as to the adaptability of this process for treating silver-ores, which, Mr. Newbery states, would have to be modified before silver-ores could be treated satisfactorily. The following is a copy of Mr. Newbery's letter:—

"The Newbery-Vautin process, now being worked by the United Pyrites Company, at Sandhurst, was originally devised for the extraction of gold from the ore of the Mount Morgan Mine, in Queensland, and is essentially a gold-extraction process, and, unless modified, is not adapted for the treatment of silver ores. The ores which find their way to the Sandhurst works contain so little silver that it would not pay to try to save it. It seldom amounts to more than a few pennyweights per ton, and does not interfere with the extraction of the gold; for this reason the process at Sandhurst has been made as simple as possible: to extract one metal only.

"From experiments recently made with some New Zealand ores, I have found that the gold and silver are in combination with selenium, and that the silver is largely in excess of the gold; and I am of the opinion that to attempt to treat such an ore by the chlorination-process would only lead to failure, and I have advised that the stone broken by a stone-breaker should be heated to a low red heat in a kiln in the presence of steam. The steam is decomposed, and the hydrogen combines with the sulphur, selenium, &c., and the silver and gold are left free and bright in the form of minute shot; the ore may then be treated by amalgamation.

"Some 15cwt. of ore are now at Sandhurst, and are, I believe, being treated in this way.

Should the ore prove refractory or contain antimony, a little salt may be added; but, if it is not necessary, it is better left out. The more rapid the current of air and steam through the kiln, the quicker the operation will be performed.

"I patented this process some years ago, but the patents were allowed to lapse, as we had no ores requiring the treatment. I think it would be much cheaper for you to try the experiment at the mine than to send the ore over here; but, if you like, I will try a sample of your stone. The only precaution to be taken is to heat the ore sufficiently, and at the same time to be careful not to produce any slag to glaze the ore.

"You may have heard that Mr. Vautin treated a quantity of ore for silver and gold at the Sandhurst works, but this was an ore rich in both metals, and they were not combined, as they are in your ores; so that, after a chlorination-roasting in a reverberatory furnace, he was able to wash out his silver before he treated the ore for gold by the chlorination-process, and this probably led to Mr. Cook writing to you that a modification of the Newbery-Vautin process could be made to treat your Upper Thames ores, he not knowing that the silver and gold were combined. As a gentleman from your colony saw my experiments with the ore, and is now in Sandhurst watching the treatment of the 15cwt., you will probably hear the result.

"P.S.—Since writing the above I have met Mr. Chapman, who has explained to me that the ores I have mentioned are from Waihi, and are not properly called Upper Thames ores, and that many of the ores do not contain the gold in combination with selenium, &c., and that he thinks the process could be applied in some cases with advantage, but he agrees with me that, for such ores as Mr. Sheppard has brought over, it could not compete with some simple process such as I have mentioned, by which both the gold and silver could be saved in one operation."

Mr. Richard P. Rothwell read a paper on this subject before the American Institute of Mining Engineers, New York, which appeared in the *Mining and Scientific Press*, of San Francisco, of the 20th October, 1883, stating the process as follows:—

"The roasted concentrates are chlorinated by the Mears process in charges of one ton in a revolving lead-lined iron cylinder. The chlorine is made from chloride of lime and sulphuric acid, from 40lb. to 50lb. of the former, to 50lb. or 60lb. of the latter being used to a ton of ore. The pressure in the cylinder rises to about 40lb. or 50lb. per square inch, and falls to 25lb. or 30lb. when the roast has not been perfectly made, as desirable. The operation lasts about two hours, though probably much less time than this will be found sufficient to chlorinate the gold when it is in fine particles.

"The lime contained in the ore was found to give rise to quite unexpected difficulties in precipitating the gold from the chlorine solution: the usual precipitant—ferrous sulphate—was found to throw down a voluminous precipitate of—principally—calcium-sulphate along with the gold. In order to avoid this we tried to get rid of the lime, first, by sulphuric acid. This was too tedious, and after many annoying delays the precipitation by charcoal was tried. The chloride-liquor is allowed to filter slowly through a mass of broken pieces of charcoal to, say, from $\frac{1}{16}$in. to $\frac{1}{2}$in. in diameter. The barrels are kept full of solution by the filtrate being brought from the bottom of one barrel in a rubber tube which terminates a few inches below the top of the next barrel. The precipitation of the gold is practically complete.

"The collection, drying, and melting of the gold is done in the usual manner. The burning of the charcoal has not yet been done here; but in North Carolina, where the same process is in use, it is burned in an open iron pan, with fire under, and, it is claimed, without loss of gold, and at a cost said to be less than 6 cents per ton."

It will be seen from this description that the process has been used in America with success at least four years ago.

The following is a description of the Lexington Silver Dry-crushing Mill at Butte City, Montana, United States of America, taken from *Engineering* of the 24th December last, and also a sketch of the same appended: "We publish this week a two-page engraving showing the general arrangement of the Lexington Dry-crushing Silver-mill, belonging to a French company, and situated at Butte City, Montana. The plant, designed by Messrs. Salkeldt and Eckart, was constructed by Messrs. Fraser and Chalmers, of Chicago. The ore to be treated is first taken to the crushing-floor, where it is thrown on a grating, the bars of which are spaced 1in. apart. What falls through is deposited in store; the remainder is fed into two Blake crushers, which reduce the ore to the desired size. The engine driving these crushers is employed for electric lighting at night. The broken ore is conveyed on a tramway to the mill, which we illustrate, where it is placed in the double furnace F to be dried. The salt used in the process, and which is obtained from Utah, is also dried, to the extent of six or seven tons a day, in the furnace F^1. There are in all forty stamps, G, 850lb., for reducing the ore, and ten smaller ones, G^1, for treating the salt. These are fed by the Tulloch apparatus H. The cam-shaft is driven at a speed of forty-six revolutions per minute, and the fall of the stamp is 7in. Archimedean screws, J, feed the pulp to the bucket-elevator K, which delivers it to a Krom screen placed on the upper part of the vat L. The reduced ore which does not pass through the screen is returned to the stamps. The crushed salt is delivered in a similar way to the vats L^1 by the elevators K^1. Under these vats are feed-screws, M. The ore and salt then fall upon a screw, J^1, and are led up to the elevator K^{11}, and thence conducted to the Stetefeldt furnace S. To prevent the circulation of dust, the mortars of the stamp are boxed up, the enclosures being connected by trunks, N, and a series of dust-chambers, O. A fan, Q, maintains a sufficient current of air to drive the dust to these chambers, which are each 110ft. long, 5ft. wide, and 6ft. high. From time to time the dust thus accumulated is discharged from openings in the floor. When collected they are deposited in the dust-receiver L^{11}, and are fed gradually into the pulp as it enters the elevator K^{11}. The two large Stetefeldt furnaces, shown at SS, and their dust-chambers at S^1, S^{11}; the cooling-floor is indicated at T, the roasted ore being raised to this floor by the elevator U. There are twenty amalgamating-pans, V, 5ft. $3\frac{1}{2}$in. in internal diameter and 3ft. high: these are driven at sixty revolutions per minute. The ten settling-pans X are 8ft. in diameter and 46in. high: they are driven at fourteen revolutions per minute. The agitators YY for the tailings are

similar to the settling-pans. The clean-up pans Z, Z^{I}, Z^{II}, receive the sweepings and other residue. They are 4ft. in diameter and 2ft. high, and are driven at twenty-seven revolutions. The retorts *aa* are arranged in pairs in the same setting. The condensed mercury from them is received in the same vat, *b*, that takes the mercury from the filters. A bucket-elevator, *d*, raises it to a vat, *e*, whence it is distributed into different pans. The zinc-granulating furnace is shown at *f*. It is simply a cast-iron tank with a very small discharge, through which the molten zinc flows into the water. The refining-furnace *g* is placed in a separate building. The illustration and foregoing description are produced from *Le Genie Civil*. The Lexington Mill is 326ft. long and 139ft. deep. The various buildings are of the following dimensions: Dry-kiln buildings, 120ft. by 27ft.; Stetefeldt furnace, 103ft. by 47ft.; pan-room, 163ft. by 65ft; engine- and boiler-room, 70ft. by 43ft.; battery-room, 120ft. by 32ft.; fireman's floor, 33ft. by 13ft.; agitator-room, 24ft. by 22ft.; bullion-furnace, 35ft. by 30ft. From the charging-floor of the drying-kilns to the boiler-room the fall is 61ft."

The Treatment of Gold- and Silver-ores in America.

The following extract on the manipulation of gold and silver-ores is taken from the "Statistics and Technology of Precious Metals," prepared by the Department of the Interior, and published by the Government of the United States in 1885, which gives a very lucid description of the methods adopted in America for the extraction of gold and silver from the ores, which may be of interest to those dealing with refractory ores in this colony.

Amalgamating-mills.

Relative Amount of Ore milled.—A considerably larger amount of ore is treated by the various processes depending on amalgamation than is smelted or leached. In California amalgamating-mills altogether outrank the smelting establishments, but are supplemented in many cases by lixiviation-works. In Nevada the Eureka smelting district is the principal exception to the rule, 78,807 out of the total 346,948 tons treated in the whole State during the census-year having been worked at Eureka. In Colorado, however, less ore was milled than smelted during the same period, the respective totals being 131,948 tons milled, as against 179,564 tons smelted. In Montana, out of a total of 86,576 tons reduced during the census period, 71,896 tons were worked in amalgamating-mills. Oregon, Dakota, and Wyoming ores are treated by amalgation. Until lately all the ores in Idaho were milled, but the discovery of important base-metal districts has given an impulse to smelting-operations. Mills take precedence in Arizona. In general it may be said that, wherever practicable, owing to the peculiar economic conditions prevailing in the far West, the amalgamation process is adopted in preference to smelting, from motives of economy in first cost of plant and in actual treatment; though, on the other hand, the percentage of precious metals saved by the mills is usually much lower than the results reached in smelting-works.

Capacity of Mills.—The quantity of the ore which can be treated per month varies from fifty to several thousand tons, according to the quality of the ore and the size of works. Among large mills the Homestake Gold-mill has a capacity of 325 tons, and the California Silver-mill 380 tons, in twenty-four hours. Some of the mills are kept steadily at work from one year's end to the other, but many of them are only running for a few weeks at a time.

Tenor of Ore treated.—The range in the assay-value of the ore treated is very great, extraordinary facilities and a large plant permitting ore to be worked in some places at a profit which, under other conditions, could only be treated at a loss. The physical character of the ore also varies greatly, the quartz in some districts being extremely coherent and tough, and in others friable. Some ores are so soft that ten tons per twenty-four hours can be crushed with a single stamp. The predominating colour in chloride or oxidized ores is a dull reddish-yellow, and in sulphuret ores various shades of grey. The ore treated by silver-mills contains nearly every known silver-mineral, the specimens collected in connection with the present census embracing an almost complete list of even the rarest species. What are known as free ores, if from near the surface and exposed to atmospheric agencies, contain chloride or horn-silver (cerargyrite), and, more rarely, native silver or sulphide (argentite) if from below the water-line, although the latter mineral is also found at or near the surface. In ores which require a preliminary roasting, stephanite, tetrahedrite, polybasite, pyrargyrite, proustite, &c., are found; in fact, the ores containing silver, and also sulphur, copper, lead, antimony, arsenic, or zinc, are met with in almost an endless variety. The most common gangue is quartz, with or without calc-spar and other minerals. As exceptions may be mentioned White Pine, Nevada, where the gangue is siliceous limestone; Eldorado Cañon, where it is calc-spar and chloride; and Silver Reef, Utah, where it is sandstone. Fluor-spar and barite, as well as many other minerals, occur occasionally as the gangue of lodes. In some cases the association of minerals is a very remarkable one: for instance, in the Spanish Belt district, Nevada, cinnabar is found in silver-bearing tetrahedrite; and at the Hackleberry Mine, Arizona, free sulphur was found in the oxidized chloride ore of a silver-mine. Gold is generally found in the ore in a free state, though frequently it is so intimately mixed with iron sulphurets that it is difficult of amalgamation. At other times the gold is so extremely fine that it is carried off on the water before it can be amalgamated. It is often supposed that a sulphuret of gold is found in some mines, and that "coated" gold, or gold which cannot be amalgamated in the ordinary way, exists as a matter of fact; but there is little authority for the belief that sulphur is chemically combined with gold in these ores.

Working Results.—The question of percentage extracted is one regarding which the expert is obliged to depend entirely upon the statement of the millman, and in many cases the percentage claimed is higher than the circumstances under which the ore was worked warrant. Sometimes the percentage extracted is calculated from the assay-value of the tailings—a method which rarely, if ever, gives true results; often it is merely determined by guess, leaving a very liberal margin in favour of the millman's skill. When silver-ore is roasted, probably from 80 to 90 per cent. is extracted on the average, though a few mills have been known to work up to 96 per cent. Of so-called free-milling ore generally not much over 70 per cent. is extracted, although mills in White

Pine, Nevada, and Silver Reef, Utah, have worked ores to 85 per cent., and on the Comstock ore has been worked to above 80 per cent. In gold-mills there is a wide difference in the percentage extracted, but it rarely exceeds 80 per cent., and often falls much below it. It is not possible to fix any definite figure for the average assay-value of tailings and slimes. The value varies exceedingly according to richness of ore and mode of treatment.

Cost of Treatment.—The cost of milling gold-ores in California varies from 54 cents (2s. 3d.) to $2 50c. (10s. 5d.) per ton. When water-power is to be had ores can be milled very cheaply at a cost of not more than $1 (4s. 2d.); and when steam-power is necessary, exceptional facilities may reduce the expenses to those of the average water-power mills. In other States and Territories it is, as a general thing, somewhat more expensive to reduce gold-ores; but in the Black Hills region the large gold-mills are operated very cheaply in spite of high freight and other disadvantages because of the simplicity of the process, the scale upon which operations are carried on, and the economy in labour which is effected by the use of automatic labour-saving devices. The cost of milling silver-ores in wet crushing is from $4 (16s. 8d.) to $8 (£1 13s. 4d.); in dry crushing from $6 (£1 5s.) to $12 (£2 10s.). With ores which require roasting it is from $12 (£2 10s.) to $28 (£5 16s. 8d.). There are, of course, circumstances when these figures are exceeded, and sometimes it may be possible to work ores at less cost than the lowest prices given. The great difference in ores in the facilities for working and in the method of extracting the precious metals renders it impossible to make a general statement as to the cost of the process.

Reducibility of Various Ores.—Those ores can be most cheaply worked which contain silver as chloride without base metals, or carry gold unmixed with sulphurets. As instances of particularly free-milling silver-ores, those of White Pine, in Nevada, and Silver Reef, in Utah, may be mentioned. Next in order come those ores which, although they contain chloride of silver, are mixed with lead (generally in the form of carbonate) and various copper, arsenic, and antimony minerals. The ore of the Comstock, although it contains but little base metal, may be classed under this head, as most of its silver is in the form of sulphides, and a part of the gold is contained in the iron-pyrites. It mills from 70 to 80 per cent. The last and most difficult class of ore to work comprises the many complex sulphides of silver and other elements; and, although it is almost invariably necessary to roast these ores, some of them (such as ore composed of quartz, silver-sulphide, and a little iron- and copper-pyrites) can be roasted and worked at a cost not much in excess of that of the baser free-milling ores, and certainly to better advantage, as at least 90 per cent. of the assay-value can thus be extracted. But these ores are very rarely met with, and by far the larger class is that in which the ore either does not contain enough sulphur to render the chloridation complete, or contains large quantities of the sulphides of zinc, antimony, and arsenic, and can therefore be roasted only at the expense of much time, care, and money. Such are those of Morey, Nevada, and many in Arizona. Frequently mistakes in deciding upon the proper plant and process to work ores are made, as it is often a delicate matter to decide whether an ore can be best milled or smelted, and, if milled, whether it requires roasting. The mining-country is covered over with reduction-works which are failures owing to the wrong method having been chosen to work the ores. Such disappointments are of rare occurrence nowadays, more prudence and experience being brought to bear on this class of investment than was formerly the case.

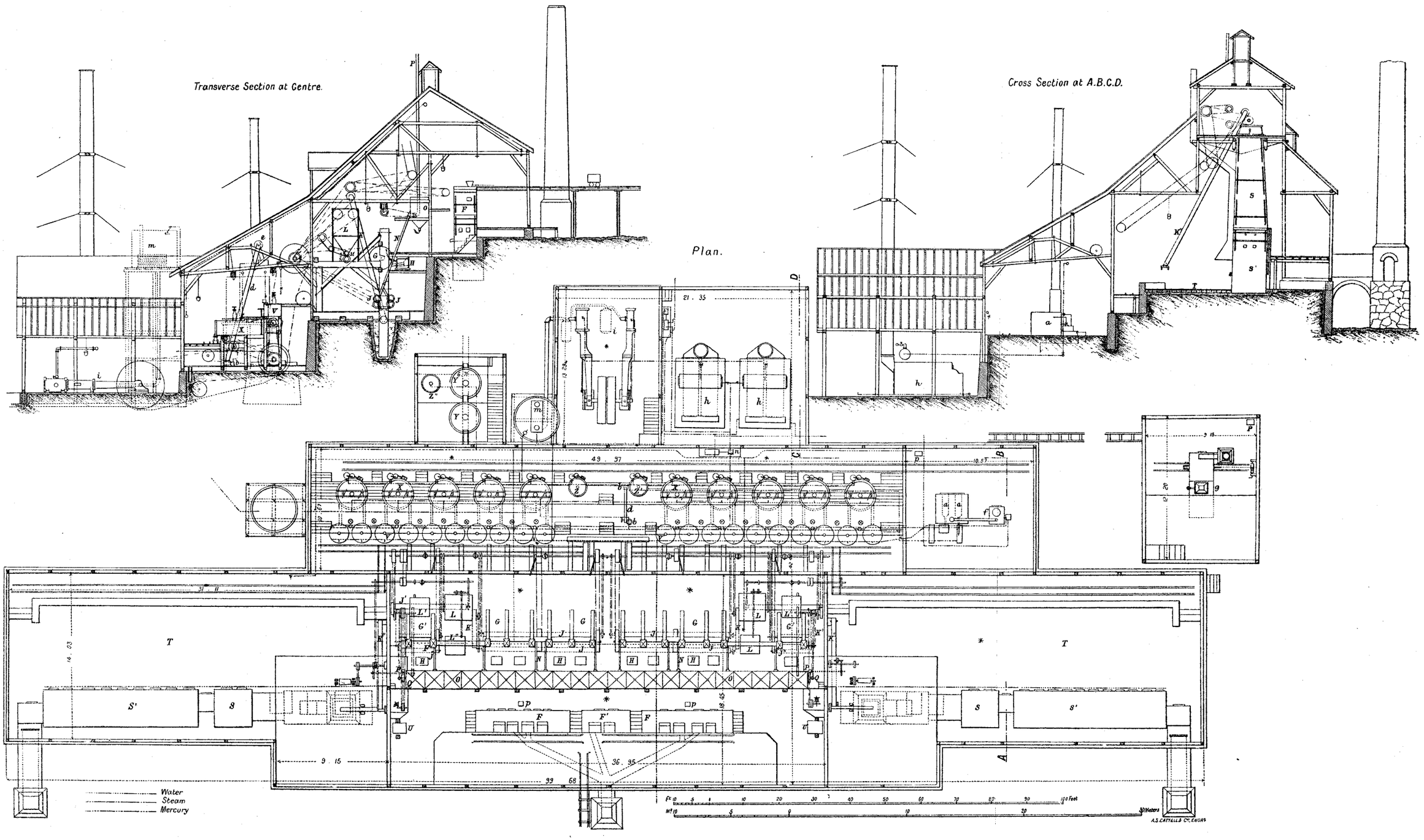
Terms of Custom-mills.—The prices charged for reducing ores are generally one-quarter to one-half as much again as the actual cost, or even more, except with such milling companies as own mines which they lease to miners, expecting to make their profit out of the "tribute" and not out of the mill. Usually gold-mills do not guarantee any percentage. In silver-mills, where the ore is worked raw, the guarantee is from 70 to 80 per cent. of the assay-value. Sometimes a clean-up is given—that is, after the ore is worked the bullion-product is gathered together and turned over to the ore-owners, who pay the charges for working. When ore needs roasting the mill generally guarantees 80 per cent.—sometimes, as in Austin, 80 per cent. on such ore only as assays over a certain fixed value. When a percentage is guaranteed, the tailings, slimes, &c., are looked upon as belonging to the mill company; but when ores have been worked on the clean-up plan they are generally regarded as belonging to the mining company, unless there has been a previous agreement in reference to them. In purchasing ores the percentage of the assay-value offered is paid after deducting the price of milling.

Stamp-batteries.

Wet and Dry Crushing.—For gold-ore the wet-crushing battery is exclusively used, and for free-milling silver-ore it is also generally employed. In some cases—as at Eberhardt, in White Pine, and the Lancaster Mill, at Tuscarora—dry crushing is practised on the ground that a much higher percentage is saved, owing to the avoidance of loss of finely-divided horn-silver in the slimes, which is apt to occur when the ore is crushed wet. This is highly probable with chloride-ore, for, although the slimes are very thin, the earthy material in them seems to be richer in silver than the ore itself. There are also some ores which, when crushed, produce so much slime that it is impossible to keep a reasonable percentage of pulp in the mill. For such ores dry crushing is preferable, but for other free-milling ores wet crushing is by far the best, as more can be crushed. There is less wear and tear on the battery per ton, and the hands are not subjected to that inconvenient and unhealthy dust that everywhere pervades the atmosphere of a dry-crushing mill in spite of an attempt to get rid of it to a certain extent. The advantages of dry crushing and wet crushing for free-milling ores are combined in the plan adopted at Bodie and elsewhere of pumping back the water from the settling-tanks into the battery. When it is intended to roast ore it is always crushed dry.

Screens.—There are four kinds of screens in use for quartz-mills, steel and brass wire, and slot- and needle-punched sheet-iron. A tin screen is mentioned in a schedule of a gold-mill in California; but the advantages are not apparent. For gold-mills, the punched-slot screen is the one most used, though steel wire is sometimes met with in wet-crushing silver-mills. Steel and brass

THE LEXINGTON DRY CRUSHING SILVER MILLS; BUTTE CITY, MONTANA, U.S.A.

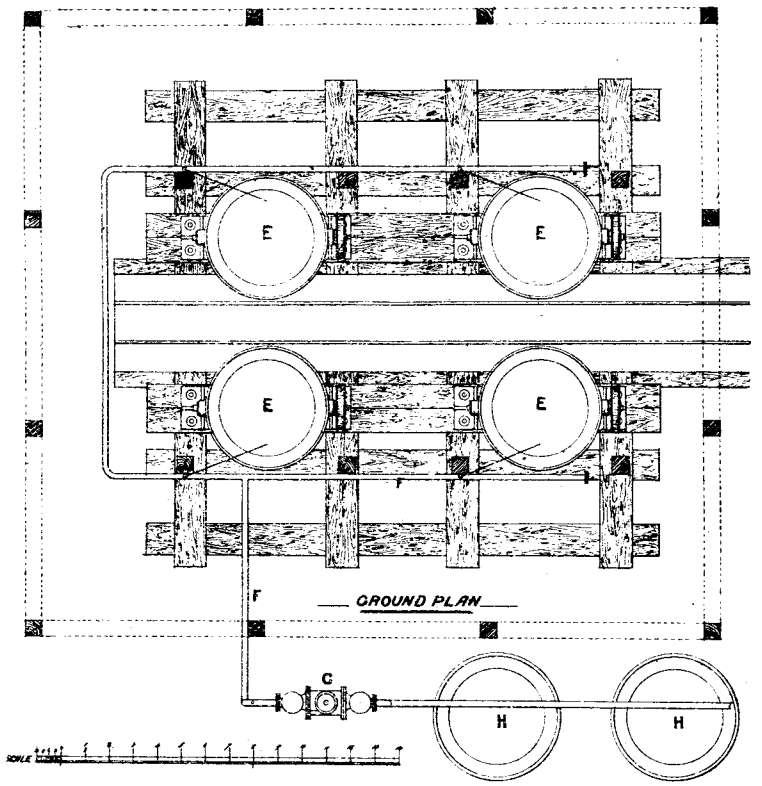


"NEWBERY-VAUTIN,"

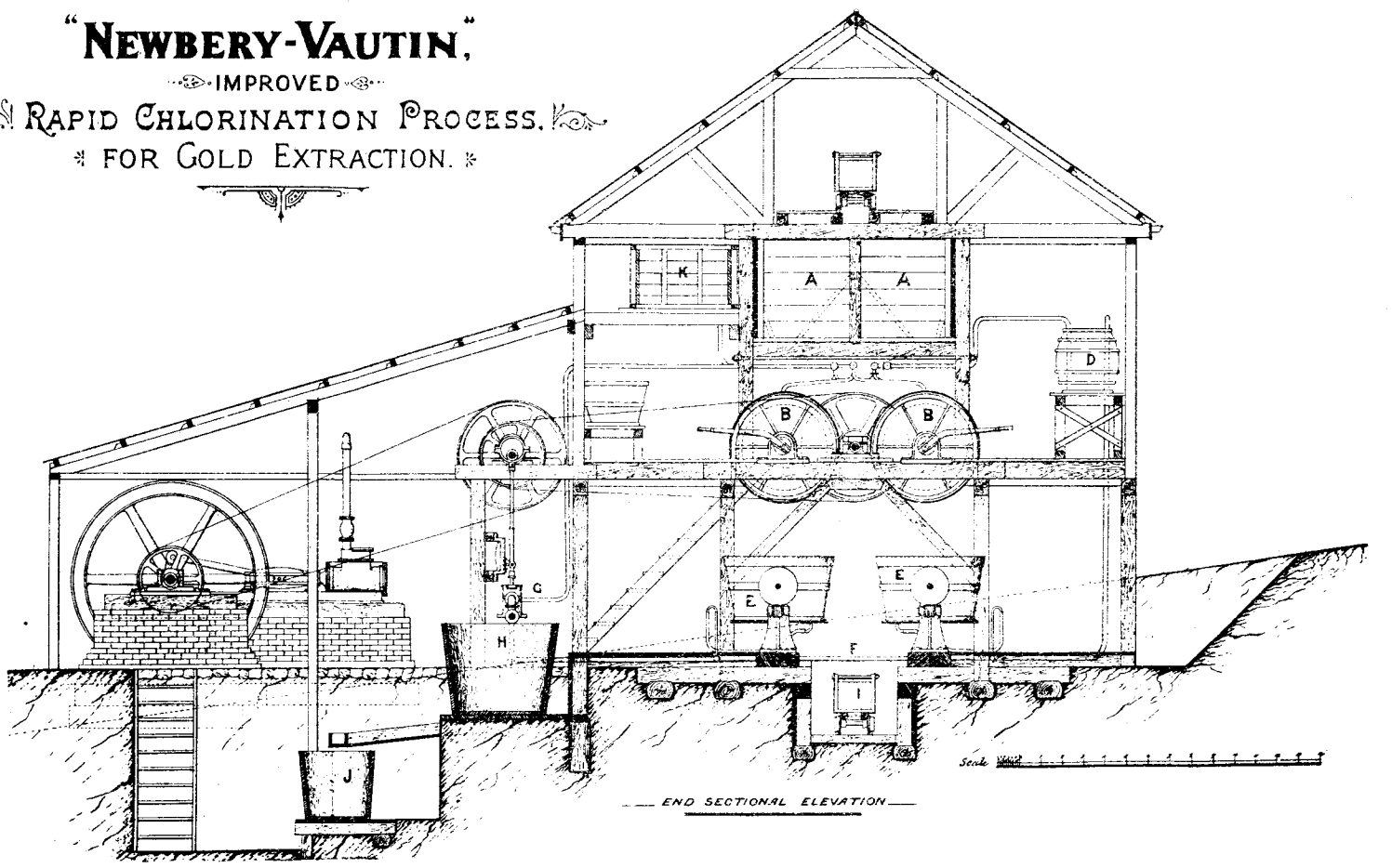
IMPROVED

RAPID CHLORINATION PROCESS,

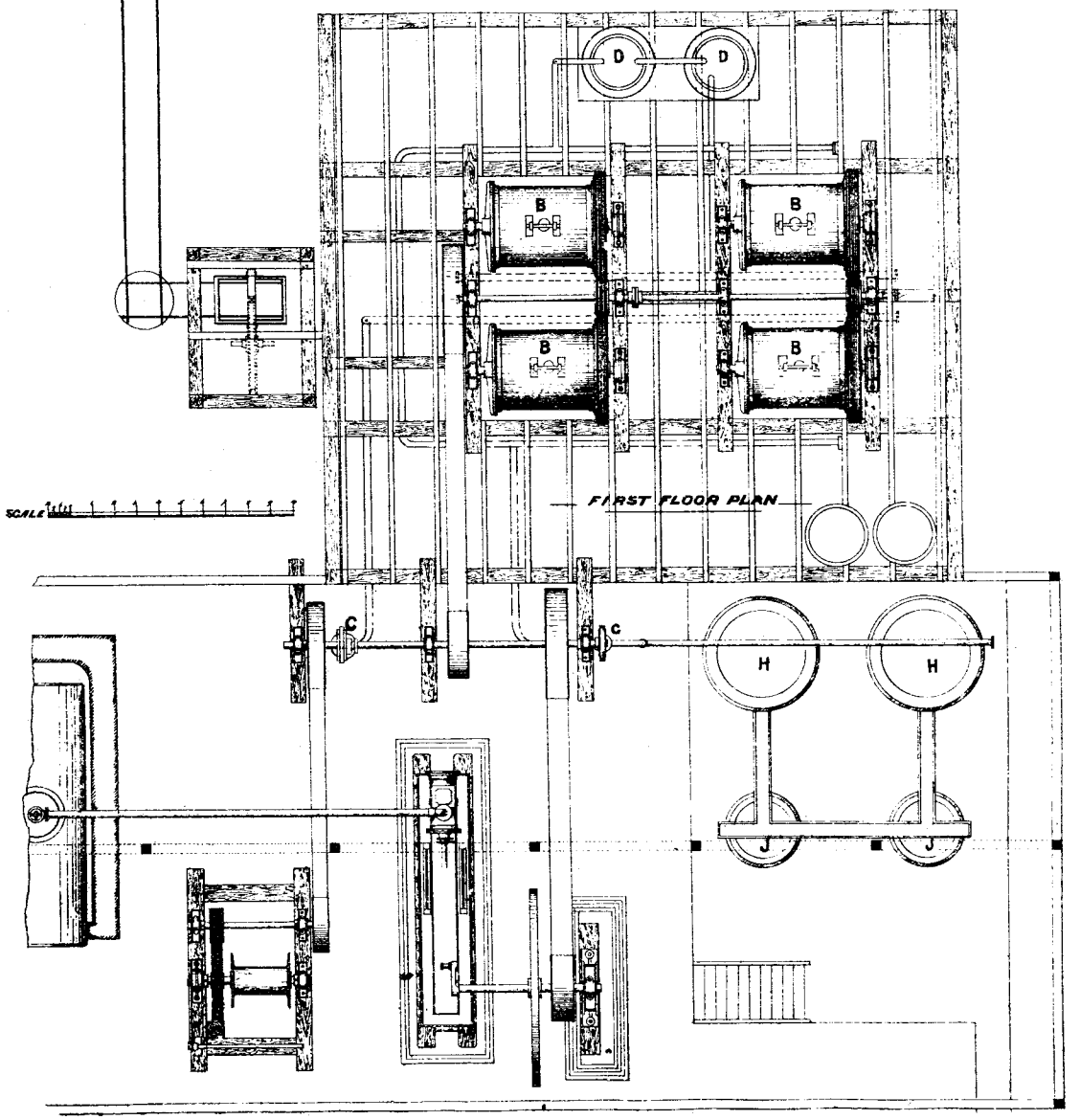
FOR GOLD EXTRACTION.



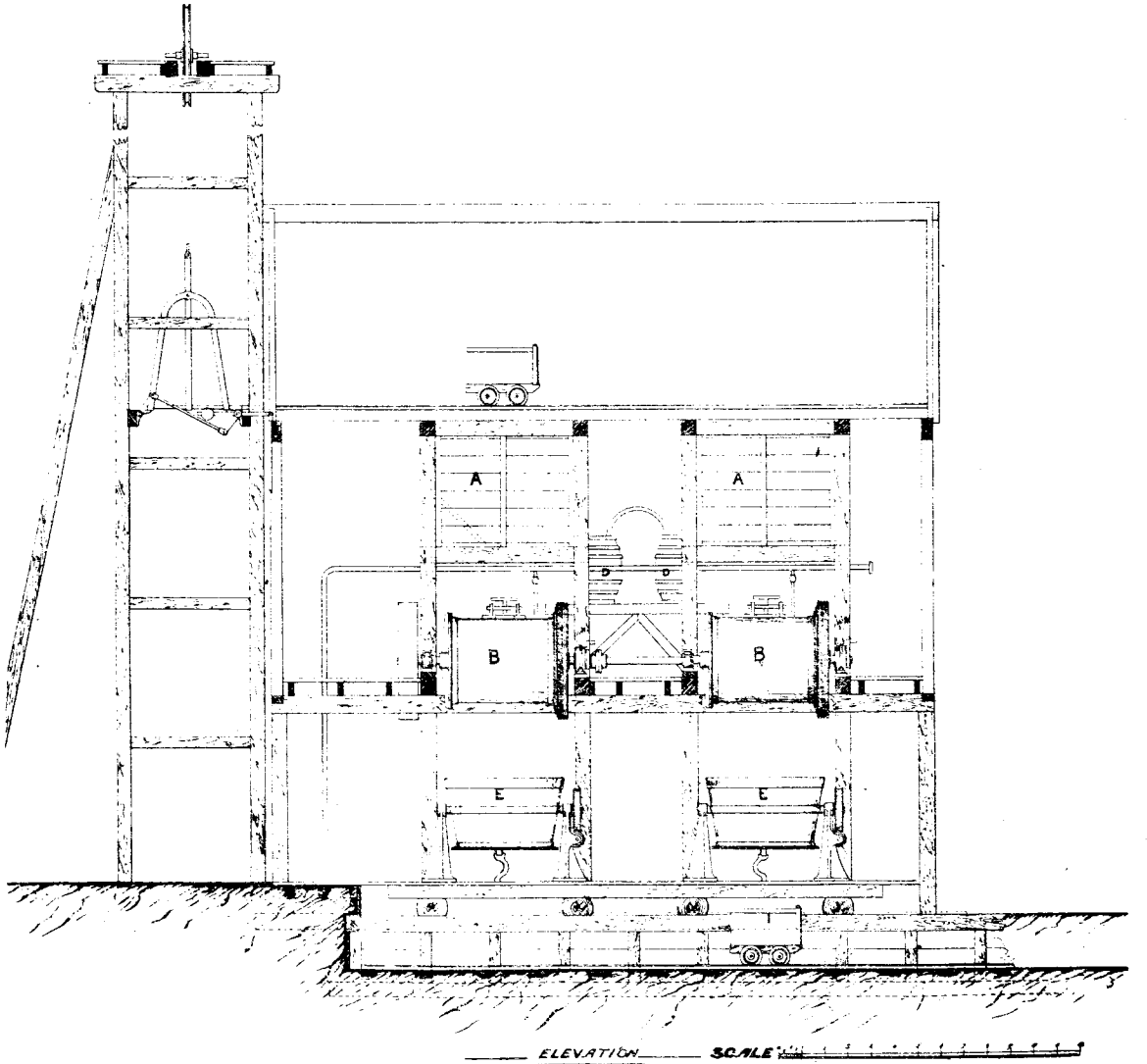
GROUND PLAN



END SECTIONAL ELEVATION



FIRST FLOOR PLAN



ELEVATION SCALE

wire and needle- or slot-punched iron are all used. The preference seems to be for the brass wire, though steel is now replacing it. Punched screens are not so much used as formerly. At the California Mill they use a horizontal-slot-punched screen, which is said to correspond to a No. 50 wire. This may be the case when the screen is new, but when it is slightly worn, as the tank-sand shows, it constantly lets through much coarser pulp. These screens are said to work exceedingly well, and are the invention of the superintendent of that mill. In dry-crushing mills the brass- and steel-wire screens are used. In gold-mills, from No. 5 to No. 9 slot is the common size; in silver-mills, wet- and dry-crushing, from No. 40 to No. 60 wire screen, although the usual number is 40. At Bodie (wet-crushing) they use as low as No. 20, and at the Manhattan, Eberhardt, and Aurora (dry-crushing), they use No. 60. No account of any concave screens is included in census schedules. The numbers by which punched screens are known correspond to those of ordinary sewing-needles, from which the punches are made. The width of the slots in slotted screens is equal to the diameter of the hole in a punched screen of the same number. The number of a wire screen is the number of meshes to the linear inch.

The Order in which the Stamps fall.—The order in which the stamps fall has a great influence upon the crushing-power of the battery. Four orders are in general use—namely, 1, 4, 2, 5, 3; 1, 5, 2, 4, 3; 1, 3, 5, 2, 4; and 1, 3, 5, 4, 2. Many other orders are used, but they are usually adopted through ignorance of the proper order. Millmen do not agree as to which one of the above-named four orders is the correct one. It is a safe rule to lay down, however, that no one of the four stamps after falling should be followed by either of its neighbours. This is the case with the second and fourth orders mentioned, and, although they do not give the pulp a bad motion, the first and third are preferable, and of these two the first seems the best. This opinion is borne out by the usage in most places, many more batteries dropping in the order 1, 4, 2, 5, 3, although 1, 5, 2, 4, 3 is the order in the California-Mill batteries and many others. There is generally one cam-shaft for every ten stamps, the second row of stamps having their cams so set that no two stamps fall at the same instant. In dry-crushing batteries it is often customary to give the outside stamps half an inch more drop than the others, in order to prevent the pulp from drifting too much to the corner.

Pan-amalgamation.

Plant.—The number of pans required in a mill in proportion to the number of stamps is governed by the character of the battery (whether it is wet or dry), the quantity of ore crushed by the battery in a given time, the time required to amalgamate the ore, and the size of the pans to be used. In wet-crushing mills the proportion varies from two pans to every five stamps, to two pans for every stamp. This latter is the case at the Leeds Mill, at Silver Reef, in Utah. Generally, from two to three pans, holding from 3,000lb. to 4,000lb., are required for every five stamps. In dry crushing two pans to five stamps are always sufficient unless the pans are small or the ore is very easily crushed; and sometimes one large pan can be made to do the amalgamating for five stamps. In mills recently built one settler is allowed for every two pans. In the Star Mill, at Cherry Creek, and at the Manhattan, in Austin, there is a settler for each pan. This is probably unnecessary, as roasted pulp is very easily settled. Agitators are in use on the Comstock, at Bodie, and in some other places; but they are not generally employed. The object in using them is not only to catch the amalgam which may sometimes escape the settler, but to save the coarse sand or concentration which may have been but imperfectly worked in the pan. The agitator is also a convenient receptacle for sweepings and metalliferous refuse. Where agitators are used the proportion is one agitator to every five or six settlers. A clean-up pan is always needed in a mill, for in it the amalgam from scraping the pans, mullers, and all castings can be separated from the pulp and sand with which it is mixed. It is also very convenient for cleaning quicksilver.

Pans for Working Ore.—The pans used in the amalgamation have a capacity of from 1,500lb. to 4,000lb., and are of various construction. One only of them will be described (*a*), the "Combination," which, with its various modifications, is the one most employed in silver-mills. When this pan is used for working free ore the sides and bottom (the latter perfectly flat) are cast in one piece. The sides flare slightly upwards, the top being an inch or two larger in diameter than the bottom. A cast-iron cover is made to fit the top closely, and in this there is a hole with a cover, through which the charge is introduced. The bottom of the pan is either provided with slots to receive the lugs of the dies, or with a false bottom, about an inch thick, provided with openings for the lugs which hold the dies in position. The bottom of the muller is flat, and also contains slots in which the lugs of the shoes are fixed. There are three wings or flanges placed at the top of the pan at equal distances on the circumference. When the muller is in motion the pulp is thrown to the outside of the pan, and, rising to the top, strikes against the wings, by which it is projected to the centre, when it again falls to the bottom. In this way a complete circulation is obtained, the pulp not only flowing around the pan, but receiving a motion from the outside to the inside and downwards, and from the inside to the outside and upwards, thereby inducing an intimate mixture between the pulp and the quicksilver. When it is necessary to grind the pulp the muller is lowered by means of a screw in the top of the sleeve until the bottoms of the shoes just touch the tops of the dies.

Some of the other pans in use also give a fair motion to the pulp, but for convenience in handling and quantity of work the Combination pan up to the present time has best fulfilled the conditions of the amalgamation of silver-ores.

When this pan is used for working roasted ores its construction is somewhat different: the bottom is of cast-iron, wooden staves are used for the sides, and the cover is made of wood; the die, instead of being in several pieces, is cast whole, completely filling the bottom of the pan; the shoes and muller are one casting, and as little metal is exposed as the necessary construction of the pan will permit. This is for the purpose of reducing as much as pos- sible the action upon the iron of the acids and acid-salts frequently present to a greater or lesser extent in roasted pulp. Pans for working

raw ore are also sometimes made with wooden shoes, this under certain conditions being a cheaper construction. In the Combination pan the number of the shoes is from six to twelve, and they weigh from 500lb. to 800lb., and are from 2in. to 3in. thick. The dies are similar in number, weight, and thickness. In some mills, as at Austin, when the shoes are worn off the mullers they are replaced by wooden ones, which answer the same purpose as the iron, the object being to give motion to the pulp, and not to grind.

Method of Heating Pans.—The usual method of heating pans is by injecting live steam directly into the pulp by means of an iron pipe, which descends near the outside of the pan to within 6in. or 8in. of the bottom. This method is unquestionably the best, but it has its disadvantages, of which the diluting of the pulp and continual wearing-away of the pipe are the greatest. This latter is particularly the case with roasted ores. In Virginia City, where the pulp is run thin, the slight dilution caused by steam is of little importance; but in places where it is necessary to keep the pulp thick it is inconvenient. It is less objectionable in working free than in working roasted ores, for there are many kinds of the latter which, although they may be charged into the pan so thick that they check the motion of the muller, yet in the course of half an hour or so, the different salts having dissolved, they become so thin that with the consequent rapid circulation they slop over, and this without the addition of steam. The effect of running roasted ore as a thin pulp is to a great extent counteracted by the fact that roasted ore, being easy of amalgamation, does not require the quicksilver to be so finely divided and so intimately mixed with it as is the case with raw ores.

Another method of heating is by means of a steam-jet under the pan, and more rarely by means of a jacket, in which exhaust steam may be used. It is only with the freest ores that it is safe to heat pans in this way, and even with such ores the pan frequently leaks into the steam-chest. The reason for this is plain: the action between the salts (whether in the shape of chemicals added to the ore or formed in the roasting) and the iron of the pan will be strongest at the hottest point—namely, the bottom of the pan, and should there be a defective spot in the casting a hole would soon be eaten through. In Bodie this method is in use; but the conditions are favourable, as the ores are free.

Number of Revolutions of Pans per Minute.—Pan-mullers generally make from sixty to ninety revolutions per minute. It is true that the faster the muller is run the more work is done in a given time; but questions of wear and tear of machinery have thus far usually limited the speed to ninety revolutions. The pans at the California Mill are geared to run ninety-five revolutions.

Weight of Charge.—A pan-charge weighs from 1,500lb. to 4,000lb., according to the size of the pans. A 4,000lb. pan is 5ft. 6in. in diameter and 30in. deep. In working rich ore the charges are generally smaller than in working low-grade pulp.

Temperature.—The temperature maintained in the pan has much influence upon the amalgamation of the ore. The effect of temperature on the amalgamation of the base metals, lead and copper, is not very well understood, and it can only be determined by careful and exhaustive experiments. It seems to be a well-established fact that in the amalgamation of chloride-ores, which carry a considerable percentage of carbonate of lead, a fine bullion may be obtained, without an appreciable loss of silver, by keeping the temperature of the charge considerably below the boiling-point, say at 120° Fahr. At exactly what temperature it will be necessary to keep a given kind of pulp experiment alone can show. Time, as before mentioned, has also an influence on the results. The reason for the earlier amalgamation of the silver at a temperature of 100° Fahr., or thereabouts, seems to be that the conversion of the carbonate into the chloride of lead (the form in which it is necessary for the lead to be in order to be precipitated by the iron and amalgamated by the quicksilver) takes place much less readily at a temperature of 100° Fahr. than it does at 200° Fahr. Were the conditions entirely uniform the metals would be amalgamated in the order of their electro-negative properties—that is to say, first silver, then copper, and last lead; but in practice this is not the case, as unquestionably lead is amalgamated at the same time as the silver. The reason is that the pan and the pulp do not furnish all the conditions of a true galvanic cell. For instance, it is possible to conceive of a particle of carbonate of lead not in conjunction with a particle of chloride of silver coming into contact with the iron of the pan in the solution of salt and bluestone, as the case may be. Under such circumstances the particle of carbonate would be converted into chloride and metallic lead, and precipitated and amalgamated.

It is customary to keep roasted ore at a temperature of 200° Fahr. At the California Mill the pans are heated to 150° Fahr.

Time of Working a Charge.—The time occupied for working a charge is from five to eight hours. It is largely governed by the value of the ore. With any given ore experience shows how far it is profitable to prolong the amalgamating process, which proceeds more and more slowly as the silver is taken up. In many cases, where a comparatively small portion of the silver is extracted by pan-amalgamation, this is not due to the imperfection of the process, but to the fact that under the local economic conditions it is not profitable to continue the process until a large percentage is saved.

Continuous Amalgamation.—A system of handling ores in wet-crushing mills, known as the "Boss" process, has been introduced at Bodie, which dispenses with the laborious work of shovelling the pulp from the settling-tanks. The ore is, as usual, crushed in a battery, but with as little water as possible, and the pulp is then conducted to the first of a series of pans in which the mullers are revolving. From this pan it flows to the next, and so on through the series, until from the last pan it passes through a sieve, and finally from the last settler out of the mill. The pans are heated by steam in false bottoms, so that the pulp is not thinned—it becomes thicker as it progresses. The chemicals are added in the first pan, and the quicksilver is added at a stage when the pulp is thick enough to hold it.

Grinding.—When ores are submitted to chloridizing roasting, grinding is scarcely necessary, because the silver-chloride passes into solution; and to some extent this is also true of raw chloride-ores: but with all other ores a finer comminution than can be attained in the battery is probably

essential to effectual amalgamation. As a rule the muller is kept down about half the time necessary to work the charge. During this period chemicals, such as bluestone and salt, if added, are supposed to have produced their full effect, and at the close of it quicksilver is added. After the addition of the quicksilver the shoes are usually raised from the dies, to avoid the flouring of the quicksilver by excessive mechanical division in the presence of more or less adherent substances. At the California Mill, it is true, grinding is continued throughout the entire treatment in the pans, and it is said with satisfactory results. This practice seems to carry great authority, because the usual method was formerly pursued under the same management. Possibly, however, the charges in the pans at this mill contain less adherent material than is ordinarily the case; it is certainly less base. Grinding after the addition of quicksilver is especially objectionable if lead is present. It is asserted by some millmen of experience that grinding is unnecessary with silver-ores unless they contain a large proportion of gold; and there is no doubt finer bullion is obtained when the ore is not ground: but gold is more readily amalgamated than silver, and if grinding is desirable when gold is present it is difficult to avoid the conclusion that it is still more essential when the ore is purely argentiferous. Thus, 76 per cent. of the assay-value of the gold contained in about 300,000 tons of Hale and Norcross ore, during eight years ending 31st January, 1874, was saved by amalgamation, while only 61 per cent. of the silver in the same ore was extracted. As is the case with all technical operations, local economic conditions determine the extent to which grinding is profitable; but experiments to determine such points are too often omitted, or conducted under the bias of preconceived opinions.

Quantity of Quicksilver added.—To effect a separation between the pulp and the amalgam it is essential that a certain volume of quicksilver should be added to the pans, for otherwise the amalgam would not gather at the bottom of the settler. Not less than 100lb. of quicksilver to a ton of ore appears to be sufficient for this purpose; and for the ordinary pan, constructed to treat two tons of ore at a time, the minimum charge of quicksilver is consequently, as a rule, 200lb., and this only when the ore is free and of low grade. When the ore is rich a further addition of quicksilver is made. The proportion of quicksilver to silver in the fluid amalgam should never be less than 1lb. to the ounce, however rich the ore may be. In working free ore the quicksilver is added from two to four hours after charging, but with roasted ores it has become a custom to add the quicksilver at once upon charging; and experience has shown that when this plan is adopted amalgamation is more complete, while the loss of quicksilver is not increased.

Chemicals used in Amalgamation.—The list of chemicals used in the amalgamation of silver-ores is growing smaller year by year. At present, except in a few isolated cases, the only chemicals employed in working ores raw are salt and bluestone. The reactions which take place in pan-amalgamation have been but little studied—indeed, chemists have not yet reached definite conclusions as to the essential reactions of the patio process, a subject to which a number of elaborate investigations have been devoted. There seems little question that the use of bluestone and salt accelerates the reduction of argentite. The sulpho-salts of silver are also attacked, but are either only partially decomposed or so slowly reduced that it is not so cheap to treat them raw with chemicals as to submit them to a preliminary chloridizing roasting.

There is no exact rule in use governing the quantity of bluestone and salt added, though larger quantities of chemicals are usually employed in working high-grade ores than in treating poor ones. The baser the ore the more bluestone and salt are commonly considered requisite; but the quantity of each can only be increased to that amount which will result in the yield of silver corresponding to the cost of the extra weight of bluestone and salt employed. There can be no doubt that much money has been wasted in the unnecessary and ineffective use of chemicals. The proportion which salt ought to bear to bluestone is another point which, although of the greatest importance economically, is not well understood. Most millmen use more salt than bluestone, but others more bluestone than salt. On the Comstock, where experiments have been conducted for many years, the proper quantity of bluestone and salt, and the proportion of one to the other, to be used with any grade of ore of that district, have been ascertained approximately; but Comstock rules would not apply in general to other ores, though, doubtless, there are many of substantially the same character. At the California Mill, with thirty-dollar ore (£6 5s. per ton), 2lb. of bluestone and 6lb. of salt are used per charge of two tons; with eighty-dollar ore (£16 13s. 4d. per ton), from 10lb. to 12lb. of bluestone and 20lb. of salt. The chemicals are added on charging. Modifications in the Comstock practice depend on the baseness of the amalgamation, the tailings-assays, and the appearance of the quicksilver. When silver occurs almost entirely in the form of chloride little or no bluestone is required.

When grease has got into the pans caustic potash, soda, ashes, or cyanide of potassium is added. The latter is also used upon the quicksilver in the tubs to keep it clean. Caustic lime is sometimes used with roasted ores containing a great deal of cupric chloride. It forms chloride of lime, reducing the cupric to cuprous chloride.

Sodium-amalgam is found to be useful in amalgamating ores which contain binoxide of manganese, as it prevents the flouring of the quicksilver which that mineral occasions. Chemicals are added on charging, with the exception of caustic potash, soda, &c., which should be added with quicksilver, which they are designed to keep bright.

At Dayton, where large amounts of the Comstock's tailings are saved and worked, it is customary to add sulphate of copper in acid solution in large quantities—sometimes as much as the equivalent of 30lb. of bluestone when it is found that the loss of quicksilver exceeds the usual quantity. The Comstock tailings contain a very large proportion of clay, and the loss of quicksilver is probably in great part a mechanical one. The clay is said to "ball up," and carry off globules of quicksilver. The acid sulphate probably acts on the clay very much as alum does, promoting its precipitation.

Use of Iron in Pans.—Iron is one of the important factors in the amalgamation of silver-ore. It is used in various forms—in the first place, as cast-iron, in the material of the pans; as wrought-iron, in the form of rings, it is sometimes put into pans, and it is occasionally added to the charge in the form of shavings, filings, &c.

In working free ore much less iron is required than in working roasted ore, and the ordinary wear of the battery and pans is generally sufficient. One pound of iron will precipitate 3·85lb. of metallic silver from the chloride; but in practice more than that amount of iron is consumed when there is copper either present in the pulp or added in the form of bluestone. Carbonate of lead is also believed to increase the consumption of iron.

With roasted ore much more iron is required, and when there is a great deal of lead and copper present sometimes as much as 20lb. of iron to the ton are consumed, not including the iron needed to precipitate the silver. The best form in which to use iron in pans is as wrought-iron filings, sifted as fine as possible; but such filings are expensive, and difficult to obtain. The turnings from a lathe are the best substitute. These wrought-iron fragments protect the cast-iron of the pan to a great extent from the corrosive action of the different salts in the roasted pulp, as they are more readily dissolved, thus relieving the pan itself from a large amount of loss.

At the Manhattan Mill, Austin, 10lb. of iron-turnings are used to the charge, and they are almost completely consumed. Four pounds of this iron would be sufficient to precipitate the silver; the other portion, as well as the iron from the pans, is probably employed in decomposing lead- and copper-salts.

Loss of Quicksilver.—The usual loss of quicksilver runs from ½lb. to 3lb. to the ton of ore treated. A reasonable limit of loss in present practice is 1½lb. per ton. The waste is in part owing to the difficulty of completely separating the quicksilver from the sand in the settler; and this is particularly the case with ores which contain carbonate of lead or other heavy minerals. To counteract the mechanical difficulty agitators are sometimes used; riffles and blankets in the sluice-box from the settlers are also occasionally employed. In ordinary cases sufficient separation can be effected in the settler by proper arrangement of the shoes on the muller and the regulation of the speed of rotation; but a certain amount of quicksilver is, no doubt, always carried off in minute globules.

A second cause of the loss of quicksilver is the formation of lead- and copper-amalgams in the treatment of ores containing these metals or in working silver-ores with bluestone. These alloys are pasty substances, which are rapidly reduced to the finest powder by grinding; in other words, the quicksilver is floured, and the separation in the settlers is very imperfect. The most radical cure for this condition of the quicksilver is the addition of sodium-amalgam in the pans before the ore is drawn off. Sometimes the loss is not sufficient to warrant the use of this expensive alloy, and in such cases it is better to gather the quicksilver and amalgam together as well as may be by prolonged treatment in the settler.

In the patio process of amalgamation a very large amount of quicksilver is converted into calomel and lost. In the pan process it is highly probable that one or both chlorides of mercury form to some extent; but these compounds are for the most part reduced by the iron. Were this not the case the loss of quicksilver would be far greater than that actually sustained.

Clean-up Pans.—In most mills which run regularly there is a general clean-up at the end of each month. A very considerable quantity of hard amalgam adheres to the shoes and dies and fills the interstices of pans and settlers, which is removed when new shoes and dies are put in place. In custom-mills a clean-up is sometimes made when each lot of ore has been worked off, if the lots are of considerable value.

Settlers.—The usual size for settlers is a diameter of 8ft. and a depth of 3ft. Occasionally they are found 9ft. in diameter, and 10ft. settlers are reported at two mills. For ordinary work a diameter of 8ft. is sufficient. At the Manhattan Mill, where the settler is used with an iron pan, the settlers are 6ft. in diameter.

There are two different kinds of mullers used in settlers. In the mills on the Comstock and some others the "spider" muller is common. This consists of four arms projecting horizontally from the centre of the muller, and upon each one of these arms a shoe, either of wood or iron, is fastened, which serves to plough up and keep in motion the sand at the bottom of the settler. The other form of muller ends downwards in a round disc of iron, which fills the bottom of the settler to within 3in. or so of its circumference, upon the under side of which long wooden shoes, 3in. thick, radiating to the outside, are fastened. A settler thus arranged is the best for base ores, as it prevents the rubbing and assimilation of the floured particles of amalgam in the bottom of the settler. The muller usually revolves from twelve to fifteen times per minute, although it is sometimes geared to make as many as eighteen revolutions. This, however, is only where very heavy ore is worked, or where the ore has been crushed through a very coarse screen. Such a speed is always attended with more than the usual loss of quicksilver. The greater the diameter of the settler the less ought to be the number of revolutions of its muller. It is customary to keep the charge in the settler until it is time to discharge a pan into it—that is to say, from two to four hours. It is much easier to settle chloridized pulp than that which has not been roasted; for in the process of roasting the particles of quartz, &c., become porous and friable; they are consequently ground finer, and can be retained in suspension in the water with much less motion of the muller.

It requires from fifteen minutes to half an hour to discharge a settler through the series of holes provided for that purpose. The top plug is, of course, first to be drawn, in order that the quicksilver may have as long as possible to settle, and to avoid the production of rapid currents, which might carry off amalgam. A more rapid discharge would defeat these objects.

Agitators.—Agitators are not very frequently used. When they are employed it is more for the sake of concentrating the settler-sands, sweepings, &c., than for catching amalgam. They are usually 7ft. in diameter and about 3ft. deep. The assay-value of the sands recovered in them is usually higher than that of the tailings, and less than that of the ore. Agitators are generally geared to make twelve revolutions per minute.

Tailings.—The tailings of free silver-ores are almost always saved; those from roasted ores are scarcely ever. Tailings from the battery of a gold-mill are handled in different ways, but the following is the usual method; After passing through the screens, the tailings, which contain con-

siderable gold-amalgam when battery-amalgamation is practised, flow over an amalgamated copper plate, or silver-plated copper plate, on which the most of the quicksilver-alloy is caught. This plate is as wide as the battery-screen, and usually from 3ft. to 5ft. long, and is called the apron. From the aprons the tailings flow into the sluices, in which are also amalgamated-silver or copper plates, alternating with boxes, or riffles, or boxes for catching the quicksilver, and finally reach the sluices, in the bottom of which blankets are laid. On these blankets the sulphurets, which are usually rich in gold, are caught. After leaving the blanket-sluices the tailings sometimes run into a concentrator, in which further valuable contents are recovered from them. The Hendy concentrator, the one mostly employed in California, is usually placed after the plate-sluices and before the blankets. Buddles are often used, as well as the Frue vanner. The blankets used are generally 20in. wide, and are manufactured for the purpose by the woollen-mills in San Francisco. The arrangement of amalgamating and concentrating apparatus in gold-mills varies greatly, however. At the Idaho Mill, for example, there is no battery-amalgamation, and the pulp from the battery is immediately concentrated on blankets. The concentrations are treated in pans, and the tailings from the blankets pass over riffles and other amalgamating apparatus to buddles.

Weathering of Concentrations.—Concentrations are allowed to weather from three months to a year, salt sometimes being added to assist the decomposition, when it is the custom to work them in pans.

Percentage recovered from Concentrations.—The Plattner chloridization process and its modifications save 90 per cent. and upwards of gold contained in sulphurets; but the percentage obtained by other methods is much less. It depends on the character of concentration, length of exposure to weathering, and the process by which the sulphurets are worked. The yield by other methods of chloridization often falls below 50 per cent., though usually it is higher.

Treatment of Tailings from Silver-ores.—With that class of silver-ores that is treated raw it is rarely possible to extract such a percentage as to render the tailings worthless, and therefore these are commonly saved and allowed to weather, salt sometimes being added to assist the decomposition. As a rule, however, there is enough salt remaining in the tailings after working the ore to produce, in course of a year or two, the required effect. It must be remembered that, no matter how fine a particle of tailings may be, there can still be a particle of silver-mineral in the centre of it so completely enveloped by earthy material that chloride cannot act upon it and quicksilver cannot touch it. When tailings are treated, only that portion of silver is amalgamated which is exposed to contact with the quicksilver. As the outsides of these tailings-particles have already been once subjected to the influence of chloride and quicksilver, the amount of silver which can be recovered by a second amalgamation—of course, taking it for granted that the ore has been properly treated in the first instance—except where long-continued grinding is practised, or where the character of the gangue has been changed by weathering, is exceedingly small. The percentage extracted from tailings does not often exceed 50 per cent. of the assay-value, and generally falls below this point. With the tailings from roasted ore, which are of lower grade than those from raw working, it is still more difficult to obtain the silver.

Slimes.—Slimes sometimes assay more than the ore itself, sometimes less. The percentage of slimes escaping from wet-crushing mills varies from 1 to 15 per cent., according to the character of the ore. Ores containing much iron-oxide generally produce the most slime. The slimes are usually first caught in large tanks, and then in shallow ponds. Eventually very little escapes if proper settling-room is provided.

Samples of Ore.—Samples of ore are sometimes taken from each car-load at the mine. This is the case at the California, where a handful is taken from each car. When the ore of a mine is treated by a custom-mill ore-samples are often taken by the mine-owners as a check upon the working of the mill.

Battery-samples.—Battery-samples are always taken at the mill, and in wet crushing generally in the following manner: Every half-hour or hour a rectangular iron box, or dipper, is passed along the lips of the mortar where the pulp falls into the sluices, and a portion of the slimes and sand is taken, care being preserved to prevent concentration by the overflowing of the box. The sample is put into a bucket with others, and at the end of twenty-four hours the clear water is poured off, and the collective samples for the day are dried and prepared for assay. In dry-crushing mills it is usual to take the sample by passing a box along the lower part of the screen every hour or so. Sometimes the sample is taken from the conveyor, or from the pulp in the bins.

Ore-assays.—Ore-assays are generally made in crucibles, though with very base ores scarifiers are sometimes used. They are seldom corrected for loss in assaying.

Roasting-furnaces.

Systems of Furnaces.—There are many different kinds of furnaces in use for chloridizing ores. Among the more common types may be mentioned the Howell, Brückner, White, Stetefeldt, O'Hara, and ordinary reverberatory. The Howell, Brückner, and White furnaces are revolving cylinders. The axis of the Howell and White furnaces is at an angle of a few degrees to the horizontal, the ore being fed at the higher end and discharged at the lower. In the White furnace the ore and the flame from the fire-box enter the furnace together at the higher end. In the Howell the ore is fed in at the higher and the flame enters at the lower. This constitutes the material distinction between these two furnaces, and the difference is in favour of the Howell. The Brückner is a cylinder of boiler-iron, with ends usually made of the same material, though sometimes they are of cast-iron. In the centre of each one of these ends, or heads, there is a hollow trunnion, through which the flame enters or passes out of the cylinder. The axis is horizontal; but, like the Howell and the White, the furnace revolves on a series of wheels or rollers. The motion is conveyed to all these furnaces by a system of gearing, a belt of cogs passing around the outside of the cylinders, which gears with a small spur-wheel on a counter-shaft below the furnace. By an improvement in

the gearing of the Brückner the speed may be varied from zero to six revolutions per minute, according to the requirements of the roasting process. In the Brückner furnace the charge—of about 3,000lb.—is introduced through a door in the cylinder, placed half-way between the two ends, which is closed by means of a clamp. These furnaces are constructed with two doors opposite each other. A characteristic feature of the Brückner cylinder is the diaphragm, which consists of iron plates about 1in. thick, fastened to tubes passing through the cylinder at right angles to its axis. The plane in which these tubes are placed makes an angle of about 30° with the axis of the cylinder, so that the line where the plates and cylinder meet is an ellipse. This diaphragm extends to within 18in. of each end, and when the furnace revolves it produces a circulation of the pulp from one end of the cylinder to the other. Although this diaphragm gives an almost perfect motion to the ore, it has several disadvantages, among which are the following: The cast-iron of which the plates are composed is corroded by the action of the sulphur and chlorine; and the lively motion conveyed to the pulp causes a great portion of it—sometimes as high as 30 per cent.—to be carried into the dust-chambers. A great part of this dust, too, leaves the furnace before it has had time to be roasted, and thus escapes decomposition altogether. In consequence of these disadvantages the diaphragm is now usually omitted. Although the furnace as at present constructed does not cholridize to quite as high a percentage as it would if provided with a diaphragm, it has been proved to be far better suited to the economical working of ores. When the charge has been properly roasted, it is discharged through the doors by opening them and revolving the cylinder. As these furnaces are at present built the speed can be increased when it is necessary to discharge by introducing a gear-wheel of larger diameter than that which ordinarily gives motion to the furnace. The Stetefeldt is a high-shaft furnace, into which the flame enters from two fireplaces on the sides at the bottom, the ore, mixed with salt, being fed into it at the top. The fumes and dust pass out through a flue at the top, descend, and, after passing through the flame of a smaller auxiliary fire, are conducted to the dust-chambers, whence the fumes escape through the stack. The ore only occupies a second or two in passing through the flame; but it is retained at the heat at the bottom of the furnace three-quarters of an hour before drawing the charge. The auxiliary fire has also been applied in connection with the revolving cylinders, and with good results. The reverberatory furnace, as applied to the chloridation of silver-ores, has sometimes one hearth, and sometimes two or three hearths. When several hearths are used the ore is first put into the one nearest the flue, and after roasting a time is raked to the next, and finally to the last near the fireplace. Thus, in a furnace with three hearths there are always three charges in different stages of roasting. The O'Hara furnace is a brick double-decked reverberatory one, 9ft. high, 8ft. wide, and 60ft. long, in which the ore is stirred with scrapers or hoes attached to an endless chain moved by the mill machinery. The two hearths are level, one above the other, and 47in. apart (arches 10in. spring), 60ft. long, and only closed at the ends by hinged sheet-iron doors. These doors close the furnace so that the draught is not injuriously affected, and also enable the scrapers to pass under them readily. There are four fireplaces, two on each side, so arranged that all may be used to heat the lower hearth, or two of them may heat the upper hearth. The draught is through a stack connecting with flues from the arches over the hearth. The endless chain passes over both hearths in opposite directions, and over a pulley at the end of the furnace. To one of these pulleys power is transmitted by spur- or friction-gearing. To the chain, at equal distances apart, are attached two scrapers. Each of these carries fourteen hoes—plates of wrought-iron, about the size of a hoe—which are dragged along the hearths through the ore. These hoes are set at a slight angle with the chain, thus moving the ore somewhat forward as well as turning it over. The hoes of one scraper are set in a reverse position from those of the other: thus the ore is not pushed to the centre or sides of the hearth, and the furrow made by one scraper is filled by the next. As the links of the chain and scrapers pass from one hearth to the other through the outer air, they are but little attacked, and last for months. It is not absolutely necessary to line any of these furnaces with fire-brick; but it is always best to use fireproof material in the neighbourhood of the flame. As a rule, fire-brick is much harder than the ordinary brick, and for that reason is better suited to stand the tear and wear of a revolving-furnace. There is not much difficulty in keeping the brick in place in the Howell and White furnaces, their diameter being small; but with the Brückner it is otherwise. The large diameter of the furnace causes the arch to be insecure unless the bricks are good and put in very tightly. A very good method of increasing the security of the lining is to divide the circular arch into four parts by running flanges of boiler-plate the length of the cylinder, thus making four independent arches. For this furnace it is cheaper in the long run to use the best fire-brick, and as little clay as possible. Salt and ashes are said to make a very good mortar for laying the bricks in place, and they certainly form a mortar which does not contract on being exposed to heat. The heads of the Brückner furnace are usually lined with the best fire-clay, tamped around and over projections of iron, or large bricks are moulded in the form of a segment of a circle and fastened to the heads by clamps and bolts.

Dimensions of Furnaces.—The dimensions of the Howell furnace are as follows: Length, from 16ft. to 27ft.; inside diameter, from 24in. to 38in. The furnace is made in several sections, which are bolted together. Formerly the two sections near the fireplace were made larger than the others, and were only lined with brick. It has been found good policy, however, to make all the sections the same diameter and line the cylinder with brick throughout. The White furnaces are usually shorter than the Howell, and of greater diameter, and are lined throughout their whole length. The bricks forming the lining of these furnaces are usually set on edge. The Brückner cylinder is usually 12ft. long and 5ft. in diameter inside, the bricks being laid flat. Some furnaces, however, have been constructed for the Ætna Company, at Galena, Nevada, 16ft. long and 6ft. 6in. in diameter. These furnaces are provided with four discharge-holes. The Stetefeldt furnace is built of different sizes: the shaft proper is usually between 30ft. and 40ft. high. The usual size of a reverberatory-furnace hearth is 12ft. square, the arch being made low in order to keep the flame as near the pulp as possible; but they are sometimes much longer. In the Howell furnace the

discharge-end is from 7in. to 10in. lower than the feed-end. The cylinder is geared to make from three to six revolutions per minute, according to the diameter of the furnace, the angle of the incline, and the character of the process. The less the diameter the greater will be the speed. These furnaces are now arranged so that the speed can be increased or decreased at will, so as to vary the length of time that the ore requires to pass through. By decreasing the speed the ore is retained longer in the furnace, thus facilitating the working of baser ores. The Brückner cylinder ought to be geared so as to make one revolution in two and a half or three minutes if 5ft. in diameter, or one revolution in four minutes if of the larger size, 6ft. 6in. in diameter.

Capacity of the Different Furnaces.—The Howell, White, Stetefeldt, and the reverberatories with several hearths, or with a single very long one, are continuous furnaces; the Brückner and the reverberatory with a single short hearth finish a given charge before a second is introduced. The capacity of the ordinary-sized Howell and White furnaces is from ten to fifteen tons, although twenty tons are sometimes put through these furnaces in twenty-four hours, and at the Alexander Mill, in Nevada, when working on ore containing most of the silver as chloride, a capacity of fifty tons was reached. The 12ft. by 5ft. Brückner cylinder will hold about two tons of ordinary ore, the amount put through in twenty-four hours depending on the time needed to roast, which is very different for different ores. A Brückner will ordinarily work six tons a day. The Stetefeldt furnace can work from twenty to sixty tons, according to its size, in a day, and the reverberatory furnaces from 1,000lb. to 2,000lb. to the charge. The only O'Hara furnaces reported have a capacity of twenty tons each in twenty-four hours.

Methods of feeding Ore into Furnaces.—In the Howell and White furnaces the ore, mixed with salt in the battery or after crushing, falls from the elevator into a chute, which carries it into the upper ends of the furnaces. For the Brückner the ore and salt are crushed in the battery together and conveyed to the hopper above the furnace; or the salt, having been ground fine in a mill or crushed by a separate battery, is added after the charge is partially roasted. At the Custer Mill, in Idaho, the salt is pulverized separately, but is added with the charge of the ore. The same methods are used with the reverberatory furnaces. In the Stetefeldt the feed of the ore and salt is regulated by mechanical appliances, so that the supply of each entering the furnace can be adapted to the necessities of the ore.

Methods of conveying Ore to Furnace.—The usual way of carrying ore from the battery to the furnaces is by means of screw-conveyors and elevator-belts with sheet-iron cups attached. Sometimes cars are used for this purpose.

Manipulation in Roasting.—In the ordinary reverberatory the work to be done consists in raking and hoeing from the flue-end of the furnace to the fire-bridge and back and forth, so as to expose every particle first to the oxidizing influence of the air, and then to the chloridizing effect of the decomposing salt. The quality of the roasting depends almost entirely upon the care and diligence with which this manipulation is performed. After the roasting is completed the ore is raked from the furnace to the cooling-floor and there sprinkled with water, either immediately or after an interval. In the Stetefeldt, every three-quarters of an hour the door at the bottom of the shaft-stack is opened, and the ore which has collected at the bottom is drawn out upon the cooling-floor and sprinkled with water. In the Howell furnace the ore falls from the lower end of the cylinder into an iron box set in a chamber between the fire-box and the furnaces, and closed by iron doors. When the box is full the doors are opened, and it is swung by means of a crane out upon the cooling-floor and dumped. It is then replaced, and the doors closed. A simple brick oven may be substituted for this movable box. When the charge in the Brückner is completely roasted the furnace is stopped, and, the discharge-doors having been opened, it is again put in motion, and as the cylinder revolves the ore falls directly on the cooling-floor. It is almost completely discharged in ten revolutions, after which another charge is introduced. Whichever furnace is employed the product is, or should be, the same. The colour varies from a light reddish-yellow to a dark brown, its shade depending on the amount of oxide of iron. It should have a light, porous, and woolly appearance, and when taken out should show no sulphurets.

Temperature Maintained.—In the Brückner and the reverberatory furnaces, after the desulphurization of the ore, which requires from two to eight hours, the temperature is raised and the chloridation period begins, which lasts from two to four hours. In other furnaces, with one exception, a uniform temperature about a cherry-red is maintained at the fire-bridge, the ore being exposed to higher and higher temperatures as it passes through the furnace. In the original White furnace the ore is heated to the highest temperature at the point of entry.

Tenor of Ore to be Roasted.—Silver-ores which require roasting before they can be amalgamated are of very varied composition. There are some ores which contain so little sulphur that only an incomplete chloridation is obtained unless sulphur, either in the form of brimstone, iron-pyrites, or copperas, is added before the ore is introduced in the furnace, sulphur in some form being necessary for the decomposition of the salt and the liberation of the chlorine. There are other ores, on the contrary, which contain so much sulphur in the form of sulphides that a long oxidizing roasting is necessary before the ore can be prepared for chloridation. The typical roasting-ore is quartz containing silver-minerals and from 10 to 15 per cent. of iron-pyrites, with a slight admixture of copper-sulphides. Calc-spar, braun-spar, and fluor-spar, if present in any quantity in the ore, retard the chloridation, as they absorb a large part of the sulphuric acid. Arsenic and antimony minerals increase the loss of silver by volatilization. Zinc-blende requires a longer oxidizing roasting to convert it into sulphate, and then a high temperature must be maintained before it will decompose the salt. When there is a large amount of zinc in the ore the chloridation is an imperfective one. Lead and copper contaminate the amalgam and the bullion. All these minerals involve the use of a large percentage of salt in roasting, but if present in only small quantities they do not perceptibly affect the chloridation. In mixing ores the sulphur and the silver contents of the charge are kept at those percentages which have been determined in actual practice to be the most favourable under the circumstances to the chloridation of the silver. The effort made to attain

rational rules as to the most expedient relations of silver, sulphur, salt, &c., was a failure, most of the managers having determined their mixtures empirically, and knowing nothing definitely of the percentage-composition of their ores. The richer and baser the ore the more salt it requires.

Duration of the Roasting Process.—In the Howell and the White furnaces the ore is exposed to the flame from seven to twenty minutes; in the Brückner and reverberatory from five to twelve hours; and in the Stetefeldt it is about two seconds falling through the flame, and remains forty-five minutes at the bottom of the furnace.

Oxidizing Roasting.—Where ores contain much arsenic and antimony much salt is saved by exposing them to a preliminary oxidizing roasting. This may be easily done in the reverberatory or Brückner furnaces; but in the Stetefeldt, Howell, and White furnaces it is not practicable. In roasting ores free from arsenic and antimony there appears to be no advantage in delaying the addition of salt.

Percentage of Salt used.—When the salt is mixed with the raw ore there is not much difference in the amount required to roast a given ore in any of these furnaces; but the Stetefeldt and the Brückner are supposed to require a smaller percentage than the others. From 3 to 15 per cent. of salt, according to the character of the ore, are the usual limits, 8 per cent. being the average. Salt is usually the chief item of expense in roasting ores, and millmen frequently use more than the quality of the ore demands. They think it is always best to be on the safe side, and by allowing a certain margin of excess often considerably increases the expense.

Sulphur-contents.—The percentage of sulphurets in roasting-ores varies from 1 to 70 per cent. The closeness with which it is necessary to keep a given sulphur-content varies with the different furnaces. In the Stetefeldt there is but little latitude, from 3 to 5 per cent. sulphur being the limits. If this quantity will not liberate chlorine enough to chloridize the silver, the ore must be reduced in grade by the admixture of poorer qualities. In the White and Howell there are larger margins, and in the Brückner and the reverberatory the very basest ores can be worked.

Percentage of Silver Chloridized.—The percentage of silver chloridized varies from 75 to 90 per cent. in these furnaces, it seeming to depend more upon the character of the ore and the method of working than upon difference of construction and manipulation. The difference in this respect is perhaps a little in favour of the Brückner and the reverberatory, as these furnaces permit of an oxidizing roasting before the salt is added.

Labour.—In all these furnaces except the reverberatory a man can roast five tons of ore per shift. One man can easily attend to two Brückner furnaces. In the reverberatory it is fair work for one man to roast one ton per shift.

Fuel.—Wood is the fuel used in all these furnaces except the Stetefeldt, where some charcoal is occasionally burnt. This wood is of many different kinds, and its value as fuel is chiefly governed by its weight. The different furnaces require on an average the following weights of wood to roast one ton of ore: Stetefeldt, 200lb.; Howell and White, 300lb.; reverberatory, 600lb.; and the Brückner, 900lb; the weights being calculated on the basis of 2,200lb. of wood to the cord. The Stetefeldt uses less wood than the others because it is solidly built of brick, and retains the heat better; the Brückner uses the most because it is a long cylinder, and it is necessary to reheat it each time it is discharged.

Power.—The power used to drive the mechanical furnaces is estimated at about two-horse power for the Brückner, and one-and-a-half-horse power for the White and Howell furnaces.

Dust-chambers and Flues.—The best arrangement of dust-chambers and flues is that of the Stetefeldt furnace. The system consists of a series of dust-chambers, sometimes as many as twelve, through which the dust and fumes must pass, giving the dust an opportunity to settle, and of a long flue connecting with a stack, which is generally placed on the hill-side some distance from the furnace. The dust-chambers nearest the furnace are opened several times a day, and the flue-dust raked out from doors at the bottom. The long flue is opened once in about six months, when the furnace is shut down. Two-thirds of the flue-dust is deposited in the first two or three chambers. The flues and dust-chambers of other furnaces are arranged in somewhat similar manner, except that they are not usually so complete. The dust-chambers are often placed under the dry-kiln, so that the heat from the furnace can be used to dry the ore, and the smoke-stack is often built in the mill itself.

Amount of Flue-dust caught.—The amount of flue-dust caught per ton of ore roasted depends on many circumstances, such as the character of the ore, its fineness, the style of furnace, and the draught. Those ores give the most flue-dust which, before they are roasted, are light and porous, and contain oxide of iron. The ores which give the least flue-dust are hard-quartz ores with sulphurets. Those ores which contain a large proportion of sulphurets do not, of course, need to be crushed as fine as those containing little, the sulphurets being readily attacked by oxygen and chlorine when unprotected by a coating of chemicals not affected by these gases. When there is no sulphur present it is necessary to add it as pyrites, brimstone, or, best of all, as copperas. The ore should then be fine, to facilitate the immediate and complete action of the chlorine. If the reverberatory furnace is properly handled it produces the least flue-dust, for the motion of the ore is less violent than in the others. With care in the reverberatory furnace the amount of flue-dust can be limited to 2 per cent. From the nature of the Stetefeldt furnace a considerable amount of the flue-dust passes into the dust-chambers, but as practically all of it settles there, and as, owing to the auxiliary fire, it is chloridized to a higher percentage than the ore itself, this fact is of no importance. As much as 10 per cent. sometimes passes over. This is also true of the Howell furnace, except that the dust is usually not so well settled as in the Stetefeldt. With the Brückner furnace the amount of fine flue-dust is usually not larger, but it is not chloridized so high as the ore, and sometimes requires a second roasting. The draught in all these furnaces can be regulated by dampers, one between the furnace and the dust-chambers, and the other in the smoke-stack.

Loss of Flue-dust.—The actual loss of flue-dust is very slight with most ores where the furnace has plenty of dust-chambers and long flues, and it probably does not exceed 1 per cent.; but when the ore is very finely divided, even under favourable circumstances, the loss may reach 5 per cent. Extensive dust-chambers are usually desirable. As regards the loss of silver and gold by volatilization, no reliable data are available. That there is such a loss cannot be questioned; but at the present there is no accurate means of estimating it. Except with ores containing much arsenic, antimony, and zinc, it is probable that it never exceeds 1 per cent.

Different Kinds of Furnaces compared with Each Other.—The principal advantages and disadvantages of the furnaces described may be briefly stated as follows:—

The Howell, of all the mechanical furnaces, is the one which is most easily handled. It is not an expensive furnace, and requires little power and few repairs. It has a continuous feed and discharge, which lightens the labour required. It is a furnace which, with the exception of the Stetefeldt, requires least fuel to roast a ton of ore. Its flue-dust is chloridized to a higher per cent. than the roasted ore, and, with the possible exception of the Stetefeldt, it requires less manual labour to run it. Like all continuous furnaces, it requires the ore to be crushed fine, and needs a larger percentage of salt when the the ore is light or at all base. These points, however, are not serious disadvantages. What prevents the furnace from being universally adopted is the fact that it is not available for the basest ores. The length of time during which a particle of ore is exposed to the action of the flame and the air is short, though in the latest furnaces the time has been considerably extended. The reason that this furnace is not adapted to chloridize the basest ores is, the period of oxidizing roasting, which begins at the flue-end of the furnace, is altogether too short to permit of any quantity of zinc-blende, galena, or other refractory minerals being oxidized, and they pass into the chloridizing portion before the metals are in a condition to combine with the chlorine gas. This defect of the furnace is of little importance as regards its availability in all cases where the ore is not of the very basest kind.

The White is a similar furnace to the Howell, and, except that the flame and ore enter the cylinder together, there is no great difference in points of construction. As regards expense of building, power required to work it, repairs, continuous feed and discharge, and labour required in manipulation, what has been said of the Howell applies also to this furnace. The fact that ore and flame enter the cylinder together precludes the possibility of distinct oxidation and chloridation periods. It is necessary to crush the ore fine, and the fine flue-dust is not usually chloridized as perfectly as the ore; nor can the basest ores be worked in.

The Brückner cylinder, like the reverberatory furnace, has the advantage that an ore which is in any way susceptible of chloridation, no matter how base, can be effectually chloridized in it; but, unlike the latter furnace, the efficiency of the work does not depend upon the diligence of the roaster, whose business is to stir the pulp. It chloridizes to a somewhat higher percentage than the other mechanical furnaces, and requires less salt. These facts may be accounted for when it is remembered that the ore can be roasted sufficiently, before the salt is added, to form the sulphates necessary to the proper decomposition of the salt; so that when that is added nothing but an increase of temperature is needed to complete the process. On the other hand it is a furnace which, in some respects, is inconvenient to handle, and requires more power to drive, as the furnace is a heavy one (from 3,000lb. to 4,000lb.) The bricks forming the lining occasionally fall out, and the furnace needs, as a rule, more repairs than the others. It also consumes more wood, for reasons already explained. It is, however, the best mechanical furnace known for working very base ores.

The Stetefeldt furnace has the following advantages: Less power is required than for any of the other furnaces, and but few repairs are needed; it has a continuous feed and discharge; it requires less fuel and the least labour of any per ton of ore roasted; and its ore and flue-dust are chloridized to a very high percentage. Its principal drawback is its original cost, for it must be built of good brick, and well anchored; and then the ore worked in it must have nearly a fixed percentage of sulphur and nearly a fixed value in silver to be well roasted. Very low- and very high-grade ores cannot, therefore, be worked to advantage. The loss of silver and of gold in this furnace is very slight; and when there is a large quantity of ore to be roasted, and the ore is of a uniform and of a suitable composition, this furnace is much to be recommended.

The reverberatory furnace does excellent work on all kinds of ore, and admits of any necessary modifications in the process; but the fact that it involves so much manual labour, thereby making the process a very expensive one, prevents it from being employed in any but very exceptional cases. Its first cost, however, is much less than that of a cylinder- or shaft-furnace, and also, of course, considerably within that of an O'Hara mechanical reverberatory. As the price of labour is nearly the same at points near main lines of communication and at localities far removed from them, while the cost of freight on the iron and fire-brick involved in the construction of most of the furnaces increases very rapidly with the distance from the railways, the reverberatory furnace may often be most economical in remote districts.

There is no doubt but that considerable attention has been directed from time to time in America with regard to the most economical and effectual methods of extracting the precious metals, as it has become an industry there of no mean importance. The value of the gold produced in 1885 was £6,625,288, while the value of the production of silver for same period was £10,749,998, making a total value of £17,375,206. The value of gold and silver produced during same period in the whole of the Australasian Colonies was £5,730,813.

Hydraulic Sluicing.

This branch of gold-mining is deserving of considerable attention, inasmuch as there is a large extent of country in the Middle Island covered with low-grade auriferous drift, which will yet be made to pay for working, and give profitable employment to a large population for many years to come. This will be accomplished by a good supply of water and a systematic method of working. It may be argued by many that this branch of mining is as far advanced as in other countries; but when the results and methods of working are compared with hydraulic sluicing in California it must be admitted we have yet a deal to learn in this direction.

It may be of interest to those engaged in hydraulic sluicing to give a synopsis of some of the principal sluicing companies in California, and show the magnitude of their workings. From statistics compiled by A. J. Bowie, jun., recently published, the following facts can be gleaned: That quicksilver is largely used in sluices and in undercurrents, which is entirely disregarded in this colony. The miners here are under the impression that the water is too cold to use quicksilver advantageously; yet the temperature of the water here, even in the coldest parts of Otago, is fully as high a temperature as that in California where the principal hydraulic operations are carried on.

Before going into detail on the methods of working the ground, it will be well to show the value of the ground worked in California and the cost of working the same. It is a difficult matter to get accurate statistics connected with this class of mining, so as to form a comparison between the hydraulic workings here and those in America; indeed, it may be truly said that no trouble has been taken to ascertain the exact value of the wash-drift in this colony, it being merely taken as payable or non-payable, as the case may be, according to the method adopted for working the ground. In working lodes in America and in the Australian Colonies, assays are carefully made to ascertain their value, and I am glad to see the mining population in New Zealand are beginning to adopt the same principle. It is only by carrying on mining on scientific principles that we may expect to see it made a commercial venture, so as to induce people to embark capital in this industry. Unfortunately, too much trafficking is carried on in taking up ground without due consideration whether it will pay for working or not; the great object being to form companies and sell the shares at a profit, so as to make money at all hazards, irrespective of consequences that must necessarily inevitably follow. This has brought mining into disrepute—made it to be looked on by many as a gambling transaction, an unsuitable occupation for men of probity and honour to be connected with. So long as this impression prevails every mining enterprise will be looked on by the outside public with distrust and suspicion. There is no reason why mining should not be conducted on the same commercial basis as any other industry. If proper steps are taken to test the value of mines before embarking capital in expensive plants and machinery, there is no more risk—if as much—than there is in agricultural or pastoral pursuits. The farmer is dependent on the seasons, and is subject to the fluctuations of the value of his produce, stock, and wool; while the only risk the miner has, is in prospecting the ground before commencing to work it. He may find that he has spent a considerable amount of money, and the prospects do not warrant him proceeding further; but this loss is a trifling one compared with the hap-hazard manner that is so commonly resorted to in bringing mining ventures before the public. To carry on mining successfully, there is no industry requires more scientific knowledge. It is to be hoped the time is not far distant when it will attract the attention of men more particularly to the conducting of mining operations on a more systematic and scientific basis. It is with this object in view that I wish to draw the attention of the miners to the usefulness and utility of keeping correct records of all workings they are engaged in, to ascertain in what particular item connected with the expense of working a saving can be effected. This appears to be carefully inquired into in California, as there is a large extent of ground of very low grade, which by a systematic plan of operations can be made to pay. At the present time I only propose to deal with hydraulic mining and the modes of working adopted for bringing about a successful issue in that country, so that the miners in this colony may make a comparison with the method of working the auriferous-gravel drifts here.

The information that I have derived from several American works on this subject leads me to believe that a large extent of low-grade auriferous-gravel deposits in Otago and on the West Coast will yet afford profitable employment for a large mining population. A work lately published by A. J. Bowie, jun., mining engineer, contains valuable information on this subject, from which I have been able to compile interesting statistics connected with the working of hydraulic sluicing claims in California.

The following tabulated statement will show the yield of gravel at important hydraulic mining claims in California, according to verified reports, from 1874 to 1877:—

Name of Claim.	Locality.	Cubic Yards Washed.	Value of Gross Yield.	Value of Yield per Cubic Yd.	Height of Bank.
			£	s. d.	Ft.
American Company ...	Sebastopol, Nevada County	5,171,834	1,077,465	1 0	120
No. 8*	N. Bloomfield, Nevada Co.	3,250,000	19,635	0 1·45	150
No. 8	" "	1,850,000	15,473	0 1·95	180
No. 8	" "	2,919,700	40,153	0 3·30	260
No. 8†	" "	2,293,930	60,578	0 6·35	265
North Bloomfield‡ ...	" "	30,000,000	543,750	0 4·35	150–350
French Corral	Sweetland "	4,200,000	363,646	1 8·75	20–100
Manzanita	Columbia Hill "	5,780,000	310,208	1 1	50–150
McCarthy's	Patricksville, Stanislaus Co.	3,000,000	72,013	0 2·15	...
Sicard	" "	155,347	4,208	0 6·5	38
Chesnau	" "	27,250	2,294	1 8·2	18
Chesnau	" "	71,810	2,052	0 6·5	55
Chesnau	" "	284,932	9,954	0 8	12–62
Chesnau	" "	338,880	13,120	0 9·3	60
New Light	" "	667,347	9,482	0 3·4	35
New Light	" "	683,244	9,467	0 3·3	24–60
Johnson	" "	196,632	1,906	0 2·3	30
New	" "	17,796	161	0 2·15	42
Kelley	La Grange "	88,600	710	0 2	85
Kelley	" "	351,152	8,990	0 6·15	75
Kelley	" "	701,685	3,285	0 1·1	100
New Kelley	" "	161,032	1,844	0 2·75	40
New Kelley	" "	252,614	7,294	0 6·9	65
New Kelley	" "	1,000,000	13,448	0 3·2	40–65
French Hill	" "	252,614	7,320	0 6·9	45
French Hill	" "	676,968	18,789	0 6·65	30
French Hill	" "	1,020,347	39,257	0 7·75	30
Light	" "	746,640	13,482	0 4·3	48
Blue Point	Smartsville, Yuba County...	93,044	24,110	5 1·5	57
Green Flat	Plumas County	22,000	3,125	2 9·75	15
Fale's Hill	"	25,000	999	0 9·5	75
Crawford's	El Dorado County	77,880	7,201	1 10·5	85
Gold Run District ...	Placer County	43,000,000	432,157	0 2·4	Not given
	Total	109,378,078	3,137,576	0 6·88	

* Paid a profit of £165. † The greater portion of top gravel removed previously. ‡ One-third of top gravel removed.

It will be seen from this statement that the value of the gravel washed varied from 1·1d. to 5s. 1½d. per cubic yard; but to take the average of the whole gravel washed, the yield was only 6⅞d. or about 3$\frac{5}{88}$gr. gold per cubic yard.

The following is a tabular statement showing the results of working of some of the hydraulic mining claims in California. These give the statistics in full detail, and will enable a comparison to be made with the working of hydraulic sluicing claims in this colony. The quantity of gravel moved per sluice-head of water was obtained by careful measurement of gravel in the bank before washing was commenced and when the washing was completed:—

TABLE showing the Results of Working some of the Hydraulic Mining Claims in California.

Name of Company or Claim.	Date and Length of Time employed in Washing.	Days actually engaged in Washing.	Sluice-heads of Water used per Day.	Grade of Sluices.	Height of Banks.	Head or Pressure of Water.	Nozzles and Pipes used in Washing.	Cubic Yards of Gravel Washed.	Gravel Washed in 24 Hours per Sluice-head of Water.	Total Cost.						Amalgam, in Pounds Avoirdupois.	Weight of Gold before Melting.	Fineness of Gold.	Fineness of Silver.	Yield of Bullion.		
										Melting and Refining.	Labour.	Blocks and Timber.	Water.	Other Material.	Grand Total.					Value of Gold.	Value of Silver.	Total Value of Bullion Produced.
					Ft.	Ft.				£	£	£	£	£	£					£	£	£
French Hill	May 30, 1874, to Oct. 30, 1876	521⅓	30	25″ to 100ft.	30	50 to 70	Three, 4″, 5″, 6″	676,968	43·3	65·2	5,953·3	604·2	1,457·9	805·4	8,806	878·93	322·83	·930	·056	18,737·8	51·2	18,789
Light claim	Feb. 12, 1875, to Sept. 30, 1876	376	25	25″ to 100ft.	24 to 60	60	Three, 6″, 6″, 7″	683,244	72·7	38	3,069	1,208	878	214	5,407	454·34	162·89	·940	·054	9,443·6	24·4	9,468
Chesnau claim	June 1, 1874, to Oct. 31, 1876	279¼	18½	25″ to 100ft.	12 to 62	50 to 80	Two, 6″, 7″	284,932	55·1	35	2,172	256	484	370	3,317	459·25	171·46	·930	·053	9,826·6	27·4	9,954
Sicard claim	May 28, 1874, to Jan. 31, 1875	107½	12⅓	22″ to 100ft.	20 to 40	90	Not given	155,347	115·5	25·5	820·7	197·8	125·3	125·7	1,292	196·75	71·94	·939	·051	3,403·7	12·3	3,417
Johnson claim	March 1, 1875, to Dec. 31, 1875	139	20	22″ to 100ft.	20 to 40	80	Not given	196,632	71·5	16	842	121	259	35	1,553	90·81	32·20	·940	·052	1,899	6	1,905

It will be seen from the above statistics that even at an early date, or over eleven years ago, steps were taken to ascertain the value of each portion of the work, and the duty of a sluice-head of water. The French Hill claim averaged about 1s. 10½d. per cubic yard of gravel washed; and the cost of labour and expenses connected with working was 3¼d. The amount of work done with one sluice-head of water was 1·8 cubic yards per hour. The Light claim averaged 3⅓d. per cubic yard of gravel washed, and total expenses connected with working were 2 1/14d. per cubic yard; while the amount of gravel washed in one hour with one sluice-head of water was 3 cubic yards. The Chesnau claim averaged 8⅓d. per cubic yard of gravel washed, and the expenses were 2¾d. The quantity of gravel washed per sluice-head of water in one hour was 2½ cubic yards. The Sicard claim averaged 5¼d. per cubic yard of gravel washed, and the expenses were about 2d. per cubic yard. The quantity of gravel washed per sluice-head of water in one hour was 4·8 cubic yards. The Johnson claim averaged 2⅗d. per cubic yard of gravel washed, and the expenses 1⅞d. per cubic yard; while the quantity of gravel washed per sluice-head in one hour was 3 cubic yards. The dimensions of the sluices in each of these claims were 4ft. wide and 2ft. 6in. deep.

The grade of the sluice-boxes is much less than any yet in use in this colony: for washed gravel-drift, indeed, the miners here would consider such a low grade quite unworkable. Nevertheless, even with this grade, very poor auriferous gravel has been made to pay. These grades are only resorted to when the fall is not sufficient for tailings-room.

The lengths and grades of the principal tunnels in the mining district of Smartsville, Yuba County, California, are as follows:—

Name of Tunnel.	Locality.	Length in Feet.	Average Grade.
Babb	Timbuctoo ...	1,200	3ft. 9½in. per 100ft.
Pactolus	" ...	1,700	4ft. 2 in. "
Rose's Bar	" ...	1,600	4ft. 2 in. "
Blue Gravel	Sucker Flat ...	1,100	4ft. 6 in. "
Pittsburg	" ...	900	4ft. 2 in. "
Blue Point	" ...	2,250	4ft. 2 in. "
Enterprise	" ...	1,200	4ft. 2 in. "
Deer Creek	Mooney's Flat ...	2,200	3ft. 5 in. "

The length, cost, and grades of the important tunnels in Nevada County are as follows:—

Name of Mine or Tunnel.	Locality.	Length in Feet.	Grade per 100ft.	Cost of Tunnel.
			Ft.	£
Boston	Woolsey's Flat ...	1,600	7¼	8,333
North Bloomfield	Humbug Cañon ...	9,200	4⅓	110,000
Farrell	Columbia Hill ...	2,200	3½	Not given
English	Badger's Hill ...	2,000	7	Not given
American	Below San Juan ...	5,000	6¼	33,333
Manzanita	Sweetland ...	3,500	4⅙	19,167
Sweetland Creek	Sweetland ...	2,200	4¾	18,750
Bed-rock	Below Sweetland...	4,400	5¼	15,625
French Corral	French Corral ...	5,048	4¾	39,583

The North Bloomfield Company is one of the most important hydraulic sluicing companies in Nevada. The ground is too cemented and hard to wash away readily by hydraulic pressure, and therefore they use a large quantity of explosives to shatter the ground before commencing to wash it away. This adds considerably to the expense of working. The value of explosives used in three years amounted to one-third the total value of labour in working the mine, as the following statement of details of work done in the company's claim No. 8 during three years, 1874 to 1877, will show:—

Year.	Days engaged in Washing.	Water used, in Sluice-heads.	Gravel washed, in Cubic Yards.	Height of Banks.	Grade of Sluice.	Gravel washed per Sluice-head per Day.	Total Expenses.						Total Expenditure.	Yield.	Yield per Cubic Yard.
							Labour.	Explosives.	Blocks.	Material.	Water.	General Expenses.			
				Ft.		C. yd.	£	£	£	£	£	£	£	£	d.
1874–75	295	33	1,858,000	180	4′ 6″ in 100	190	4,748	613	627	1,180	3,016	876	11,060	15,473	2
1875–76	342	52	2,919,700	260	4′ 6″ in 100	164	8,537	2,142	1,086	1,927	4,530	1,534	19,756	31,153	3½
1876–77	318	47	2,293,900	318	4′ 6″ in 100	153	11,196	5,287	1,198	2,116	4,535	5,264	29,596	60,578	6⅕
Averages and totals	955	44	7,071,600	279	..	168	24,481	8,042	2,911	5,223	12,081	7,674	60,412	107,204	3¾

This claim averaged 3¾d. per cubic yard of gravel washed during a period of three years, and the expenditure connected with working the claim for same period averaged 2d. per cubic yard; while the quantity of gravel washed from the bank per sluice-head of water per day was 7 cubic

yards. This is largely in excess of the quantity washed by the other companies referred to; but it will be seen that, instead of a grade of 2ft. 1in., this company had a grade of 4ft. 6in. per 100ft. The dimensions of the sluice were 6ft. wide and 2ft. 8in. deep.

The character of the ground in this company's mine is more compact than the general character of the auriferous gravel on the West Coast, but it resembles it by having a large quantity of stones and huge boulders mixed through the gravel.

Blasting Gravel-banks.

When the ground is very hard and cemented, blasting is resorted to in order to shatter the material and make it easily washed. To give some idea of the magnitude of the blasting operations, it will not be out of place to quote what A. J. Bowie writes on the subject:—

"*Dardanelles Mine Blast.*—At Dardanelles hydraulic and drift mine, near Forest Hill, Placer County, a blast was made with 36,400lb. of Judson's powder (old), shattering about 500,000 cubic yards of cement-gravel. The gravel-bank had a face of 1,200ft. in length, with a height of 175ft. This deposit reposed on a rising bed-rock. Five parallel drifts, 180ft. apart, were run in from the face a length of 70ft. each. From each of these drifts two arms (right and left) or cross-cuts were driven, 70ft. long, thus leaving 40ft. between the ends of the cross-drifts from the main drifts. The powder, in 50lb. boxes, was charged, in lots of 1,000lb. to 1,500lb., in different chambers. In each chamber three exploders were placed in the powder, each exploder being carefully connected by an insulated copper wire with the main wires on the outside drifts. The drifts were all well tamped with clay and boulders. The wires from the exploders connected outside of the main drifts with two copper wires from an electro-magnetic battery which was situated to the right, and about 200ft. from the face of the bank. When everything was ready the blast was fired. The back ground was raised bodily 4ft. or 5ft., and the face was thrown forward. At the Blue Tent Mine, Nevada County, in 1880, a bank 200ft. high was thrown down (similarly to that already described) with 43,000lb. of powder."

The amount of explosives used in bank-blasting at the Manzanita Mine, Sweetland, Nevada, between February, 1879, and March, 1883, was 448,900lb., a little over two hundred tons. The powder principally used was Judson's, only a small proportion of it being black powder. What is termed Judson's powder in America is a nitro-glycerine compound corresponding to dynamite. The magnitude of blasting operations must have been considerable when fifty tons of nitro-glycerine explosives were used per annum, which is equal to about 150 tons of ordinary blasting-powder.

During the four years ending March, 1883 the amount of gravel shattered by blasting was 33,721,775 cubic yards, or an average of 75 cubic yards of gravel to every pound of explosive used.

Tail-races and Sluices.

In order that the maximum discharge of sluices may be obtained, they should be laid in as straight a line as possible; but where a straight line cannot be got there should be equally as much care displayed in setting out the curves as in laying down a railway. Whenever a curve has to be made the bottom of the sluice on the outside of the curve should be slightly higher than the inside, and when the material to be washed is mixed with clay or cemented gravel, drops in the sluices will materially add to the better washing of the dirt; but when drops are made the grade of the sluice for about 40ft. past the drop should be more than the general grade of the sluice, in order to allow the material to acquire the momentum lost by such drops, or else the boxes are liable to choke, and the tailings block up below the drops. Sluices with drops have been found to be very effective in saving gold.

Grade.—The grade of sluices depends on the amount of fall that can be obtained to provide for sufficient deposit of the tailings, and it is a subject which demands a proper investigation before constructing the sluices. The nature of the material to be sluiced—cemented gravel, or gravel mixed with clay—requires a good grade to properly wash the stuff; and, especially when the gravel is cemented, drops are necessary to break up the cemented portions.

General Efficient Grade.—Experience in California shows that when it can be obtained, from 4ft. to 4ft. 6in. in 100ft. is a very efficient grade, and one in which a sluice-head of water will wash about from 6 to 7 cubic yards per hour. Where light grades are used care has to be taken to have the streams as shallow as possible, so as to move the large stones in the sluice, and prevent the fine heavy sand from packing up the riffles. The best results are obtained, when there is a large proportion of heavy gravel, by having about from 10in. to 12in. in depth of water in the sluices, or just sufficient to cover the largest boulders sent down.

Size of Sluices.—The dimensions of a sluice depend on the character of the material and quantity of water available, but experience in California shows that where fifty or sixty sluice-heads of water are used the sluice should be 6ft. wide by 3ft. deep, and where twenty to thirty-five sluice-heads are used the sluice should be 4ft. wide by 2ft. 6in. deep, and where only from fifteen to twenty-five sluice-heads are used the sluice should be 3ft. wide by 2ft. 6in. deep. The great error that is usually made in this colony is constructing sluices too narrow for the amount of work they are expected to perform. The great object of companies here is to construct the sluices as cheaply as possible, without giving the matter due consideration whether they are properly proportioned or not: an instance of this is obvious in the Kumara Sludge-channel, which costs a considerable amount of money to keep it clear from blockages. These blockages not only occur from the sluice being too narrow for the quantity of material and water it has to carry, but also from the inclinations at which the branch sluices enter the main channel. Every branch race joining a main tailings-channel should be brought into it with a proper curve, so as not to retard the velocity of the water and material that it has to transport. A great deal has been said from time to time about parties having a heavy grade in their branch sluices blocking this channel; but it must be admitted that

the material from the branch sluices, coming as it does at not less than an angle of 30°, strikes the opposite side of the channel and retards the velocity of the water in the main channel, and thereby is the means of causing so many blockages to take place; whereas if the branch races were brought in with a proper curve this would rarely take place. The annexed sketch shows the care that is exercised in California in joining branch tail-races with the main sluice to produce the most effective results. A turn-out sluice should also be constructed on the same principle.

Construction of Sluices.—The sluices used in California are made of 1½in. to 2in. planking, with sills and side straps of from 4in. by 4in. to 4in. by 6in. The sills are placed from 3ft. to 4ft. apart, and the side straps are halved into the sills and firmly spiked, every second or third strap being braced with an angle-strap from the end of the sill. The bottom planking is grooved on the edges to receive a soft-wood tongue, so as to make the bottom thoroughly tight, and prevent the loss of quicksilver. The amount of material and cost of each 12ft. box, 6ft. wide and 2ft. 8in. deep, in the North Bloomfield Company's sluice is as follows:—

	Ft.	in.
Eight side straps, 4in. by 6in. by 3ft. 2in.	50	8
Four sills, 4in. by 6in. by 8ft.	64	0
Three bottom planks, 2in. by 24in. by 12ft.	144	0
Four side planks, 1½in. by 16in. by 12ft.	96	0
Two top rails, 2in. by 8in. by 12ft.	32	0
Sixteen braces, 2in. by 4in. by 4ft.	42	8
	429	4

	£	s.	d.
430ft. of timber at 11s. per 100ft.	2	7	4
Nineteen blocks, 20½in. square by 13in. deep = 721ft., at 6s. per 100ft.	2	5	0
Side lining: 24ft., 3in. by 12in. = 72ft., at 11s. per 100ft.	0	7	10
Tongues and riffle-slips	0	5	0
Nails, 30lb. at 3d.	0	7	6
Labour, at 10s. and 12s. per day	1	12	4
Cost per 12ft. length of sluice	£7	6	0

The prices here correspond with the price of labour and materials in this colony. If, therefore, the average length of sluice be taken at 1,800ft., it would cost about £1,500.

Blocks.—Experience has shown in California that wood blocks are the best at the head of the sluices. Mr. A. J. Bowie, writing on this subject, gives the following reasons: (1) The cross riffle they make is not excelled by any other form; (2) their cheapness, under ordinary conditions of timber-supply; (3) the convenience of cleaning up, which can be quickly and cheaply done. Experience has also proved that square-block riffles are the best for saving gold, and being easily shifted when cleaning is of great importance, because they find it desirable to collect the gold at frequent intervals, as it is injudicious to expose amalgam collected in the riffles to wear by gravel running over it at long periods. The wear and tear, however, on wood blocks are very considerable. Blocks 13in. deep only last, with fifty to sixty sluice-heads of water and gravel in the sluice, about three weeks; therefore stone blocks are used for the lower ends of the sluices, and sometimes even in the upper ends of the sluices stone and wood are used alternately. The character of the wood that is used in blocks in California is principally pitch-pine. It is found that hard timber that wears smooth, such as oak, is not desirable; wood which is long-grained and brooms up makes the best riffle. The New Zealand white- and red-pine are admirably suitable for block-riffles.

Laying down Wooden Blocks.—The blocks are not only laid down so as to break joints longitudinally, but they are laid in rows crosswise, having a slip of timber, about 1¼in. thick and 2in. or 3in. deep, laid in between each row on the bottom of the sluice. These slips are nailed on to each row of blocks, which keeps the slips in their places, and tends to bind the blocks together. The side-lining, which is about 3in. thick and from 10in. to 12in. deep, is nailed to the side of the sluice above the top of the blocks.

Rock-riffles.—Where rock-riffles are used the stones are quarried of irregular size and shape, but have something of a uniform depth. They are laid in the sluice with a slight tilt down-stream, but no particular care is taken to shape and square them, as is done with the stone paving used in the sludge-channel at Kumara.

Undercurrents.—I cannot do better than give Mr. A. J. Bowie's description of these, which is as follows: "In order to relieve the sluices of the fine material, and thereby aid in saving the gold, undercurrents are introduced into the sluice-line. These may be described as broad sluices, set on a heavy grade at the side of and below the main sluice. Where a drop-off can be made in the main line parallel steel or iron bars, 1in. by 4in., at intervals of 1in. between them, and from ten to twenty in number, according to the size of the undercurrent, are placed edgewise across the sluice. A set of such bars is called a grizzly. It is set 1in. below the sluice-pavement, which is raised as it wears down. If too low, the grizzly clogs with gravel. The coarse material passes over the grizzly, and, if the topography permits, is dropped and picked up again in sluices at a lower level. The finer gravel drops through the bars into a box about 20in. deep, lined with blocks, and set at right angles to the main line. This box carries the material to the chute at the upper end of the undercurrent. This chute is lined with cobbles, and provided with dividers of wood to evenly distribute the material over the surface of the undercurrent. It is a 2- or 3-per-cent. grade (2ft. or 3ft. in 100ft.), and gradually narrows towards the lower end. The undercurrent proper is a shallow wooden box, from 20ft. to 50ft. wide, and from 40ft. to 50ft. long, with sides about 16in. high. It should have, if possible, eight to ten times the width of the main sluice. The bottom is made of 1½in. plank,

tongued and grooved, and set on a grade of 8 to 10 per cent. according to the smoothness of the riffles used. It is paved with cobbles, wooden rails shod with strap-iron, or small wooden blocks. With the smooth rails a grade of 12in. in 12ft. is sufficient, but with blocks the grade should be increased to 14in. in 12ft., and with cobbles to 16in. in 12ft. The gravel escaping from the undercurrent is led back to the main sluice. The chief cost of maintenance is occasioned, not by the undercurrent itself, but by the repairs on the main-sluice and grizzly, caused by the introduction of the latter into the sluice-line. The running-expense of a wide undercurrent is no more than that of a narrow one, excepting in the slight matter of pavement and cleaning-up. At French Corral, with a tail-sluice 5ft. wide, the yield of the first undercurrent, which was 20ft. wide, was 20 per cent. of the yield of all the undercurrents. An addition of 10ft. to the width increased its yield to 27 per cent. of the total, and the grizzly in the main sluice was not changed."

Annexed is a plan, longitudinal and elevational section, of an undercurrent used by the North Bloomfield Company, which shows the general arrangement of the undercurrents and paving adopted.

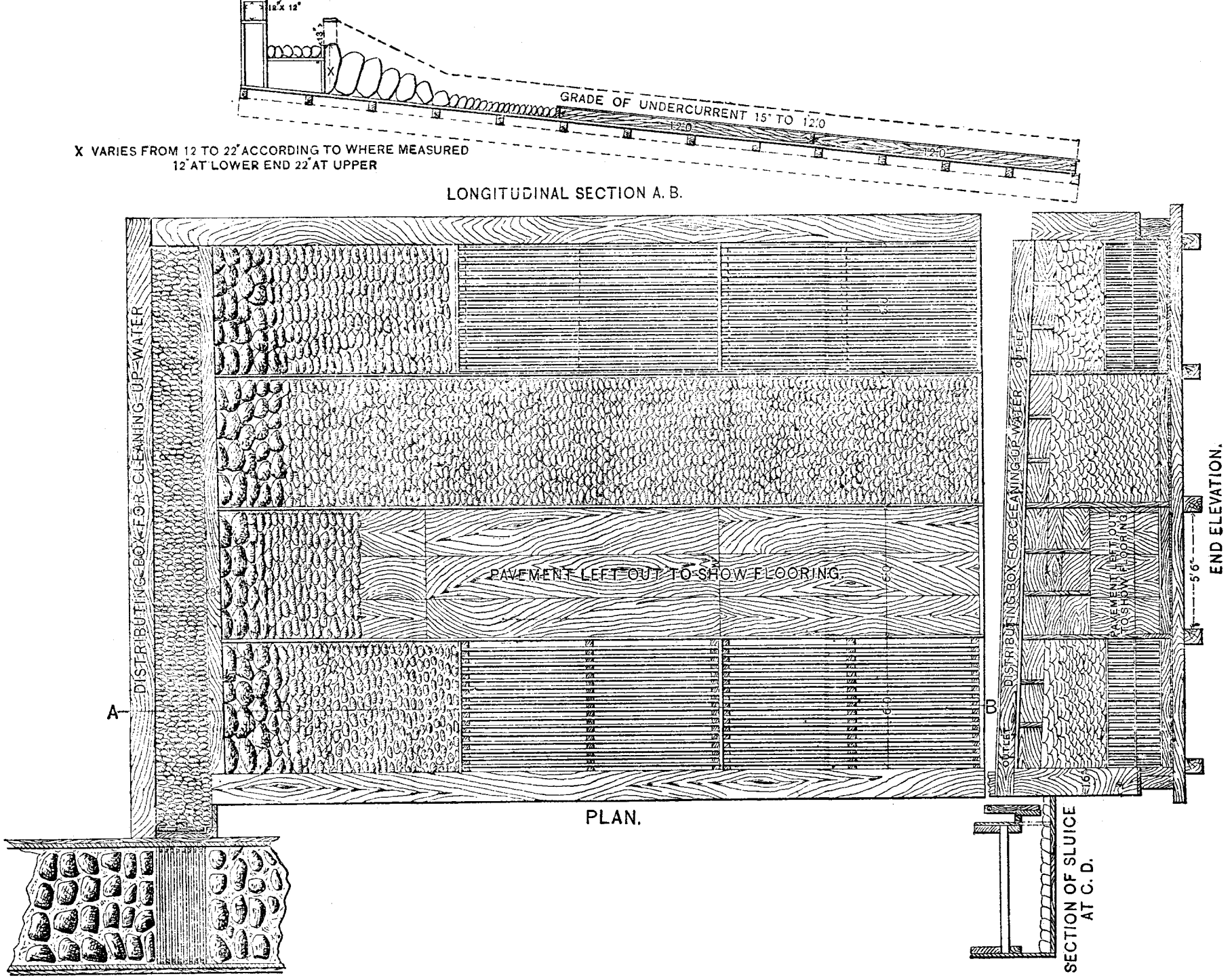
Cleaning up.—The periods between cleaning up depend on the quantity of material sent through the sluice. Mr. A. J. Bowie states as follows: "The length of 'runs' is dependent upon many circumstances, but chiefly on the wear of the pavement. Some claims are cleaned up every three weeks, others run two and three months, whilst a few, where the water-season is short, are cleaned up only every season. All pavements should be cleaned up as soon as they begin to wear in grooves. Where a large quantity of water is used, and a relatively large amount of gravel washed, it is considered advisable to clean up the first 1,000ft. or 1,800ft. of sluices (which are paved with wooden blocks) every two weeks. With a gang of miners this work is done expeditiously, not occupying more than half a day. The tail-sluices are cleaned up only once a year. The undercurrents should be cleaned up whenever quicksilver is found spread over their lower riffles, with tendency to discharge over their ends. When it is decided to clean up, the bed-rock and cuts are piped clean. No material is turned into the sluices, clear water alone being run until the sluices are clear of dirt. When thus prepared only a small head of water, such as men can conveniently work in, is turned through the sluice, and the blocks are taken up by means of crowbars, washed to free them from amalgam, and laid at the side of the sluice. This is done in sections approximating 100ft. Between each section one row of blocks is left in the sluice. These rows serve as riffles to prevent the gold and quicksilver from passing down the sluice. After the first section of blocks is taken up men follow the gravel and dirt as these are slowly washed down the sluice, and pick up the quicksilver and amalgam with iron scoops, with which they are put into sheet-iron buckets. As each riffle is reached the amalgam and quicksilver are collected, the block-riffles removed, and the residue is washed down to the next riffle, and so on down the entire length of sluice. When this operation is completed the water is turned off, and the workmen attend to the nail-holes and cracks in the sluices, crevicing with silver spoons to obtain the amalgam collected in them. After this the side-lagging is overhauled, and the blocks are replaced. Where sluices are of great length the lower portions are usually lined with heavy rock, which can be used for longer periods without cleaning up. It is customary in mines which have very long sluices, and which are run at night, to clean up during the day as long a section as can be cleaned and put in order for further work, and to resume further washing at night, until the whole line is cleaned up. At the end of the water-season the entire works are cleaned up and put in order for next season's run."

Charging the Sluices.—The sluices are run half a day in order to pack them. The water is then turned off, and a charge of quicksilver is put into the upper 200ft. or 300ft. of the sluices, a small quantity being distributed along the entire length except the last 400ft. In a 6ft. sluice the charge will be about three flasks (210lb.). The undercurrents are charged at the same time, and a little quicksilver put into the tail-sluice. Quicksilver is added daily during the run in gradually lessening quantities, the object being to keep the mercury uncovered and clean at the top of the riffles; and therefore the charge is regulated by the amount exposed to view. At the North Bloomfield Mine, where the main sluice is cleaned up every twelve days, the amount of quicksilver used in a run varies from fourteen to eighteen flasks. A 24ft. undercurrent will require a charge of from 80lb. to 88lb. of quicksilver. In charging riffles all splashing of the quicksilver should be avoided. When it is sprinkled into the sluice (a practice to be condemned) it divides itself into minute particles, the bulk of which is easily carried off by the swift stream, while the lighter portions float even in the clear water.

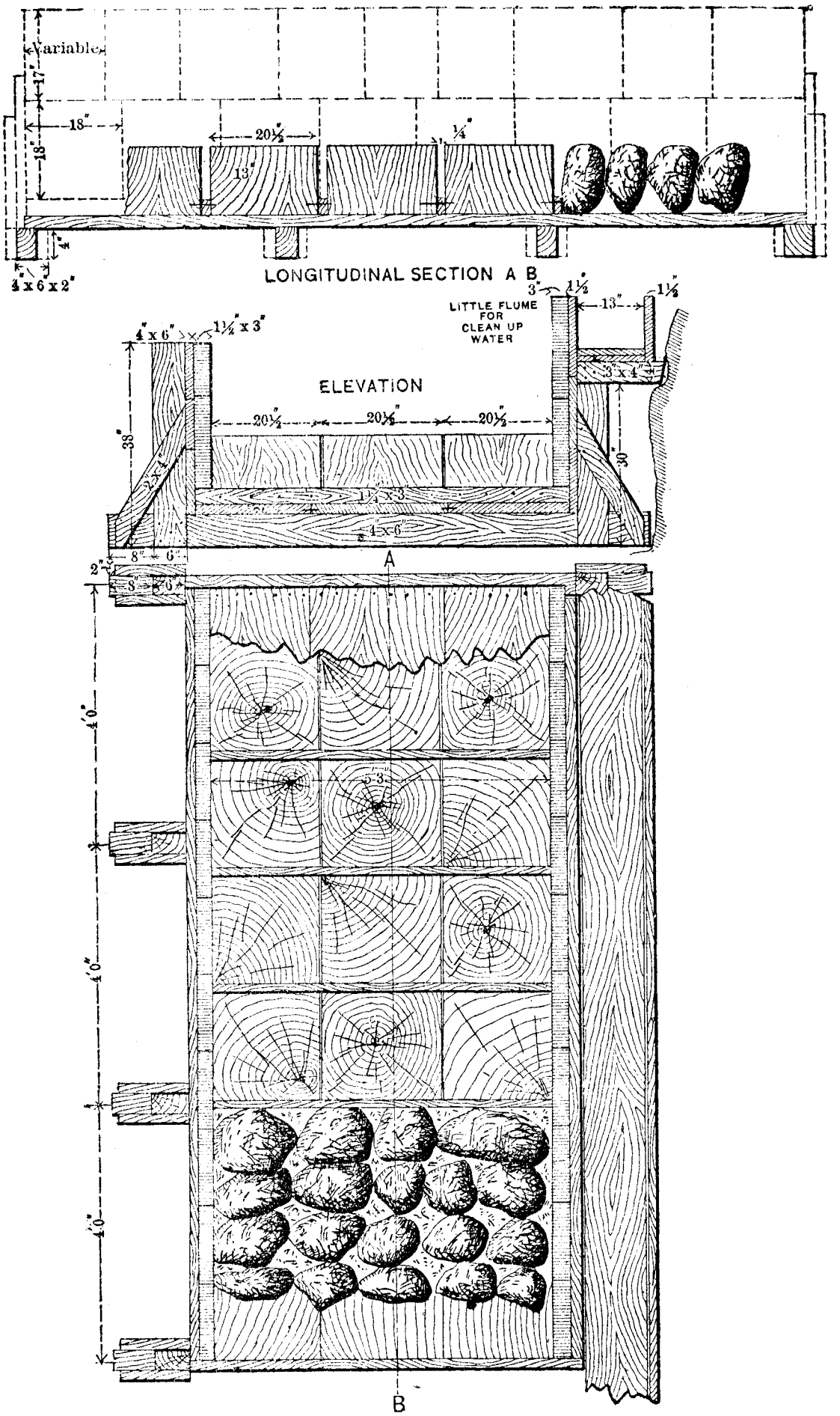
Loss of Quicksilver.—The loss of quicksilver in some of the sluicing-claims in California is very considerable, and where a large quantity of quicksilver is lost it must necessarily carry away gold with it. This loss depends on the character of the gravel washed, the quantity of water used, the grade, length, and condition of the sluices. The use of long sluices and a number of undercurrents tends to diminish the loss. The amount of quicksilver lost by the La Grange Company, working six claims, in two years and a half, during which period 2,275,967 cubic yards of gravel was washed, was 553¾lb. In the North Bloomfield Company's mine, from 1876 to 1882 inclusive, the loss was 21,512lb., and during the same period the total value of bullion produced was £423,449.

Distribution of Gold in Sluices.

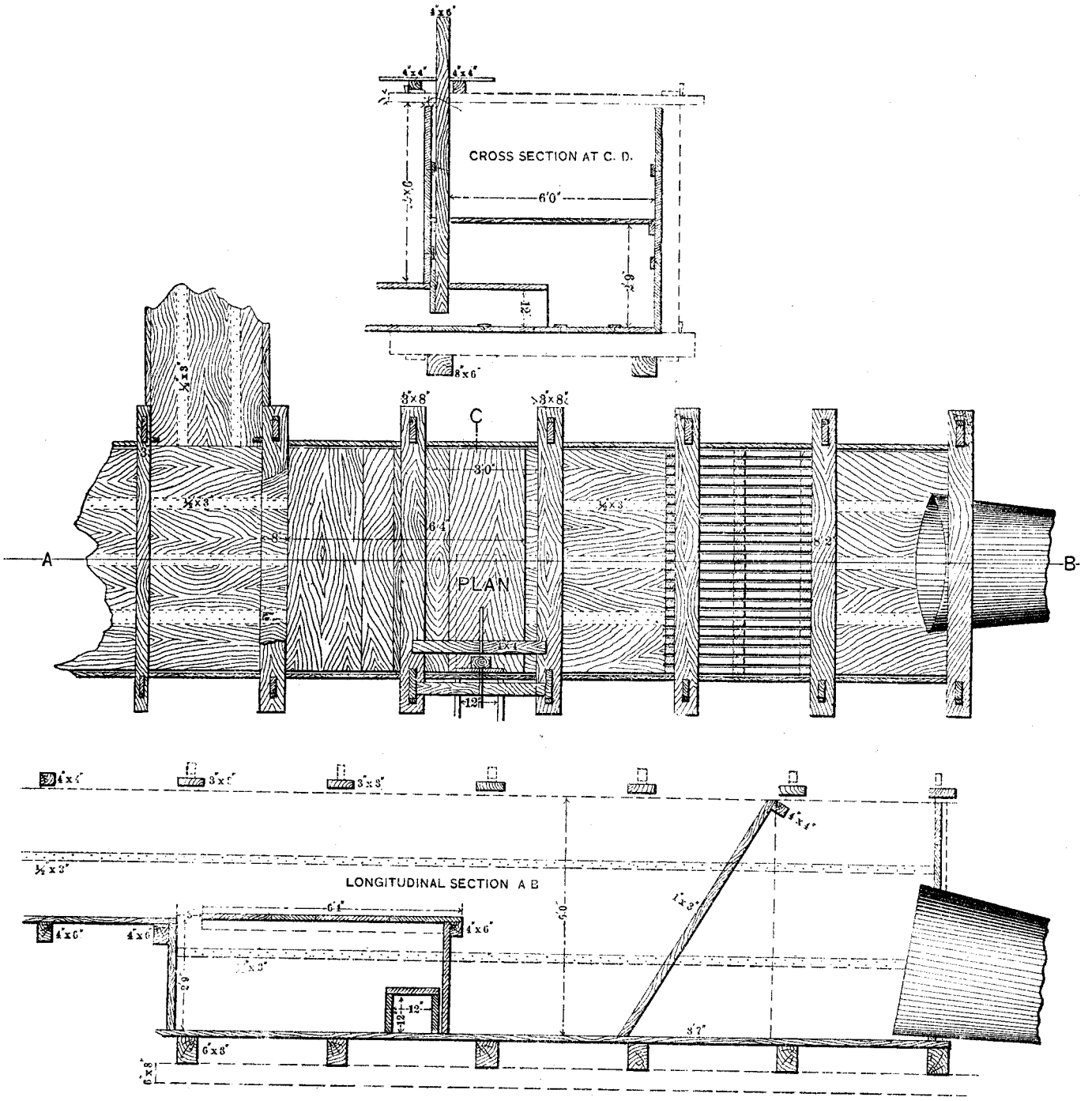
The largest percentage of gold is always found at the head of the sluice and in the cut leading into it; but it may be of interest to show the statistics which have been compiled by the North Bloomfield Company on this subject. The following statement shows the sources whence gold was collected in the North Bloomfield Mine from 1876 to 1882 :—



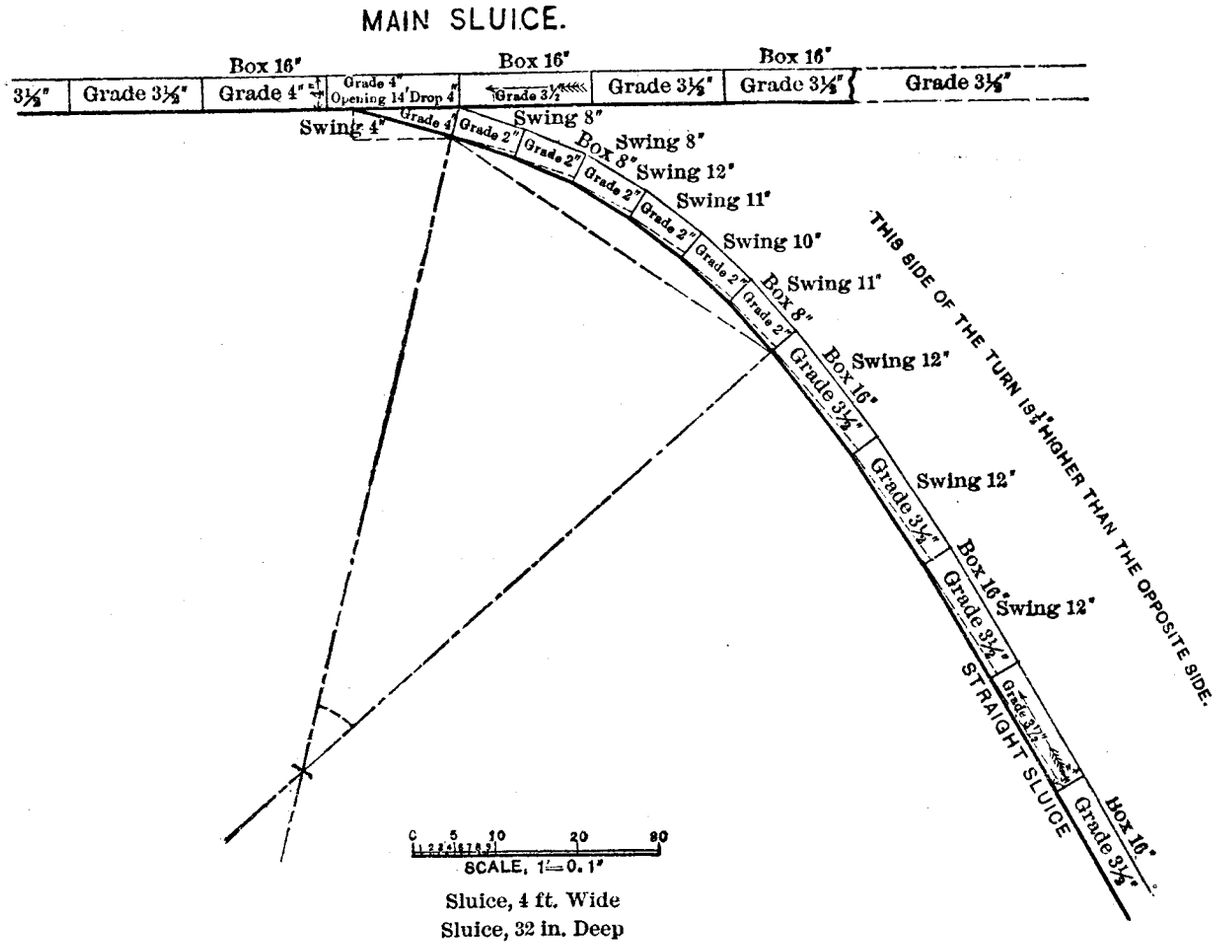
NORTH BLOOMFIELD UNDERCURRENT.



TUNNEL SLUICE BOX AT NORTH BLOOMFIELD.



North Bloomfield Pressure Box.



Sluice, 4 ft. Wide
Sluice, 32 in. Deep

TURN-IN SLUICE AT HEAD OF TUNNEL, DELANEY CLAIM, PATRICKSVILLE.

STATEMENT showing SOURCES where GOLD was collected in the NORTH BLOOMFIELD SLUICE from 1876 to 1882.

—	1876.		1877.		1878.		1879.		1880.		1881.		1882.	
	1,800ft. Sluice in Tunnel, 300ft. Sluice in Cañon.	Per Cent.	1,800ft. Sluice in Tunnel. 300ft. Sluice in Cañon.	Per Cent.	1,700ft. Sluice in Tunnel. 300ft. Sluice in Cañon.	Per Cent.	1,600ft. Sluice in Tunnel. 150ft. Sluice in Cañon.	Per Cent.	1,400ft. Sluice in Tunnel. 150ft. Sluice in Cañon.	Per Cent.	1,400ft. Sluice in Tunnel. 300ft. Sluice in Cañon.	Per Cent.	1,500ft. Sluice in Tunnel. 150ft. Sluice in Cañon.	Per Cent.
	£ s. d.		£ s. d.		£ s. d.		£ s. d.		£ s. d.		£ s. d.		£ s. d.	
From undercurrent, 24ft. wide, 48ft. long..	493 13 7	45·2	865 18 11½	44·6	529 1 3	30·8	750 0 0	31·3	657 10 0	30·3	662 10 0	29·4	1,117 14 11	34·9
From undercurrent No. 2, from one grizzly, 24ft. wide, 24ft. long	*175 4 2	16	374 14 7	19·3	236 0 10	13·7	437 10 0	18·2	396 11 3	18·3	375 0 0	16·6	577 6 1½	18·1
From undercurrent No. 3, from one grizzly, 24ft. wide, 36ft. long	*108 10 10	10	338 13 9	17·4	234 15 10	13·7	437 10 0	18·2	373 2 6	17·2	312 10 0	13·9	385 12 6	12
From undercurrent No. 4, 18ft. wide, 36ft. long	313 3 11	28·8	191 17 5	9·9	204 11 8	11·9	187 10 0	7·8	136 17 6	6·3	125 0 0	5·7	160 4 0	5
From undercurrent No. 5, one grizzly, 24ft. wide, 24ft. long	..	..	*92 1 11½	4·7	202 10 0	11·8	208 6 8	8·7	167 14 2	7·7	223 19 2	10	303 5 8	9·4
From undercurrent No. 6, one grizzly, 24ft. wide, 24ft. long	..	..	*79 8 4	4·1	114 9 7	6·6	200 0 0	8·4	116 17 6	5·4	156 5 0	7	160 16 3	5
From undercurrent No. 7, 54ft. wide, 48ft. long	..	..	..	..	197 5 10	11·5	177 1 8	74	230 6 3	10·6	260 8 4	11·6	342 8 4	10·7
From undercurrent No. 8, 48ft. wide, 48ft. long	..	..	..	..	..	..	..	..	90 6 3	4·2	130 4 2	5·8	154 11 4	4·9
Total from undercurrents ..	1,090 12 6	2·72	1,942 15 0	3·27	1,718 15 0	2·65	2,397 18 4	3·52	2,169 5 5	3·61	2,245 16 8	4·56	3,201 19 2	3·98
From tail-sluices in cañon	375 0 0	0·94	1,708 6 8	2·82	787 10 0	1·21	520 16 8	0·76	416 13 4	0·70	208 6 8	0·42	946 8 6	1·17
From tunnel below sluice-flume.. ..	1,518 15 0	3·78	1,718 15 0	2·84	3,437 10 0	5·30	2,604 3 4	3·82	5,895 16 8	9·83	4,520 16 8	9·16	5,791 13 4	7·20
From cuts above tunnel-sluices	314 11 8	0·79	2,395 16 8	3·92	2,962 3 11	4·57	4,687 10 0	6·88	5,500 0 0	9·13	2,437 10 0	4·93	9,166 13 4	11·39
From sluices in tunnel and above ..	36,854 6 4½	91·77	52,812 11 9	87·15	55,943 7 4	86·27	57,864 10 8	85·02	46,002 6 7	76·73	39,486 9 9	79·99	61,340 8 3	76·26
Clearing bed-rock	..	..	..	..	..	..	..	..	..	..	458 6 8	0·94	..	..
Total yield	40,153 5 6½	..	60,578 5 1	..	64,849 6 3	..	68,074 19 0	..	59,984 2 0	..	49,357 6 5	..	80,447 2 7½	..

* Half-year.

NOTE.—The tailings from undercurrent No. 4 did not run through Nos. 5 and 6, and the tailings from No. 7 did not run through No. 8.

It will be seen by this statement that bullion to the value of £14,771 was obtained from the undercurrents, or 3½ per cent.; £4,946 from tail-sluices in cañon, or 1⅛ per cent.; £25,529 from tunnel below sluice, or 6⅛ per cent.; £27,923 from cuts above tunnel-sluices, or 6¾ per cent.; and £350,282 from main sluices, or 82½ per cent.: the total value of the bullion produced during the seven years being £423,449.

In California, where sluicing is carried on day and night, the electric light is used to illuminate some of the large claims. The electric-light machine used by the North Bloomfield Company is one of the Brush pattern, and nominally of 12,000-candle power, requiring four-horse power to work it, which is supplied by a hurdy-gurdy water-wheel. The light is used in two lamps. The machine, lamps, wire, and all connections set up cost £417. After being in constant use for two and a half years, running from eight to twelve hours each night, the average cost per night was as follows:—

	s.	d.
Six carbons, ½in. by 12in.	2	1
Brushes and segments	0	6
Oil	0	1½
Attendance, half one man's time	6	3
Water	0	11½
Total cost per night	9	11

Hydraulic Pipes.

There is no portion of a hydraulic plant that requires more careful investigation than the iron piping. The miner has to depend on the opinion of others to a great extent as to the diameter of the pipes and the thickness of iron used in their manufacture, as well as the best system of riveting the joints to give the greatest amount of strength. This requires both a theoretical and practical knowledge to be fully acquainted with this subject. The difficulty that the miners generally experience when getting iron pipe constructed is to know the exact volume of water that a pipe of given dimensions will carry after the fall or inclination is fixed; and, as the inclination varies considerably in different places, a pipe that would be large enough to convey sufficient water in one place would be of no use at another if the inclination was less and the same quantity of water required. The first thing the miner has to ascertain is the inclination or the length of pipe, divided by the height of the intake end above the discharge end. Knowing this and the quantity of water he requires the diameter of the pipe can easily be calculated. There are many formulæ adopted for ascertaining this. Mr. Hamilton Smith has adopted the following formula from a number of experiments made by himself and others with flow of water in pipes ranging from ⅝in. to 4ft. in diameter: $V = M\sqrt{\frac{d\,h'}{L}}$, where V = the velocity in cubic feet per second, M = a variable coefficient from 67 to 33 (but in pipes of 8in. in diameter and upwards this variable coefficient ranges from 67 to 47, the average coefficient being 54), d = the diameter of the pipe in feet, h' = the effective head, and L = the length of the pipe in feet.

The effective head h' is obtained from the total head h as follows: $h - h' = \frac{V^2}{2gc^2}$, where g = the acceleration of gravity and c the coefficient of contraction at the entrance, which was found to vary from 1 to 0·920; so that for all practical purposes h' may be disregarded and the following formula adopted:—

$$\text{Velocity in feet per second} = 50\sqrt{\frac{\text{diameter in pipe in feet} \times \text{total head in feet}}{\text{total length of pipe in feet}}}.$$

This formula is based on the one used by Trautwine, the coefficient used being a trifle less, and it is the same as that used by Professor Rankine.

The best English authority on the flow of water in pipes adopts the following general formula: $V = 140\sqrt{R\,S} - 11\sqrt[3]{R\,S}$ where V = the velocity in feet per second, R = the hydraulic radius in feet (the diameter of the pipe divided by 4), and S = the sine of inclinations or the total fall divided by the total length. I have, however, found by experiments that this formula gives too high a percentage at high velocities.

In all calculations for the flow of water in pipes it must be borne in mind that a new pipe will discharge more than one which is coated with rust inside; therefore a margin should always be provided in laying down pipes, to meet this case.

For the convenience of miners who are using hydraulic pipes, the following table will enable them readily to ascertain the diameter of a pipe that is required to discharge a given number of sluice-heads of water, or the amount in cubic feet per second, when the fall or inclination of the pipe is determined:—

TABLE showing the QUANTITY of WATER that Pipes are capable of discharging in Cubic Feet per Second or Sluice-heads per Minute.

Total Length divided by Total Fall or Hydraulic Inclination.	Diameters of Pipes.																					
	7″	8″	9″	10″	11″	12″	13″	13½″	14¾″	15″	15½″	16½″	17½″	18″	18½″	19″	20″	21″	22″	24″	26″	28″	30″
1 in 10	3·12	4·35	5·87	7·68	9·85	11·95	14·97	16·28	20·07	21·60	23·38	26·96	31·59	33·65	37·57	39·15	44·40	50·27	56·61	70·40	83·74	98·67	108·75
1 in 20	2·14	3·02	4·06	5·32	6·72	8·32	10·26	11·38	13·79	14·84	16·16	18·63	21·96	23·52	25·95	27·29	32·89	34·71	39·11	48·53	58·17	70·38	81·40
1 in 30	1·79	2·55	3·41	4·47	5·69	7·03	8·68	9·60	11·46	12·90	13·63	16·72	18·52	19·16	21·91	23·91	25·94	28·92	33·10	41·00	50·00	63·81	72·11
1 in 40	1·60	2·28	3·04	3·99	5·04	6·42	8·13	8·82	10·41	11·76	12·05	14·00	17·23	18·00	19·51	21·26	23·08	26·96	30·38	36·87	45·90	56·72	64·68
1 in 50	1·54	2·19	2·94	3·76	4·74	5·95	7·40	8·10	9·70	10·86	11·25	13·10	16·00	16·70	18·10	19·68	21·30	25·00	28·33	33·50	41·46	51·56	58·63
The discharges above this, although calculated from Neville's formula, are multiplied by coefficients, as the discharge by the formula is too great with long pipes at high inclinations.																							
1 in 60	1·42	2·01	2·70	3·56	4·40	5·50	6·82	7·50	9·08	9·90	10·55	12·23	14·80	15·50	16·90	18·32	20·30	23·08	26·39	31·50	38·26	47·58	53·56
1 in 70	1·31	1·86	2·50	3·27	4·11	5·10	6·39	6·90	8·50	8·94	9·88	11·41	13·66	14·42	15·80	17·00	19·00	21·24	23·79	29·30	35·44	44·08	49·97
1 in 80	1·20	1·72	2·28	3·00	3·80	4·70	5·91	6·37	7·91	8·35	9·22	10·63	12·53	13·40	14·80	15·70	17·73	19·84	22·21	27·54	32·89	40·26	45·57
1 in 90	1·13	1·60	2·13	2·89	3·55	4·38	5·45	5·93	7·38	7·77	8·59	9·91	11·50	12·51	14·03	14·86	16·36	18·43	20·68	25·91	30·72	37·77	42·77
1 in 100	1·07	1·51	2·02	2·67	3·29	4·12	5·15	5·58	6·93	7·37	8·08	9·31	10·97	11·77	12·98	13·94	15·15	17·23	19·35	24·34	28·88	35·91	40·37
1 in 125	0·93	1·31	1·76	2·32	2·86	3·61	4·45	4·88	6·09	6·44	7·19	8·17	9·63	10·30	11·38	11·84	13·05	15·23	17·16	21·20	25·19	30·64	34·77
1 in 150	0·84	1·20	1·54	2·10	2·46	3·28	4·07	4·38	5·46	5·73	6·36	7·34	8·65	9·27	10·23	10·60	12·00	13·62	15·39	19·10	22·73	27·79	31·58
1 in 175	0·75	1·08	1·43	1·91	2·34	2·96	3·69	4·02	5·00	5·31	5·82	6·71	7·91	8·39	9·20	9·65	11·18	12·42	14·08	17·54	20·58	25·65	29·18
1 in 200	0·68	0·99	1·32	1·77	2·22	2·77	3·38	3·72	4·62	4·90	5·38	6·21	7·32	7·80	8·65	8·98	10·18	11·42	12·98	16·23	19·05	23·87	27·18
1 in 250	0·62	0·87	1·21	1·54	1·90	2·38	2·99	3·27	4·09	4·40	4·73	5·46	6·44	6·92	7·61	8·00	9·09	10·22	11·44	14·13	16·25	20·67	23·58
1 in 300	0·56	0·78	1·10	1·36	1·70	2·12	2·69	3·08	3·66	3·88	4·26	4·92	5·80	6·18	6·86	7·38	8·18	9·02	10·12	12·79	15·05	18·89	21·58
1 in 350	0·59	0·72	0·99	1·27	1·59	2·00	2·46	2·72	3·35	3·48	3·91	4·50	5·31	5·71	6·27	6·74	7·45	8·21	9·46	11·78	13·82	17·46	19·99
1 in 400	0·47	0·67	0·88	1·18	1·45	1·88	2·30	2·50	3·10	3·27	3·38	4·17	4·92	5·30	5·82	6·00	6·90	7·61	8·58	10·76	12·60	16·03	18·38

This table is calculated from Neville's formula, $V = 140\sqrt{RS} - 11\sqrt[3]{RS}$. From this table it will be seen that a pipe 12in. in diameter, having a fall or inclination of 1 in 30, is capable of delivering 7·03 cubic feet of water per second, or the same number of sluice-heads per minute; but if the inclination be reduced to 1 in 400, the quantity of water delivered will only be 1·88 cubic feet per second, or the same number of sluice-heads per minute. As I have previously mentioned, I have found this formula give rather a high percentage when the water is flowing at high velocities; therefore the discharges, although calculated from the formula, are multiplied by coefficients to get the actual discharge, from experiments in long pipes at high inclinations. Where bends occur, or where the pipes are not clean and smooth inside, an allowance will have to be made for extra friction.

Construction of Pipes.

Thickness of Iron.—The thickness of iron used in the construction of hydraulic pipes depends entirely on the head or pressure of water they have to stand; but the custom in California is to calculate for the iron to be subjected to a working tensile strain of from 5 tons to 10 tons per sectional inch. The following table is taken from A. J. Bowie on "Hydraulic Mining," which shows the tensile strain to which wrought-iron pipes belonging to different companies have been subjected:—

Locality.	Diameter of Pipe.	Thickness of Iron.		Pressure.		Maximum TensileStrain per Sectional Inch.
		BWG No.	In.	Ft.	Lbs. per Sq. In.	
	In.					Lbs.
Amador City(1)	15	14	·083	260	112·5	10·165
Moore's Flat	12	14	·083	400	173·2	12·520
Moore's Flat(2)	22	14 16	·083 ·065	80	34·6	5·862
San Juan(3)	40	7 11	·187 ·125	80	34·6	3·700 5·542
San Juan(4)	36	14 12	·083 ·109	55	23·8	5·161
San Juan	16	18	·049	200	86·6	14·120
San Juan(5)	12 11	18	·049	184	79·6	9·755
Smartsville(6)	16	18	·049	180	77·9	12·725
Smartsville(7)	18	14	·083	200	86·6	9·390
Spring Valley Water Company(8) ...	30	14	·083	300	129·9	23·476
Spring Valley Water Company(9) ...	30	11	·125	365	158·0	19·000
Virginia City Water Company(10) ...	11½	0	·324	1,720	750·0	13·310
Cherokee	30	00	·375	887	384·0	15·360
French Corral(11)	22	10	·134	430	186·0	15·276
Malakoff Diggings	22	10	·134	450	194·8	15·991
Malakoff Diggings	15	12	·109	450	194·8	13·403
Texas Creek(12)	17	8	·165	760	329·0	16·952

(1) Longitudinal rivets, 1¼″ apart; circular-seam rivets, 1½″ apart.
(2) Length of line, 3,500ft.
(3) The pipe is laid on wooden blocks on the top of the ground. The pipes are slipped into each other, one length of pipe being made a little larger than the other. The largest or outside pipe is ⅛″ in thickness, and the smaller or inside one $\frac{3}{16}$″. Rivets in all seams 2″ apart, hot-riveted, and lap of seam 2″. Pipe put up in 20ft. sections. Length, 2,200ft. Coal-tar on outside, nothing inside. Has stood five years. Cost $20,000.
(4) Rivets 1½″ apart, laps 2″. Pipe 2,500ft. long. Coated inside with coal-tar and turpentine. Laid aboveground.
(5) Not coated. In use eight years.
(6) 900ft. long. Courses 30″, with rivets on longitudinal seam 1½″ apart, and on circular seam 2½″. Painted outside, but not inside. In use five years.
(7) Courses 24″ long. Longitudinal seams riveted 1½″ apart, circular seams 3″, lap 1½″. No coating.
(8) Experiment made by the company. Rivets, $\frac{3}{16}$″ diameter, 1″ apart.
(9) Experiment. In both cases the pipe leaked, but was made tight with sawdust.
(10) Length of pipe, 37,000ft. Discharge, about 2,000,000 gallons per twenty-four hours.
(11) Pipe 4,000ft. long.
(12) An inverted siphon, 4,438ft. long, made of double-riveted wrought-iron. Joints made by sleeves with lead packing. Coated with coal-tar and asphaltum. Quality of iron very poor—damaged by salt water. The pipe burst twice in 1878–79, and again at its greatest depression in 1883. An examination of the iron at this point showed that it was eaten through with rust.

NOTE.—The formula used for determining the thickness of iron is $T = \frac{RP}{F}$, where R = radius in inches, P = pressure of iron in pounds per square inch, T = thickness of iron in inches, F = tensile strain per sectional inch in pounds.

By referring to the diagram showing the profile of the wrought-iron pipe for the Cherokee Gravel-mines, Butte County, California, it will give interesting information as to the thickness of iron used. The pipe was 30in. in diameter and 12,000ft. long. Up to 150ft. below the hydraulic-grade line the thickness of the iron was No. 14 BWG, from 150ft. to 270ft. No. 12, from 270ft. to 350ft. No. 10, from 350ft. to 420ft. No. 7, or $\frac{3}{16}$in., from 420ft. to 590ft. ¼in., from 590ft. to 840ft. $\frac{5}{16}$in., from 840ft. to 887ft., which was the total depth, the thickness of the iron was ⅜in. This, together with the diagram of North Bloomfield Gold-mining Company Texas Creek, pipe, will give a good illustration of the thickness of iron that is generally used.

Riveting.—For light pressure single-riveted joints are sufficient; but where there is a heavy pressure the longitudinal joints should have two rows of rivets. The rivets should be spaced about 1¼in. apart and ⅝in. from each other. The sizes of rivets generally used in America for the construction of hydraulic pipes are as follows:—

BWG.	BWG.
Nos. 18 and 16, $\frac{3}{16}$in. by ⅜in. long	Nos. 10, 9, and 8, ⅝in. by ¾in. long
No. 14, ¼in. by ½in. long	Nos. 7 and 6, ½in. by 1¼in. long
Nos. 12 and 11, $\frac{5}{16}$in. by ⅝in. long	No. 3, ½in. by 1½in. long.

In constructing thin-iron pipes the riveting is done cold; but when the iron is thick all riveting should be done hot. The pipes should be made so that the iron is rolled or bent crosswise: the practice of rolling iron for pipes lengthwise is not commendable.

Joints.—The pipes are first made in lengths according to the widths of the sheet of iron used, and afterwards these sections are riveted together into 20ft. and 30ft. lengths. The best mode of joining these lengths on the ground is a subject which deserves consideration. Many systems have been adopted both here and in America, such as riveting together on the ground, or having flanges of angle-iron on the ends to bolt together; while some are slipped into each other in stove-pipe-fashion, without rivets, bolts, wire, or any other contrivance being necessary to hold them together.

There is a system adopted in America for joining the long lengths which has not yet been tried here—that is, by having a ferule or band of wrought-iron, made about 5in. broad and ⅜in. larger than the diameter of the pipe. These bands are slipped on over the ends when the pipes are laid down, the ends butted together with some spun-yarn packing put over the centre of the joint to hold the band in its place until molten lead is poured in to fill up the space between the outside of the pipe and the inside of the band. This ferule acts the same as a facet on cast-iron pipes, and the joints are made exactly in the same manner, the lead being afterwards tightly caulked at both ends of the band. The bands are generally made $\frac{1}{16}$in. thicker than the iron in the pipe. In some cases there are lugs or brackets riveted on each end of the pipe to be joined; then there is a longitudinal strap bolted on to these brackets or lugs, which holds the pipes together.

The annexed sketch will show the general arrangement of the whole process of joining.

Air-valves and Blow-offs.—Where long lines of pipes or a siphon occur air-valves are required at intervals to provide for the escape of air from the pipe when filling, and to prevent a collapse of the pipe in the event of a breakage taking place. These air-valves can be made in various ways, and are quite simple in construction. A class of air-valve and blow-off, as advocated by A. J. Bowie, in his treatise on hydraulic mining, is shown in annexed sketches. These are used on the Virginia City and Gold Hill Water Company's siphon, and are fixed in the position as shown in the sketch.

Mr. Bowie describes the air-valve as follows: "When the water is on, the valve *a* is kept open and the valve *c* closed, while the self-acting valve *b* is shut by the pressure. If any air accumulates in the pipe it is blown off occasionally by opening the cock *c*. Should a break occur in the main pipe-line at a point lower than the air-cock, and within its district, the valve *b* falls down and admits the air, so as to prevent a vacuum. After the break is repaired the water is let on again. The valve *b* being down, or open, the air rushes out, the valve-stem being weighted *d* so as to close only when the water reaches it."

Coating Pipes.—All wrought-iron pipes should be coated with a mixture of coal-tar and asphaltum, to prevent the oxidation of the iron. A. J. Bowie states that "thin pipes well coated are still in good condition after fifteen years' service."

The following preparations for coating wrought-iron pipes have been found valuable in practice:—

Crude asphaltum, 28 per cent.;
Coal-tar (free from oily substances), 72 per cent. or,

Refined asphaltum, 16½ per cent.;
Coal-tar (free from oily substances), 83½ per cent.

"The (Santa Barbara) asphaltum, in small pieces, and the coal-tar are heated to about 400° Fahr., and well stirred. The pipe is thoroughly dried and immersed in the mixture, where it remains until it has acquired the same temperature as the mixture. When coated it is removed and placed on a trestle, to drip and dry in the sun and air. For convenience of immersion, wrought-iron troughs are used, some 30ft. long, 3ft. wide, and 2ft. deep. No. 14 BWG iron requires to be immersed for about seven minutes, and No. 6 gauge from twelve to fifteen minutes."

Cost of Hydraulic Pipes.

The cost of hydraulic pipes in America, as far as statistics show, is as follows: 22in. pipe, No. 16 U.S. wire gauge, or ·05in. thick, constructed for La Grange Hydraulic Mining Company, single-riveted seam, 4s. 4d. per foot.

North Bloomfield Company: A 22in. pipe, No. 10 BWG, seams double-riveted, cost 8s. 4d. per foot; and one pipe, 22in. in diameter, No. 12 BWG, seams double-riveted, cost 6s. 4½d. per foot.

These companies manufactured their own pipes on the ground, the cost of a plant to construct pipes up to No. 10 gauge iron being about £83.

As the cost of transit of pipes in New Zealand is a great item in some cases, I have calculated Table No. 7, which shows the weight of each pipe per lineal foot. I have taken the diameter of pipe

that the ordinary sheets of iron will construct without cutting any to waste. (Wrought-iron pipes, double-riveted, for hydraulic sluicing, and siphons with flanges or faucets every 20ft. in length of pipe. The diameter of pipe that sheets of iron will make without cutting to waste is marked thus *. The figures in the columns of BWG and eighths of an inch represent the weight of a lineal foot of pipe riveted, including flanges every 20ft.)

Diameter of Pipes in Inches.	No. 18, 0·049in. BWG.	No. 16, 0·065in. BWG.	No. 14, 0·083in. BWG.	No. 12, 0·109in. BWG.	⅛in. 0·125in.	3/16in. 0·187in.	¼in. 0·25in.	5/16in. 0·317in.	⅜in. 0·375in.
	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.
*7⅛	3·87	5·20	...	...	...	...	...	...	...
8	4·65	6·25	8·20	...	...	...	...	...	...
*9	5·11	6·88	9·07	12·04	...	...	...	...	...
10	5·58	7·50	9·90	13·14	15·00	...	...	...	...
*11	6·13	8·25	10·72	14·45	16·50	...	...	...	...
12	6·70	9·00	11·55	15·77	18·00	27·00	...	...	...
*13⅛	7·12	9·57	12·63	16·77	19·15	28·72	...	. .	...
*13½	7·27	9·77	13·00	17·10	19·50	29·26	...	...	...
14	7·44	10·00	13·20	17·52	20·00	30·00	...	...	...
*14¾	7·90	10·62	14·06	18·39	21·00	31·50	42·00	...	...
*15¾	8·37	11·20	14·85	19·62	22·00	33·00	44·00	...	...
*16⅝	8·83	11·87	15·67	20·71	23·30	35·25	46·60	...	...
*17⅝	9·30	12·40	16·50	21·61	24·80	37·20	49·60	...	...
*18⅝	9·76	13·12	17·30	22·60	26·25	39·37	53·50	66·62	...
*19½	10·23	13·75	18·15	23·85	27·50	41·25	55·00	68·75	...
21	10·84	14·57	19·23	25·30	29·15	43·72	58·30	72·87	...
*22⅝	11·62	15·62	20·62	27·12	31·25	46·87	62·50	79·12	...
24	12·38	16·65	21·97	29·04	33·30	49·95	66·60	83·25	99·90
*26¼	13·48	18·22	23·92	31·61	36·25	54·37	72·50	90·62	108·75
28	14·23	19·15	25·27	33·39	38·30	57·45	76·60	95·75	114·90
30	15·34	20·62	27·27	35·97	41·25	61·87	82·50	103·12	123·75

NOTE.—Single-riveted joints, and without flanges or faucets, will be about 3 per cent. lighter; single-riveted joints with flanges or faucets will be about 1¼ per cent. lighter.

The following table shows the cost per lineal foot of constructing wrought-iron pipes, of best quality of iron, with either single- or double-riveted joints, in 20ft. lengths, with wrought-iron flanges drilled for bolts, all sheets or plates bent with the grain, and pipes, while hot, dipped in boiling tar and asphaltum :—

Inside Diameter of Pipe, in Inches.	BWG No. 18.		BWG No. 16.		BWG No. 14.		BWG No. 12.		⅛in.		3/16in.		¼in.		5/16in.	
	Single Riveted.	Double Riveted.	Single Riveted.	Double Riveted.	Single Riveted.	Double Riveted.	Single Riveted.	Double Riveted.	Single Riveted.	Double Riveted.	Single Riveted.	Double Riveted.	Single Riveted.	Double Riveted.	Single Riveted.	Double Riveted.
	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
7⅛	2 9	3 0	3 0	3 3	3 3	3 6	..	..	..	..	..	..	..	..	..	..
8	3 3	3 6	3 6	3 9	3 9	4 0	5 3	6 3	..	..	..	..	..	..	..	..
9	3 6	3 9	3 9	4 1	3 10	4 2	5 6	6 6	..	..	..	..	..	..	..	..
10	3 8	4 2	3 11	4 5	4 1	4 8	5 9	6 9	7 2	7 9	9 4	9 9	..	..	..	..
11	3 10	4 4	4 1	4 7	4 4	4 10	6 0	7 0	7 4	8 0	9 6	10 0	..	..	..	..
12	4 6	5 0	4 9	5 2	4 10	5 4	6 3	7 3	7 7	8 3	9 9	10 3	..	..	..	..
13⅛	4 9	5 3	5 0	5 6	5 2	5 8	6 2	7 6	7 10	8 6	10 0	10 6	..	..	..	..
13½	5 0	5 6	5 3	5 9	5 4	5 11	6 5	7 9	8 1	8 9	10 3	10 9	..	..	..	..
14	5 3	5 9	5 6	6 0	5 8	6 2	6 8	8 0	8 6	9 0	10 6	11 0	12 7	13 3	..	..
14¾	5 5	5 11	5 8	6 2	5 10	6 4	6 11	8 3	8 9	9 3	10 9	11 3	12 10	13 6	..	..
15¾	5 7	6 1	5 9	6 3	6 0	6 6	7 2	8 6	9 0	9 6	11 0	11 6	13 1	13 9	..	..
16⅝	5 9	6 3	6 0	6 6	6 3	6 9	7 4	8 9	9 3	9 9	11 2	11 9	13 4	14 0	..	..
17⅝	5 10	6 4	6 2	6 8	6 6	7 0	7 8	9 0	9 6	10 0	11 5	12 0	13 7	14 3	..	..
18⅝	6 0	6 8	6 6	7 3	7 0	7 6	7 11	9 3	9 9	10 3	11 8	12 3	13 10	14 6	..	..
19½	6 3	7 0	6 9	7 6	7 3	7 9	8 2	9 6	10 0	10 6	11 11	12 6	14 0	14 9	..	..
21	6 6	7 6	7 0	8 0	7 6	8 6	8 5	9 9	10 3	10 9	12 2	12 9	14 3	15 0	..	..
22⅝	7 0	8 0	7 9	8 9	8 6	9 6	8 6	10 0	10 6	11 0	12 4	13 0	14 9	15 6	17 1	18 0
24	..	..	..	..	..	10 0	9 0	10 6	11 0	11 6	12 10	13 6	15 3	16 0	17 7	18 6
26¼	..	..	..	..	..	10 3	9 6	11 0	11 5	12 0	13 4	14 0	15 8	16 6	18 1	19 0
28	..	..	..	..	..	10 6	10 0	11 6	11 11	12 6	13 9	14 6	16 2	17 0	18 6	19 6
30	..	..	..	..	..	11 0	10 6	12 0	12 5	13 0	14 3	15 0	16 8	17 6	19 0	20 0

NOTE.—For all sizes, No. 12 BWG, 25 per cent. will be deducted if flanges are not required. For all sizes, ⅛in. thick and over 5 per cent. will be deducted if flanges are not required. These prices are given for lengths of pipes not less than 200ft.

This table shows the approximate cost of pipes manufactured in New Zealand, which is far in advance of the price for which they can be constructed in America; but the difference is that each company is its own manufacturer. There is still another thing to be taken into account—viz., that the price quoted in American statistics is for pipes in sections of 20ft. long; these have to be afterwards laid in position and joined: whereas the estimate in Table No. 8 is to construct and fix the pipe in position.

Nozzles.—There is no part of a hydraulic plant that requires more care in its construction than a nozzle. It should be as light as possible consistent with strength, so as to be easily handled and shifted; and also the form of the nozzle should be such that it throws the water in a solid body without scattering. The last is an essential element, for without this the effective force of the water is destroyed, both for bringing down falls and also for breaking up the dirt. There are very few hydraulic-sluicing nozzles yet made that throw the water for any distance in a solid form; therefore the full benefit of the water due to the head is not realized. The best nozzles in use here are the American giant nozzles, fitted with deflectors. These are easily and conveniently worked; still, they have the fault previously alluded to, that they do not throw the water for any distance in a sufficiently-concentrated form. The discharge end of the nozzle requires to be protected to prevent indentations on the edge of the mouth, which have the effect of scattering the water as it is discharged. The best form of protection is to chamber out a short piece on the end of the nozzle, about $\frac{5}{16}$ of an inch in depth and $\frac{1}{4}$ of an inch greater in diameter than the discharge end. There is also another element to take into consideration. The head of the pipe which conveys the water to the nozzle should be submerged in water to prevent air getting into the pipe, which also causes the water to scatter when discharged through the nozzle. The size of the nozzle must be regulated by the head and quantity of water required to work the ground. The following table shows the discharge in sluice-heads from nozzles of different dimensions and under different heads. It is calculated from the formula, $Q = [(H)^{\frac{1}{2}} \times d^2 \times C]$, when Q equals the number of sluice-heads discharged per minute, H the head of water, d the diameter of the nozzle in eighths of an inch, and C a variable coefficient of discharge according to the relation that the wetted perimeter has to the size of the nozzle C, being from ·00064 to ·00066, which gives from 95 to 98 per cent., the theoretical velocity of the water. [See table, page 104.]

Water-motors.—The simplest and most effective water-motor that has yet been in use in the colony is what is known as the Pelton hurdy-gurdy water-wheel. These were first introduced here by Mr. G. F. Bull, of Hape Creek, Thames. A description of the trials of this wheel was published in the *Scientific and Mining Press*, of San Francisco, when a premium was offered by the Idaho Company for the best description of a water-motor, combining cheapness, simplicity, and economy. These wheels were tested at a public competition, and gave a higher percentage of power for the water used than any other.

A series of comparative tests were made at the Idaho Mine, Grass Valley, with the Fredenburr, Pelton, Knight, and Taylor water-wheels. Prony's friction dynamometer was used to test their efficiency, the brake acting on the wheels being 6ft. in diameter. The supply-main was 6,900ft. long, 22in. in diameter, with a head of 386½ft. at the nozzle, which was 1·89in. in diameter. The water from the wheel was discharged into a flume 36ft. long, 36½in. wide, and 24in. deep. There were three check-boards placed in the flume below where the water entered; and at the lower end of the flume there was a weir 12in. deep, 36½in. wide, made of ⅛in. iron, over which the water flowed without contraction. France's formula for the discharge of water was adopted as the basis of calculation.

The following are the official returns: The Fredenburr wheel utilized $69\frac{6}{10}$ per cent.; the Pelton wheel, $90\frac{2}{10}$ per cent.; the Knight wheel, $77\frac{2}{10}$ per cent.; and the Taylor wheel, $55\frac{1}{10}$ per cent. of the force and impact of the water.

Mr. Bowie, in writing on these trials, states: "The accuracy of the weir-measurements may be considered doubtful. From the data obtained it did not appear that the increased discharge due to the velocity of approach had been taken into account. To check this estimate of flow the diameter of the nozzle could not be used, as it was not accurately measured, and the coefficient of efflux had not been established. However, sufficient is known to justify the assumption that the efficiency of the Pelton wheel is at least 86 per cent."

In conducting experiments three years ago at the Thames, I found that the Pelton wheel in use there gave 81 per cent., the tangential wheels 72 per cent., and the best-constructed Leffel turbine, which Messrs. Firth and Clarke imported from America, gave 69 per cent. of the power of the water; thus showing that the Pelton hurdy-gurdy wheel gave 12 per cent. more power than any of the others. Their portability, cost, simplicity, and effectiveness cannot fail to cause them to be brought into general use; but in introducing any new motive-power it takes a considerable time to bring about its adoption, especially among the mining community, who look with suspicion on any new machine until its efficiency is thoroughly established.

A great many experiments were made with buckets having different curves, and also the angle that the water from the nozzle struck the bucket. It was found the greatest effect was attained where the water struck the bucket at right angles to its face directly underneath the wheel, and also that the speed of the periphery of wheel was about one-half the velocity of the water.

The tables on page 105 show the horse-power of these wheels under different heads of water, the number of revolutions they require to be driven at, and their first cost.

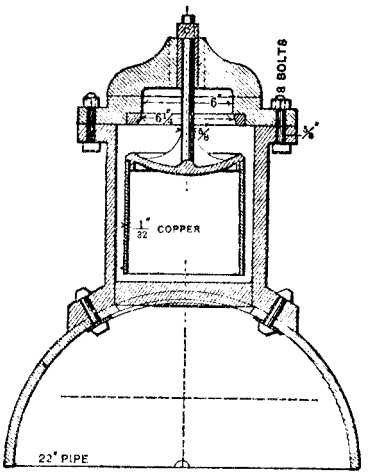
Lifting the Boulders.—In America strong derricks are used in the hydraulic mines to remove the large boulders and rocks that are found in the wash-drift. The derricks are generally constructed with a mast about 100ft. high and a boom 92ft. long; the former is stepped into a cast-iron block set in sills, and is held in position by six guys of galvanized iron-wire ropes 1in. in diameter. A whip-block, with steel-wire rope ¾in. in diameter, is used for hoisting-tackle.

These derricks are generally worked by a hurdy-gurdy water-wheel. They lift stones weighing 11 tons. The guys are held by double capstans. It is stated that these derricks can be readily moved 100ft. in about ten hours.

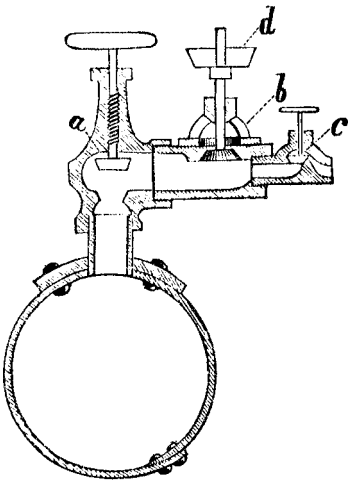
I am greatly indebted for the information that I have acquired respecting the subject of hydraulic sluicing in America to A. J. Bowie's "Treatise on Hydraulic Sluicing," recently published by D. Van Nostrand, New York, and from private letters on this subject from men engaged in this branch of mining in California.

TABLE showing the QUANTITY of WATER Discharged in Sluice-heads from Nozzles of different Dimensions under different Heads of Water.

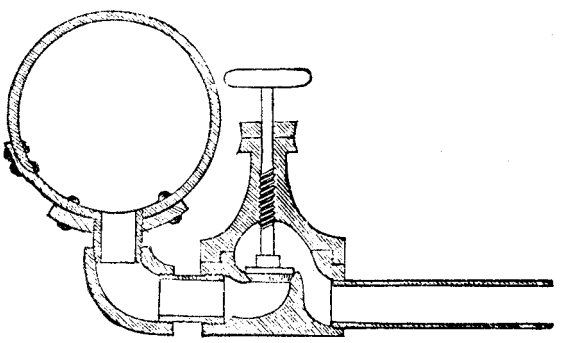
Head on Nozzle, in Feet.	Diameter of Nozzles, in Inches.														
	1	1¼	1½	1¾	2	2¼	2½	2¾	3	3½	4	4½	5	5½	6
	Sluice-heads discharged per Minute.														
10	0·129	0·202	0·290	0·394	0·517	0·650	0·808	1·000	1·202	1·636	2·137	2·702	3·339	4·041	4·808
20	0·183	0·285	0·410	0·560	0·730	0·925	1·144	1·385	1·700	2·314	3·022	3·822	4·722	5·714	6·800
30	0·224	0·349	0·504	0·688	0·896	1·136	1·400	1·696	2·082	2·834	3·699	4·681	5·784	6·998	8·328
40	0·259	0·405	0·581	0·792	1·034	1·309	1·626	1·958	2·404	3·272	4·274	5·403	6·678	8·080	9·617
50	0·290	0·453	0·650	0·906	1·157	1·466	1·813	2·190	2·688	3·659	4·779	6·043	7·467	9·035	10·753
60	0·317	0·496	0·712	0·970	1·269	1·605	1·984	2·399	2·944	4·007	5·234	6·620	8·178	9·896	11·779
70	0·344	0·536	0·770	1·048	1·370	1·733	2·141	2·591	3·180	4·329	5·654	7·150	8·834	10·690	12·721
80	0·365	0·573	0·824	1·122	1·464	1·853	2·288	2·761	3·389	4·613	6·025	7·619	9·413	11·390	13·553
90	0·387	0·605	0·874	1·189	1·581	1·968	2·426	2·938	3·606	4·909	6·411	8·106	10·017	12·121	14·425
100	0·408	0·640	0·922	1·256	1·640	2·074	2·560	3·098	3·801	5·175	6·759	8·547	10·560	12·777	15·207
110	0·429	0·672	0·965	1·312	1·717	2·173	2·693	3·224	3·987	5·386	7·084	8·895	10·993	13·299	15·834
120	0·448	0·701	1·008	1·392	1·794	2·272	2·805	3·393	4·164	5·668	7·403	9·362	11·567	13·996	16·657
130	0·467	0·728	1·050	1·429	1·866	2·363	2·917	3·523	4·334	5·900	7·705	9·744	12·040	14·568	17·336
140	0·482	0·757	1·090	1·485	1·938	2·453	3·029	3·665	4·498	6·123	7·997	10·112	12·494	15·120	17·992
150	0·501	0·784	1·128	1·536	2·005	2·536	3·136	3·794	4·655	6·336	8·276	10·467	12·931	15·640	18·622
175	0·540	0·845	1·219	1·664	2·168	2·737	3·386	4·098	5·029	6·844	8·940	11·306	13·969	16·902	20·114
200	0·580	0·904	1·306	1·773	2·317	2·931	3·621	4·381	5·376	7·317	9·577	12·084	14·933	18·070	21·505
250	0·648	1·010	1·453	1·984	2·589	3·280	4·048	4·897	6·011	8·181	10·686	13·514	16·696	20·203	24·043
300	0·710	1·106	1·600	2·173	2·837	3·590	4·434	5·365	6·585	8·962	11·705	14·802	18·290	22·130	26·337



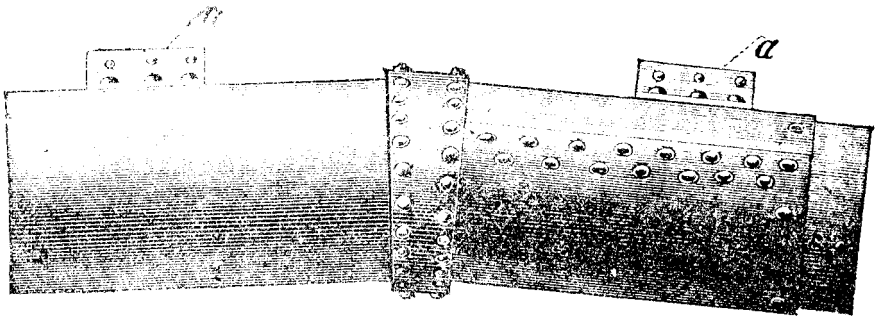
AIR-VALVE FOR 22″ WATER-PIPES.



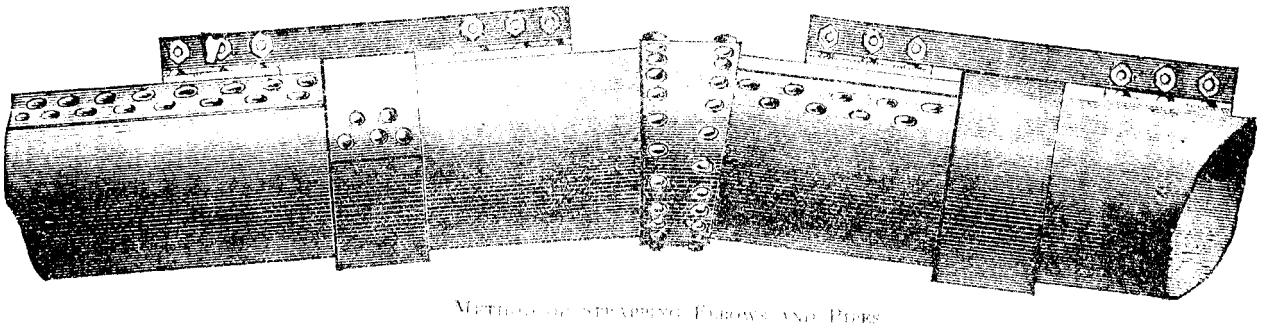
SELF-ACTING AIR-VALVE.



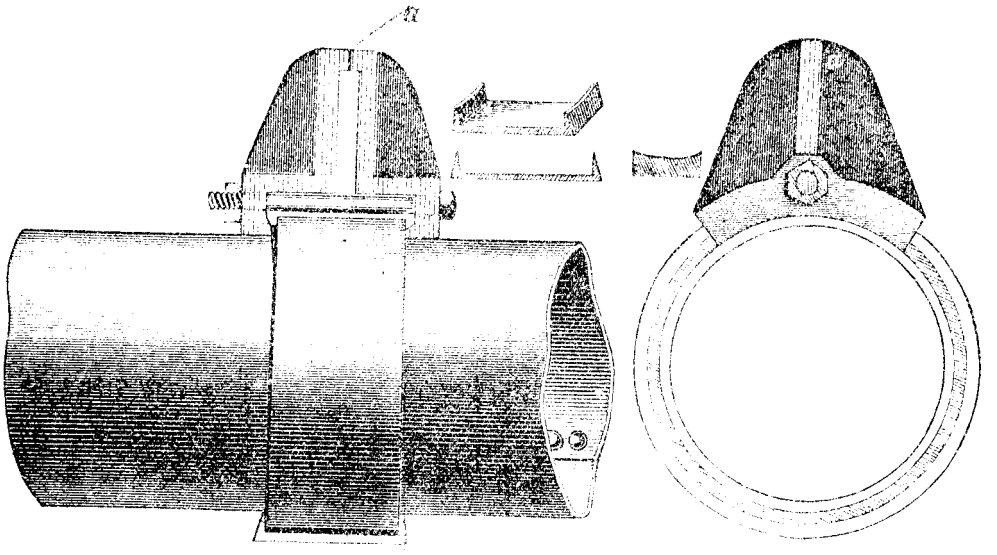
BLOW-OFF IN A LOW PLACE.



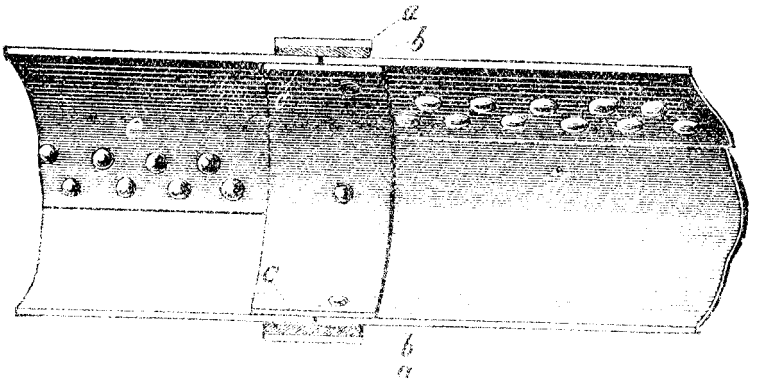
Elbow for Short Curves.



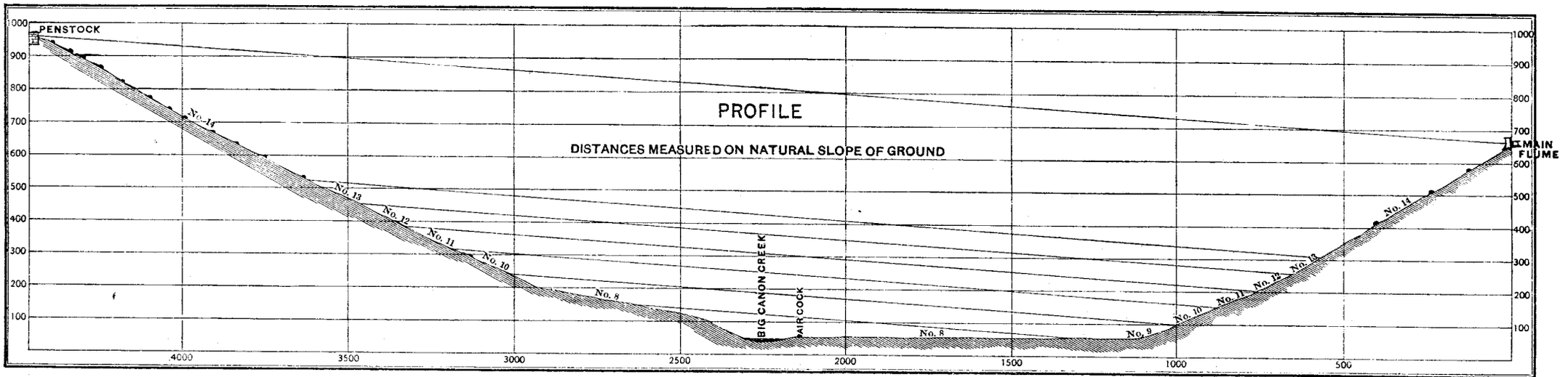
Method of Stripping Elbows and Pipes

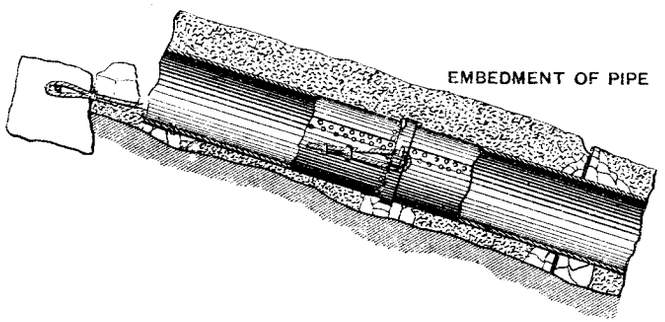


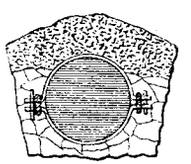
Method of Forming Lead Joints.

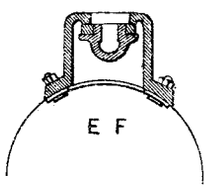


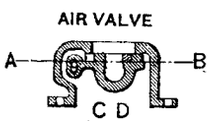
Lead Joint.

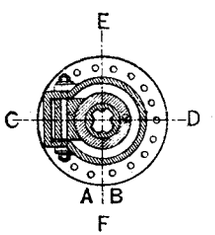






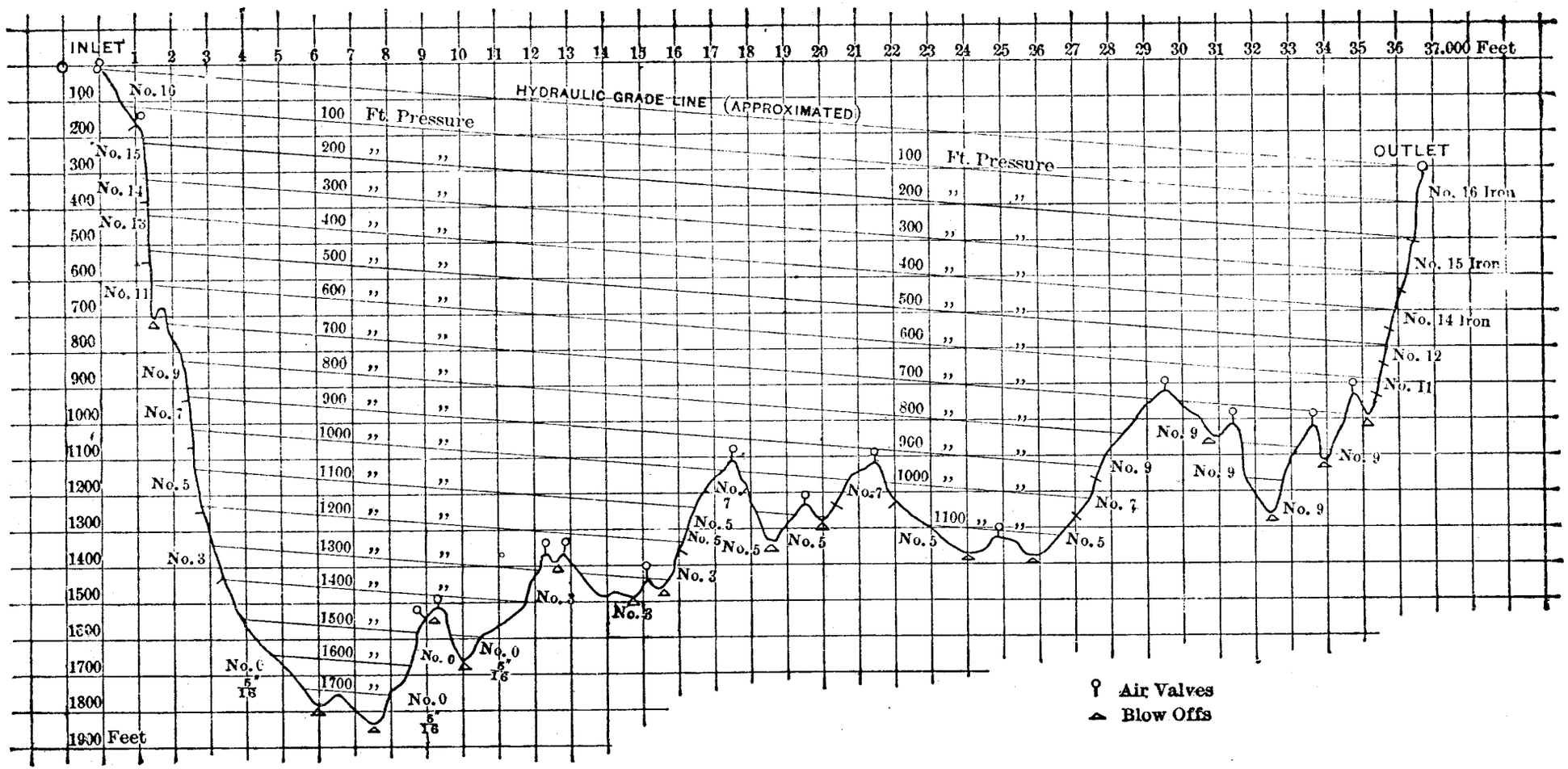






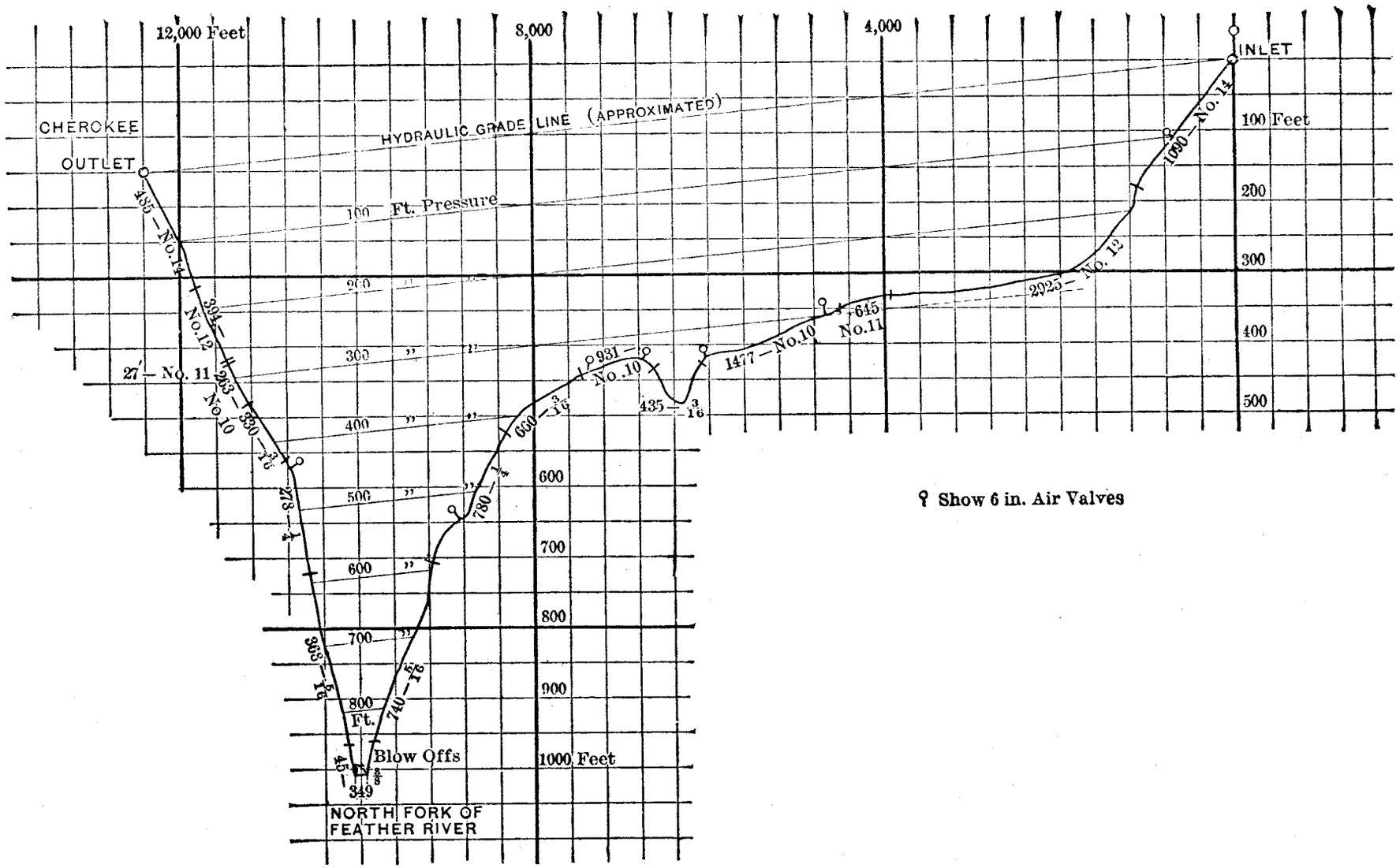
SKETCH OF NORTH BLOOMFIELD GOLD-MINING COMPANY'S TEXAS CREEK PIPE, NEVADA COUNTY, CALIFORNIA.

Diameter of Pipe, 17 inches. *Length of pipe*, 4,439 *feet*. *Head of water*, 303 *feet*. *Discharge per second*, 31 *cubic feet*. *Nos.* 8, 9, *etc.*, *thickness of pipe*, *Birmingham Gauge*. *Dots on profile*, *air-valves*.



PROFILE OF IRON PIPE FOR THE VIRGINIA AND GOLD HILL WATER-WORKS.

Average Diameter of Pipe, 11½ *inches. Circular seams single-riveted, longitudinal seams double-riveted. Capacity, about* 2,000,000 *gallons in* 24 *hours. Pressure*, 1,720 *feet, or* 746 *pounds per square inch. Length of pipe, abou'* 37,100 *feet. Laid in* 1872 *by Hermann Schussler, Civil Engineer. Total fall*, 300 *feet.*



PROFILE OF WROUGHT-IRON PIPE FOR THE CHEROKEE GRAVEL MINES, BUTTE COUNTY, CALIFORNIA.

Pipe, 30 inches in diameter. Circular seams single-riveted, longitudinal seams double riveted. Capacity, 53 cubic feet per second. Total fall, 150 feet. Laid in 1870.

THE PELTON WHEEL.

Diameter, revolutions, fall of water, inches, cubic feet per minute, and horse-power of same.

Inches.	5	10	20	30	40	50	60	70	80	90	100	120	140	160	180	200	Head in Feet.	Diameter of Wheels in Feet.						
Cubic Feet per Minute.	8	16	32	48	64	80	96	112	128	144	160	192	224	256	288	320		1½	2	3	4	5	6	8
Head in Feet.	H.P.	H.P.	H.P.	H.P.	H.P.	H.P.	H.P.	H.P.	H.P.	H.P.	H.P.	H.P.	H.P.	H.P.	H.P.	H.P.		Working-revolutions per Minute.						
20	·25	·51	1·02	1·53	2·05	2·57	3·08	3·60	4·11	4·62	5·15	6·17	7·20	8·24	9·27	10·30	20	217	163	108	81	65	45	40
30	·37	·76	1·53	2·29	3·08	3·86	4·62	5·40	6·17	6·95	7·72	9·26	10·81	12·36	13·90	15·45	30	265	200	133	100	80	66	50
40	·51	1·02	2·05	3·08	4·11	5·15	6·17	7·20	8·23	9·26	10·30	12·36	14·41	16·48	18·54	20·60	40	307	230	153	115	92	77	57
50	·63	1·27	2·57	3·86	5·15	6·43	7·72	9·01	10·30	11·59	12·87	15·45	18·02	20·62	23·18	25·75	50	343	257	172	129	103	86	64
60	·76	1·53	3·08	4·62	6·17	7·72	9·26	10·81	12·36	13·90	15·45	18·53	21·62	24·72	27·81	30·90	60	376	282	188	141	113	94	70
70	·89	1·80	3·60	5·40	7·20	9·01	10·82	12·61	14·41	16·22	18·02	21·62	25·23	28·84	32·45	36·06	70	406	305	203	153	123	102	76
80	1·00	2·05	4·11	6·17	8·23	10·30	12·36	14·41	16·47	18·53	20·60	24·72	28·83	32·96	37·09	41·21	80	434	328	217	163	130	109	81
90	1·15	2·31	4·62	6·95	9·26	11·58	13·90	16·22	18·53	20·86	23·17	27·81	32·45	37·09	41·72	46·36	90	461	346	230	173	138	115	86
100	1·28	2·56	5·15	7·72	10·30	12·87	15·45	18·02	20·60	23·18	25·75	30·90	36·05	41·21	46·36	51·51	100	486	364	243	182	146	121	91
110	1·41	2·82	5·66	8·48	11·32	14·16	16·98	19·82	22·66	25·48	28·32	33·98	39·66	45·33	50·99	56·66	110	509	382	255	191	153	127	95
120	1·53	3·08	6·17	9·26	12·36	15·45	18·53	21·62	24·72	27·81	30·90	37·08	43·26	49·45	55·63	61·81	120	532	399	266	200	160	133	100
130	1·63	3·33	6·68	10·03	13·38	16·73	20·08	23·42	26·78	30·12	33·47	40·17	46·87	53·57	60·27	66·96	130	554	416	277	208	166	139	104
140	1·78	3·60	7·20	10·81	14·41	18·02	21·62	25·23	28·83	32·45	36·05	43·26	50·46	57·69	64·90	72·12	140	573	431	287	216	172	144	108
150	1·92	3·85	7·71	11·58	15·45	19·31	23·17	27·03	30·90	34·76	38·62	46·35	54·08	61·81	69·54	77·27	150	595	446	297	223	178	149	112
160	2·05	4·11	8·23	12·35	16·47	20·60	24·72	28·83	32·96	37·08	41·20	49·44	57·68	65·93	74·18	82·44	160	615	461	307	230	184	154	115
170	2·18	4·37	8·75	13·12	17·57	21·88	26·26	30·61	35·02	39·40	43·78	52·53	61·30	70·06	78·81	87·57	170	633	475	316	237	190	158	118
180	2·31	4·62	9·26	13·90	18·53	23·17	27·81	32·41	37·10	41·72	46·36	55·62	64·90	74·18	83·45	92·72	180	651	489	326	244	196	163	122
190	2·43	4·88	9·77	14·67	19·57	24·46	29·36	34·25	39·14	44·04	48·93	58·72	68·51	78·30	88·09	97·87	190	669	502	335	251	201	167	125
200	2·57	5·15	10·30	15·45	20·60	25·75	30·90	36·05	41·20	46·36	51·51	61·81	72·11	82·42	92·72	103·03	200	686	514	343	257	206	171	128
210	2·69	5·40	10·81	16·22	21·62	27·03	32·44	37·86	43·26	48·68	54·08	64·90	75·72	86·54	97·36	108·18	210	703	528	352	264	211	176	132
220	2·82	5·66	11·32	16·98	22·66	28·32	33·98	39·66	45·32	50·98	56·66	67·98	79·32	90·66	101·99	113·33	220	720	540	360	270	216	180	135
230	2·95	5·91	11·83	17·76	23·68	29·61	35·53	41·46	47·38	53·31	59·24	71·09	82·93	94·78	106·63	118·48	230	736	552	368	276	221	184	138
240	3·05	6·17	12·36	18·53	24·72	30·90	37·08	43·26	49·45	55·62	61·81	74·17	86·53	98·90	111·27	123·63	240	752	564	376	282	226	188	141
250	3·21	6·42	12·87	19·31	25·75	32·18	38·62	45·07	51·51	57·94	64·38	77·26	90·13	103·03	115·90	128·78	250	768	576	384	288	230	192	144
260	3·33	6·68	13·38	20·08	26·78	33·47	40·17	46·87	53·57	60·26	66·96	80·36	93·73	107·15	120·54	133·93	260	783	587	391	294	235	196	147
270	3·47	6·95	13·90	20·86	27·81	34·76	41·72	48·67	55·62	62·58	69·53	83·44	97·33	111·27	125·18	139·09	270	798	598	399	299	239	199	150
280	3·59	7·20	14·41	21·62	28·83	36·05	43·26	50·47	57·68	64·90	72·11	86·53	100·94	115·39	129·81	144·24	280	812	609	406	305	243	203	152
290	3·72	7·46	14·92	22·40	29·87	37·33	44·81	52·28	59·75	67·22	74·68	89·62	104·56	119·51	134·45	149·39	290	827	620	413	310	247	206	155
300	3·85	7·72	15·45	23·17	30·90	38·62	46·36	54·08	61·81	69·53	77·26	92·72	108·17	123·63	139·09	154·54	300	841	631	420	315	252	210	157

Price and capacity of each wheel under various heads.

Diameter of Wheels in Feet.	25ft. Head. H.P.	50ft. Head. H.P.	75ft. Head. H.P.	100ft. Head. H.P.	200ft. Head. H.P.	300ft. Head. H.P.	400ft. Head. H.P.	500ft. Head. H.P.	600ft. Head. H.P.	Price.	Price includes
1½	0·1 to 0·4	½ to 1	½ to 2	1 to 3	2 to 7	4 to 15	6 to 23	8 to 32	12 to 47	£18	Shaft, Pulley, Boxes, Gate, and Nozzle.
2	0·2 to 0·7	½ to 2	1 to 3	2 to 5	4 to 14	7 to 26	10 to 40	15 to 59	21 to 84	£30	
3	0·4 to 1·5	1 to 4	2 to 8	3 to 11	8 to 31	15 to 58	23 to 90	33 to 134	47 to 189	£45	
4	0·7 to 2·7	2 to 7	4 to 14	5 to 19	15 to 58	27 to 106	41 to 160	60 to 238	84 to 336	£60	
5	1·0 to 4·0	3 to 11	6 to 22	8 to 31	23 to 90	42 to 166	65 to 257	93 to 371	..	£80	
6	1·5 to 6·0	4 to 16	8 to 32	12 to 46	33 to 130	61 to 240	93 to 370	134 to 535	..	£90	
8	4·5 to 18·0	12 to 48	24 to 96	36 to 138	99 to 393	183 to 720	..	..	..	..	

VALUE OF WORKS CONSTRUCTED.

The total value of works constructed under the Mines Department, since the votes were placed under the control of the Hon. the Minister of Mines, for opening up the goldfields, and roads to mines other than gold, either wholly undertaken by the department, or by subsidies to local bodies, mining associations, and companies, and the amount authorized towards their construction, together with the expenditure and liability, are as follows :—

Nature of Work.	Total Cost of Construction, or Amount authorized to be expended.	Expenditure, by way of Subsidy or otherwise, by Mines Department.	Amount of Liability by Mines Department on Works in Progress.
Up to Years 1882–83 and 1883–84.	£ s. d.	£ s. d.	£ s. d.
Water-races	29,252 1 11	14,853 9 5	14,398 11 6
Roads on goldfields	21,437 11 2	13,089 16 0	8,347 15 2
Roads and tracks undertaken by County Councils, subsidized by Mines Department	52,841 17 0	21,844 16 7	10,207 15 9
Works undertaken by prospecting associations, subsidized by Mines Department	13,216 13 4	3,350 0 0	3,400 0 0
Construction of drainage- and sludge-channels, subsidized by Mines Department	5,750 0 0	2,468 15 4	781 4 8
	122,498 3 5	55,606 17 4	37,135 7 1
1884–85.			
Water-races	4,846 1 9	14,596 2 9	4,648 11 6
Roads on goldfields	13,667 10 1	9,630 9 6	12,384 15 9
Roads and tracks undertaken by County Councils, subsidized by Mines Department	13,566 14 1	6,293 16 6	12,739 17 6
Roads to mines, other than gold, subsidized by Mines Department	4,594 10 0	111 19 0	2,888 1 0
Works undertaken by prospecting associations, subsidized by Mines Department	850 0 0	108 0 0	3,692 0 0
Construction of drainage- and sludge-channels, subsidized by Mines Department	4,050 0 0	1,050 0 0	1,931 4 8
Diamond and other drills	3,600 0 0	1,858 0 0	..
	45,174 15 11	33,648 7 9	38,284 10 5
1885–86.			
Water-races	8,759 5 9	6,063 2 3	6,964 4 4
Roads on goldfields	27,543 18 8	12,360 14 9	27,567 19 8
Roads undertaken by County Councils, subsidized by Mines Department	14,773 2 3	13,043 15 9	12,477 9 2
Roads to mines, other than gold, subsidized by Mines Department	1,584 16 6	4,327 0 10	490 12 8
Works undertaken by prospecting associations, subsidized by Mines Department	11,860 18 0	1,999 5 7	6,389 5 9
Construction of drainage- and sludge-channels, subsidized by Mines Department	10,051 14 9	3,994 16 6	6,995 9 9
	74,573 15 11	41,788 15 8	60,885 1 4
1886–87.			
Water-races	..	1,828 14 4	3,466 0 8
Roads on goldfields	12,253 3 5	22,329 16 1	17,791 7 0
Roads and tracks undertaken by County Councils, subsidized by Mines Department	11,005 11 2	6,901 1 6	10,455 1 5
Roads to mines, other than gold, subsidized by Mines Department	..	276 1 0	110 13 10
Works undertaken by prospecting associations, and companies, subsidized by Mines Department	5,670 19 6	4,498 15 3	4,618 4 7
Construction of drainage- and sludge-channels, subsidized by Mines Department	..	5,242 18 0	672 6 10
Diamond and other drills	422 15 6	422 15 6	..
	29,352 9 7	41,500 1 8	37,113 14 4

Summary.

Water-races	42,857 9 5	37,341 8 9	3,466 0 8
Roads on goldfields	74,902 3 4	57,410 16 4	17,791 7 0
Roads and tracks undertaken by County Councils, subsidized by Mines Department	92,187 4 6	48,083 10 4	10,455 1 5
Roads to mines, other than gold, subsidized by Mines Department	6,179 6 6	4,715 0 10	110 13 10
Works undertaken by prospecting associations and companies, subsidized by Mines Department	31,598 10 10	9,956 0 10	4,618 4 7
Construction of drainage- and sludge-channels, subsidized by Mines Department	19,851 14 9	12,756 9 10	672 6 10
Diamond and other drills, subsidized or otherwise by Mines Department	4,022 15 6	2,280 15 6	..
	271,599 4 10	172,544 2 5	37,113 14 4

From this it will be seen that works to the value of £271,599 4s. 10d. have been undertaken, on which amount £172,544 2s. 5d. has been paid as subsidies and otherwise by the Mines Department, and the liability of the department at the end of March last was £37,113 14s. 4d. It will also be seen from the table for 1886–87 that the value of works undertaken during the year ending March last was £29,352 9s. 7d., the contributions paid by the Mines Department were £41,500 1s. 8d., and the liabilities amounted to £37,113 14s. 4d., as against the liabilities at the end of the previous year, which were £60,885 1s. 4d. The liabilities at the end of last year are less than any preceding year since the construction of works has been under the control of this department.

There still remains a great deal to be done in constructing tracks and roads, for without these the impenetrable nature of the country, especially in the mining and mineral districts, renders it impossible to get supplies and machinery brought on the ground to test its value.

Annexed is a list taken from the Mines Department records of works constructed and in progress for the development of the mineral resources of the colony.

I have, &c.,

HENRY A. GORDON, M.A. Inst. M.E.,
Inspecting Engineer.

The Hon. the Minister of Mines.

LIST of WORKS on GOLDFIELDS undertaken wholly by the Mines Department, or by Subsidies to County Councils, Local Bodies, and Prospecting Associations, in Progress on the 31st March, 1887.

Locality and Nature of Works.	Total Cost, or Amount authorized.	Amount of Contribution paid by Mines Department.	Amount due by Mines Department on Works still in Progress.
NORTH ISLAND.			
ROADS (SUBSIDIZED).			
Coromandel County.	£ s. d.	£ s. d.	£ s. d.
Vizard's towards Marebel	200 0 0	70 0 0	63 6 8
Extending and widening Waitaia Road	100 0 0	..	66 13 4
Makarau to Waiau	700 0 0	400 0 0	66 13 4
Manaia to Waikawau	500 0 0	..	333 6 8
Old Saw-mill towards Awakanae	700 0 0	400 0 0	66 13 4
Paul's Creek to Cabbage Bay	200 0 0	80 0 0	53 6 8
Extending Waikoromiko Track	100 0 0	..	66 13 4
Old Saw-mill to Matawai	100 0 0	..	66 13 4
	2,600 0 0	950 0 0	783 6 8
Thames County.			
Sea-beach to Waiomo	750 0 0	..	375 0 0
Karaka Creek to Lucky Hit	600 0 0	..	300 0 0
Waiotahi towards Mercury Bay	316 3 0	..	210 15 4
Thames Borough Boundary to Hape Creek No. 2	600 0 0	165 11 9	134 8 3
Upper Karaka Road	179 13 0	..	119 15 4
	2,445 16 0	165 11 9	1,139 18 11
Ohinemuri County.			
Waitekauri to Goldfield, Parakawai	400 0 0	..	200 0 0
Sledge-track, Tui Creek	426 13 4	..	213 6 8
Extension Karangahake Track towards Te Aroha	549 9 0	..	366 6 0
Road from battery tramway to Waihi Gold- and Silver-mines	300 0 0	..	150 0 0
Karangahake to Railey's reduction-works	400 0 0	..	200 0 0
	2,076 2 4	..	1,129 12 8
Piako County.			
Tracks up Stony Creek, Te Aroha Goldfield	162 16 9	36 0 0	72 11 2
Sledge-track from tramway to county boundary	60 0 0	..	30 0 0
	222 16 9	36 0 0	102 11 2
Waimea County.			
Road to open up Tableland Diggings	260 0 0	..	130 0 0
SOUTH ISLAND.			
Collingwood Road Board.			
Bridge over Aorere River	220 0 0	70 0 0	76 13 4
Buller County.			
Road up Nile Valley	75 0 0	..	37 10 0
Denniston extension	700 0 0	99 16 0	300 4 0
Promised Land towards Motueka	380 0 0	..	190 0 0
Road over Gentle Annie	200 0 0	..	100 0 0
North Terrace to Poverty Terrace	100 0 0	..	50 0 0
Extension, Lyell Creek to Low-level Tunnel	120 0 0	..	60 0 0
Extension of track 50 chains south of Brighton	140 0 0	..	70 0 0
Continuation of road, Deadman's Creek	200 0 0	..	100 0 0
	1,915 0 0	99 16 0	907 14 0
Inangahua County.			
Crushington to Globe Company's Works	365 0 0	..	182 10 0
Glenroy to Horse Terrace	247 0 0	..	123 10 0
Track, Snowy Creek	85 15 0	..	42 17 6
Reefton to Big River	1,792 0 0	1,169 16 8	24 16 8
Owen River Road to Uno Battery	300 0 0	..	200 0 0
Larry's Creek to Lyell Road	1,500 0 0	..	750 0 0
Hatter's Terrace Road	800 0 0	..	400 0 0
Deep Creek to Bell Hill	800 0 0	..	400 0 0
	5,889 15 0	1,169 16 8	2,123 14 2
Grey County.	800 0 0	239 6 8	294 0 0
Road, Limestone to Maori Creek	750 0 0	401 5 0	98 15 0
Red Jack's to Nelson Creek	2,240 0 0	1,212 0 0	281 6 8
Barrytown to Deadman's	2,400 0 0	750 0 0	450 0 0
Irishman's to Lake Brunner	120 0 0	..	60 0 0
German Gully to Arnold's Flat			
	6,310 0 0	2,602 11 8	1,184 1 8

LIST of WORKS on GOLDFIELDS, &c.—*continued.*

Locality and Nature of Works.	Total Cost, or Amount authorized.	Amount of Contribution paid by Mines Department.	Amount due by Mines Department on Works still in Progress.
SOUTH ISLAND—*continued.*	£ s. d.	£ s. d.	£ s. d.
Westland County.			
Track, Bullock's Creek to Abbey Rocks	1,080 0 0	..	540 0 0
Extension track, Gentle Annie Terrace	220 0 0	83 13 4	63 0 0
Rough Wainihinihini to Upper Dam	450 0 0	..	360 0 0
Browning's Pass to Reefs	3,000 0 0	1,484 2 8	515 17 4
Okarito Forks to Teel Creek	600 0 0	..	400 0 0
	5,350 0 0	1,567 16 0	1,818 17 4
Lake County.			
Pack-track, Criffel Diggings	150 0 0	33 11 0	66 9 0
Left-hand Branch Road, Skipper's	80 0 0	31 14 11	8 5 1
Snow Poles, Roxburgh to Campbell's	373 11 0	..	249 0 8
	603 11 0	65 5 11	323 14 9
Tuapeka County.			
Road to open up quarry for Waitahuna Bridge	200 0 0	106 19 11	26 6 9
Waipori to Bungtown	750 0 0	50 0 0	325 0 0
	950 0 0	156 19 11	351 6 9
Taieri County.			
Road, Mullocky Gully to Silver Peak	600 0 0	333 3 4	66 16 8
Maniototo County.			
Track to Kyeburn Peninsula with main road	100 0 0	..	50 0 0
Track to connect Shepherd's Hut Flat and Vinegar Hill	100 0 0	..	66 13 4
	200 0 0	..	116 13 4
Wallace County.			
Pack-track to Round Hill, Orepuki, and Colac	1,125 0 0	450 0 0	200 0 0
Roads to open up Mines other than Gold.			
Track, Ohinemuri Coal-seam	300 0 0	103 11 8	96 8 4
Road, Kanieri Coalfield	600 0 0	285 14 8	14 5 6
	900 0 0	389 6 4	110 13 10
ROADS CONSTRUCTED WHOLLY BY MINES DEPARTMENT.			
Opening Mokau River	590 16 9	552 8 0	38 8 9
Lyell to Mokihinui	5,800 0 0	1,815 10 4	3,984 9 8
Mokihinui to Karamea	14,428 0 11	10,511 16 1	3,916 4 10
Brighton to Seventeen-mile Beach	2,700 9 0	1,213 14 4	1,486 14 8
Cobden to Seventeen-mile Beach	3,193 0 5	2,102 1 4	1,090 19 1
Wangapeka to Karamea	2,000 0 0	1,825 15 10	174 4 2
Aorere Valley to Karamea	1,000 0 0	400 0 0	600 0 0
Owen Valley Road	1,542 7 6	1,233 12 3	308 15 3
Hatter's Terrace to Bell Hill	400 0 0	100 0 0	300 0 0
Bridle-track to Upper Anatoki	600 0 0	..	600 0 0
Tracks for opening-up land and prospecting, Collingwood, &c.	1,000 0 0	..	1,000 0 0
Improving tracks, Collingwood to Takaka, Motueka, and Karamea	8,095 5 11	5,253 0 1	2,842 5 10
Cedar Creek Road	3,000 0 0	2,790 1 0	209 19 0
Jackson's Bay to Cascade and Gorge Rivers Districts	1,500 0 0	560 14 3	939 5 9
Arthur's Point to Skipper's	7,570 4 1	7,570 4 1	..
	53,420 4 7	35,928 17 7	17,791 7 0
WATER-RACES.			
Argyle Water-race	7,653 15 1	7,653 15 1	..
Nelson Creek Water-race	956 10 7	956 10 7	..
Waimea-Kumara Water-race	10,765 10 3	10,765 10 3	..
Mikonui Water-race	13,997 1 4	13,997 1 4	..
Round Hill Water-race	2,400 0 0	133 19 4	1,466 0 8
Mount Ida Water-race	3,100 0 0	3,100 0 0	..
Water-supply, Criffel Diggings	3,000 0 0	..	2,000 0 0
Contingencies	634 12 2	634 12 2	..
	42,507 9 5	37,241 8 9	3,466 0 8
DRAINAGE AND SLUDGE-CHANNELS.			
Ophir Tail-race	2,300 0 0	1,099 8 6	50 11 0
Ross Sludge-channel	1,500 0 0	1,360 6 9	139 13 3
Lawrence Drainage-channel	1,150 0 0	956 14 0	193 6 0
Muddy Creek Channel	2,400 0 0	1,000 0 0	..
St. Bathan's Channel	2,000 0 0	711 3 10	288 16 2
Increased water-supply on goldfields	100 0 0	100 0 0	..
	9,050 0 0	5,227 13 1	672 6 11

LIST of WORKS on GOLDFIELDS, &c.—*continued.*

Locality and Nature of Works.	Total Cost, or Amount authorized.	Amount of Contribution paid by Mines Department.	Amount due by Mines Department on Works still in Progress.
SOUTH ISLAND—*continued.*	£ s. d.	£ s. d.	£ s. d.
PROSPECTING SUBSIDIES.			
Deep-level Tunnel, Reefton	6,900 0 0	2,787 0 0	663 0 0
Deep-level Tunnel, Tokatea	700 0 0	246 17 9	163 2 3
Deep-level Tunnel, Manaia	500 0 0	148 16 0	101 4 0
Deep-level Tunnel, Owharoa	800 0 0	150 4 0	249 16 0
Deep-level Tunnel, Tapu	1,500 0 0	470 9 2	279 10 10
Deep-level Tunnel, Cedar Creek	1,207 10 0	303 15 0	300 0 0
Manuka Flat Prospecting Association	1,000 0 0	100 0 0	400 0 0
Red Hill Minerals Company	1,000 0 0	204 0 0	296 0 0
Tuapeka Prospecting Association	300 0 0	138 10 0	11 10 0
Cardrona Prospecting Association	800 0 0	303 12 10	96 7 2
Cromwell Prospecting Association	500 0 0	207 10 7	42 9 5
Coromandel County	400 0 0	100 0 0	100 0 0
Thames County	600 0 0	43 10 0	256 10 0
Thames Borough	200 0 0	27 15 0	72 5 0
Buller County	500 0 0	50 0 0	200 0 0
Inangahua County	1,000 0 0	90 8 0	409 12 0
Westland County	1,000 0 0	291 18 6	208 1 6
Grey County	1,000 0 0	289 1 3	210 18 9
Deep-level Prospecting Association, Waipori	600 0 0	216 4 10	83 15 2
Waipu Prospecting Association	200 0 0	90 0 0	10 0 0
Southland County	500 0 0	..	250 0 0
Hokianga County	200 0 0	50 0 0	50 0 0
Hokianga County, prospecting for coal	100 0 0	..	50 0 0
Vulcan Smelting Works, Onehunga	50 0 0	15 0 0	10 0 0
Ohinemuri County	100 0 0	30 0 0	20 0 0
Waitaki County	50 0 0	14 12 6	10 7 6
Waihemo County	100 0 0	..	50 0 0
William Fox and party	417 6 8	208 13 4	..
Kirk and party	176 9 10	88 4 11	..
Hodge and party	98 13 8	49 6 10	..
Carey and Hyndman	276 15 4	138 7 8	..
Don, Boyce, and party	75 12 0	37 16 0	..
Quentin McKinnon	36 0 0	9 5 0	8 15 0
Prospecting Brock's Run	150 0 0	..	75 0 0
Contingencies	401 0 10	200 10 5	..
	23,439 8 4	7,101 9 7	4,618 4 7

Summary of Works.

	£ s. d.	£ s. d.	£ s. d.
Roads (subsidized)—			
Coromandel County	2,600 0 0	950 0 0	783 6 8
Thames County	2,445 16 0	165 11 9	1,139 18 11
Ohinemuri County	2,076 2 4	..	1,129 12 8
Piako County	222 16 9	36 0 0	102 11 2
Waimea County	260 0 0	..	130 0 0
Collingwood Road Board	220 0 0	70 0 0	76 13 4
Buller County	1,915 0 0	99 16 0	907 14 0
Inangahua County	5,889 15 0	1,169 16 8	2,123 14 2
Grey County	6,310 0 0	2,602 11 8	1,184 1 8
Westland County	5,350 0 0	1,567 16 0	1,818 17 4
Lake County	603 11 0	65 5 11	323 14 9
Tuapeka County	950 0 0	156 19 11	351 6 9
Taieri County	600 0 0	333 3 4	66 16 8
Maniototo County	200 0 0	..	116 13 4
Wallace County	1,125 0 0	450 0 0	200 0 0
	30,768 1 1	7,667 1 3	10,455 1 5
Roads to open up mines other than gold	900 0 0	389 6 4	110 13 10
Roads constructed wholly by Mines Department	53,420 4 7	35,928 17 7	17,791 7 0
Water-races	42,507 9 5	37,241 8 9	3,466 0 8
Drainage- and sludge-channels	9,050 0 0	5,227 13 1	672 6 11
Prospecting subsidies	23,439 8 4	7,101 9 7	4,618 4 7
Totals	160,805 3 5	93,555 16 7	37,113 14 5

HENRY A. GORDON,
Inspecting Engineer.

LIST of WORKS on GOLDFIELDS constructed wholly by the Mines Department, or by Subsidies to County Councils, Local Bodies, and Prospecting Associations, and completed on the 31st March, 1886.

Locality and Nature of Works.	Total Cost.	Amount of Contribution paid by Mines Department.
NORTH ISLAND.		
ROADS.		
Coromandel County.	£ s. d.	£ s. d.
Improving road to Iona and Just in Time Companies' Mines	200 0 0	133 6 8
Making and improving track from Tokatea towards Kennedy Bay	320 0 0	213 6 8
Making and improving track from Golden Belt to Tiki	239 3 3	159 8 10
Making road from Ring's Bridge to Kapanga Mine	150 0 0	100 0 0
Making road to Kapanga Mine	132 0 0	88 0 0
Temporary track from Tokatea Saddle to Waikoromiko	50 0 0	33 6 8
Continuation of track from Success Company's Mine to top of main range	80 0 0	53 6 8
Completion of road from Tokatea Saddle to Tokatea Battery	50 0 0	33 6 8
Widening road from Matawai to Vaughan's Claim	357 0 0	238 0 0
Improving track, Mercury Bay to Waitai	100 0 0	66 13 4
Continuation and improving Waikoromiko Track	150 0 0	100 0 0
Emily Battery to Rocky Creek	60 0 0	40 0 0
Track, Bismarck Battery to Kennedy Bay	200 0 0	133 6 8
Road up Manaia	675 10 6	450 7 0
Extension of Vaughan's and Wizard's Tracks	150 0 0	100 0 0
	2,913 13 9	1,942 9 2
Thames County.		
Making new road from Ohinemuri River to Karangahake Quartz-mine	650 0 0	433 6 8
Dray-road to connect Otanui Mines with crushing-battery at Maungawherawhera Creek	710 0 0	473 6 8
Improving roads from Waitekauri Road to Katikati Road	250 0 0	166 13 4
Improving road up Karaka Creek to Lucky Hit Company's Mine	263 1 0	175 7 4
Improving road to upper mines, Waitahi	258 18 10	172 12 7
Karangahake to battery	300 0 0	200 0 0
Ralph's Battery, Waitekauri	399 1 0	199 10 6
Otanui Road to mines	299 18 0	199 18 8
Road to Wicks's Battery	70 0 0	46 13 4
Rocky Point Road, Tararu	300 0 0	200 0 0
Thames Borough boundary to hematite mine	350 0 0	233 6 8
Widening road from bridge over Hape Creek to Otanui Mines	183 17 0	122 11 4
Track, Karangahake Goldfield	784 1 0	522 14 0
Kauaeranga Valley to Otanui	470 7 0	313 11 4
Tapu Road to mines	66 0 0	44 0 0
Tauranga Road to Karangahake Bridge-site	341 5 0	227 10 0
Karangahake Bridge	229 6 6	152 17 8
Track up Maungakerikeri Creek	93 4 4	62 2 11
	6,019 9 8	3,946 3 0
Ohinemuri County.		
Track up Tui Creek	306 0 0	153 0 0
Prospecting-track, Whangamata and Waitekauri	200 0 0	166 13 4
	506 0 0	319 13 4
Piako County.		
Extension and completion of Te Aroha Tramway	18,000 0 0	12,000 0 0
Tramway to Fergusson's Battery, Waiorongomai	1,500 0 0	1,000 0 0
Road, Waiorongomai	497 17 0	331 18 0
Track to claims at Buck's Reef	55 5 6	36 17 0
Track, Fern Spur to Butler's Spur	231 17 9	154 11 10
	20,285 0 3	13,523 6 10
Hutt County.		
Road to connect Otorongo Bay with Albion Company's battery; also to connect Terawhiti Quartz-mine with battery	509 16 6	210 17 0
SOUTH ISLAND.		
Tuapeka County.		
Making road from top of Terrace to Waipori Bush	300 0 0	200 0 0
Road, Beaumont to Remarkable Bush	300 0 0	200 0 0
Improving road from Waipori Township to antimony-mines, Lammerlaw Ranges	200 0 0	133 6 8
Waipori Township to Waipori Bush	200 0 0	133 6 8
Clutha River to Campbell's	76 9 0	50 19 4
Waitahuna to copper-mine	200 0 0	133 6 8
	1,276 9 0	850 19 4
Southland County.		
Improving tracks from Mataura to Nokomai	75 0 0	50 0 0
Improving road, Waikaka to Leatham	150 0 0	100 0 0
Improving road from Waikaka Township to Leatham Creek	30 0 0	20 0 0
Improving road from Waikaka to Waikaka railway-siding	150 0 0	100 0 0
Widening and improving bush-track to Waikawa	150 0 0	100 0 0
Waikaia to Whitcombe	150 0 0	100 0 0
Waikaka to Switzer's	150 0 0	100 0 0
Road near Waikaka Township	150 0 0	100 0 0
	1,005 0 0	670 0 0

List of Works on Goldfields, &c.—*continued.*

Locality and Nature of Works.	Total Cost.	Amount of Contribution paid by Mines Department.
	£ s. d.	£ s. d.
Westland County		
Improving track, Butcher's Creek to Gentle Annie Terrace	120 0 0	80 0 0
Bridle-track to Kanieri Lake	719 11 0	359 5 6
Bridle-track to Eel Creek	168 9 0	84 4 6
Tunnel-track, Galway Beach to Gillespie's Beach	437 5 0	218 12 6
Road from Duffer's Creek, Greenstone Road, to fifteen-mile peg, Christchurch Road	726 9 0	480 4 6
Continuation of track, Back Creek to Eel Creek	249 4 0	166 3 4
Bridle-track, Duffer's Creek, Bowen and Okarito Road, to sea-beach	333 18 0	222 12 0
Ross Borough boundary to Mount Greenland	1,280 15 0	853 16 8
Track, Kanieri Lake to Humphrey's Gully	279 2 0	186 1 4
Track, Larrikins to Loopline Dam	449 11 0	299 14 0
	4,764 4 0	2,950 13 4
Grey County.		
Road from Notown to Deep Creek	1,100 0 0	550 0 0
Road from Langdon's to Moonlight	1,600 0 0	800 0 0
Contribution from goldfields vote towards main road	2,296 6 6	2,296 6 6
Track, Waipuna to Clarke's River	1,200 0 0	800 0 0
Track, Cameron's to Cape Terrace	700 0 0	466 13 4
	6,896 6 6	4,912 19 10
Marlborough County.		
Track, Deep Creek to Dead Horse Creek	68 0 0	45 6 8
Inangahua County.		
Dray-road from Soldiers Creek to Devil's Creek	647 0 0	431 6 8
Dray-road from Inangahua to Rainy Creek Battery	909 10 0	606 6 8
Dray-road from Capleston up Little Boatman's Creek	379 0 0	252 13 4
Dray-road from Capleston up Main Boatman's Creek	697 0 0	464 13 4
Dray-road from Westport Road to Inangahua River	224 5 0	149 10 0
Track from Devil's Creek to Big River	134 3 6	89 9 0
Track from Waitahu River to Capleston	358 0 0	238 13 4
Survey and expenses	250 0 0	166 13 4
Track from Cariboo to Big River	728 0 0	364 0 0
Dray-road up Murray Creek to United Inglewood Claim	3,472 0 0	2,314 17 4
Road from Reefton to Big River *viâ* Devil's Creek	614 0 0	307 0 0
Road up Big River	922 19 0	615 6 0
Continuation of dray-road up Little Boatman's Creek	169 7 6	112 18 4
Road from Capleston to Larry's Creek	640 0 0	426 13 4
Track to connect Capleston with Lone Star	75 0 0	50 0 0
	10,220 5 0	6,589 0 8
Buller County.		
Deviation of road from Candlelight Flat to Deep Creek, Charleston	370 0 0	246 13 4
Road from Orowaiti Lagoon to North Terrace	256 18 6	171 5 8
Prospecting-track from Razorback to Paparoa Range	100 0 0	66 13 4
Track from Seatonville to Larrikins	438 9 6	292 6 4
Waimangaroa to Denniston	787 0 0	393 10 0
Road to connect alluvial workings with Charleston Road	400 0 0	266 13 4
Track, Four-mile Creek towards Grey Valley	300 0 0	200 0 0
Road to connect alluvial diggings north of Deadman's Creek	278 0 0	185 6 8
Ngakawhau to Mokihinui, *viâ* beaches	100 0 0	66 13 4
Road to connect Ngakawhau Railway with Mokihinui Coal Company's workings	193 0 0	128 13 4
Lyell Bluff to Victor Emmanuel Claim	650 0 0	433 6 8
Beach, Little Wanganui to Mokihinui	300 0 0	100 0 0
Cape Foulwind Road	450 0 0	300 0 0
	4,623 7 0	2,851 2 0
Lake County.		
Track, Skipper's to Phœnix and Scandinavian Reefs	292 2 3	194 14 10
Track to connect scheelite-mine with Lake Wakatipu	225 0 0	150 0 0
Arrowtown to Macetown, construction	225 0 0	150 0 0
Arrowtown to Macetown, maintenance	150 0 0	100 0 0
Invincible Quartz-reef Track, Rees River	300 0 0	200 0 0
Rees Valley to company's workings	61 7 6	30 13 9
	1,153 9 9	825 8 7
Wallace County.		
Track, Colac Bay to Round Hill	200 0 0	133 6 8
Maniototo County.		
Road to Serpentine Diggings	136 10 0	91 0 0
Pig and Whistle to Clarke's Diggings	200 0 0	133 6 8
	336 10 0	224 6 8
Collingwood Road Board.		
Road, West Wanganui	300 0 0	200 0 0
Fiord County.		
Dusky Sound Tracks	300 0 0	200 0 0

LIST of WORKS on GOLDFIELDS, &c.—*continued.*

Locality and Nature of Works.	Total Cost.	Amount of Contribution paid by Mines Department.
	£ s. d.	£ s. d.
Waitaki County.		
Road, Naseby to Livingstone	41 12 0	20 16 0
DIAMOND AND OTHER DRILLS.		
Inangahua County Council (diamond)	2,000 0 0	1,000 0 0
Springfield Colliery Company (diamond)	1,250 0 0	625 0 0
Westland County Council (tiffin)	350 0 0	233 0 0
Diamond drills for prospecting purposes	422 15 6	422 15 6
	4,022 15 6	2,280 15 6
AIDS TO PROSPECTING.		
Construction of low-level tunnel, Terawhiti	750 0 0	150 0 0
Queen of Beauty Company, prospecting deep levels	300 0 0	150 0 0
Caledonian Low Level Company, prospecting deep levels	300 0 0	150 0 0
Red Hill Gold-mining Company, prospecting deep levels	600 0 0	300 0 0
Caledonian Low Level Company, low-level tunnel	2,700 0 0	300 0 0
Lyell Creek Extended Company, low-level tunnel	300 0 0	150 0 0
New Cromwell Gold-mining Company	250 0 0	100 0 0
Deep Level Association, Waipori	450 0 0	300 0 0
Little Boatman's deep-level tunnel	600 0 0	300 0 0
Oterongia Prospecting Association	198 17 2	99 8 7
Vincent County	137 9 0	68 14 6
Tapanui Prospecting Association	25 0 0	12 10 0
Tuapeka County	12 0 0	6 0 0
Maniototo County	500 0 0	250 0 0
Pullar, Shelmerdine, and Basan	200 0 0	100 0 0
Royal Oak Association	206 9 2	103 4 7
Star of the East Quartz-mining Company	150 0 0	75 0 0
West Coast Prospecting Association	300 0 0	150 0 0
McBride and party	113 7 2	56 13 7
McLean and party	66 0 0	33 0 0
	8,159 2 6	2,854 11 3
WATER-RACES.		
Water-main, Bull's Battery	350 0 0	100 0 0
DRAINAGE- AND SLUDGE-CHANNELS.		
Drainage-channel, Laurence (total cost, approximate)	3,000 0 0	2,000 0 0
Subsidy towards purchase of Messrs. Laidlaw and Crawford's freehold in Spotti's Creek, to allow tailings to be deposited (Tinker's Diggings)	500 0 0	400 0 0
Damage by floods, Thames	1,000 0 0	500 0 0
Sludge-channel, Smith's Gully, Bannockburn	1,000 0 0	251 1 0
Round Hill Sludge-channel survey	52 19 7	52 19 7
Compensation to J. Costello, damage done by tailings	788 0 0	788 0 0
Long Gully Sludge-channel	150 0 0	100 0 0
New Pipeclay Gully Sludge-channel	1,547 18 0	773 19 0
Kumara Sludge-channel, No. 2	2,762 17 2	2,762 17 2
	10,801 14 9	7,528 16 9
ROADS WHOLLY CONSTRUCTED BY GOVERNMENT.		
Lyell to United Italy Claim, Eight-mile	2,899 17 6	2,899 17 6
Reconnaissance survey of road, Italy Claim, Eight-mile, to Seatonville, Mokihinui	300 0 0	300 0 0
Construction of road, Arrowtown to Macetown	9,570 6 8	9,570 6 8
Road to open up Woodstock Goldfield	1,000 0 0	1,000 0 0
Ahaura to Amuri	2,504 19 7	2,504 19 7
Waikaia Bush Road	1,000 0 0	1,000 0 0
Waitahuna Bridge	750 0 0	750 0 0
Merrivale Tracks	400 0 0	400 0 0
Mokihinui to Specimen Creek	1,238 7 5	1,238 7 5
Wilberforce Quartz-reef Road	1,818 7 7	1,818 7 7
	21,481 18 9	21,481 18 9
ROADS TO OPEN UP MINES OTHER THAN GOLD.		
Aniseed Valley to Champion Copper-mine	4,963 10 6	4,116 10 6
Richmond Hill to Copper-mine	315 16 0	209 4 0
	5,279 6 6	4,325 14 6

LIST of WORKS on GOLDFIELDS, &c.—*continued.*

Locality and Nature of Works.	Total Cost.	Amount of Contribution paid by Mines Department.
Summary of Works.		
Roads (subsidized)—	£ s. d.	£ s. d.
Coromandel County	2,913 13 9	1,942 9 2
Thames County	6,019 9 8	3,946 3 0
Ohinemuri County	506 0 0	319 13 4
Piako County	20,285 0 3	13,523 6 10
Hutt County	509 16 6	210 17 0
Tuapeka County	1,276 9 0	850 19 4
Southland County	1,005 0 0	670 0 0
Westland County	4,764 4 0	2,950 13 4
Grey County	6,896 6 6	4,912 19 10
Marlborough County	68 0 0	45 6 8
Inangahua County	10,220 5 0	6,589 0 8
Buller County	4,623 7 0	2,851 2 0
Lake County	1,153 9 9	825 8 7
Wallace County	200 0 0	133 6 8
Maniototo County	336 10 0	224 6 8
Collingwood Road Board	300 0 0	200 0 0
Fiord County	300 0 0	200 0 0
Waitaki County	41 12 0	20 16 0
	61,419 3 5	40,416 9 1
Diamond and other drills	4,022 15 6	2,280 15 6
Aids to prospecting	8,159 2 6	2,854 11 3
Water-races	350 0 0	100 0 0
Drainage- and sludge-channels	10,801 14 9	7,528 16 9
Roads wholly constructed by Government	21,481 18 9	21,481 18 9
Roads to open up mines other than gold	5,279 6 6	4,325 14 6
Totals	111,514 1 5	78,988 5 10

HENRY A. GORDON,
Inspecting Engineer.

RETURN showing the RECEIPTS and EXPENDITURE on, and Collateral Advantages derived by the working of, the Water-races constructed and maintained by Government, during the Year ending the 31st March, 1887.

Name of Water-race.	Receipts.	Maintenance.	Profit or Loss.	Cost of Construction.	Total Cost of Construction.	Percentage on Capital invested.	Number of Men employed.	Approximate Amount of Gold obtained.	Value of Gold obtained.	Average Weekly Earnings of Men after deducting Cash paid for Water.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.			Oz.	£ s. d.	£ s. d.
Waimea	1,688 3 2	1,116 10 0	*571 13 2	118,862 11 8		½%	102	3,021	11,479 16 0	1 16 11
Kumara	8,461 6 11	1,398 18 10	*7,062 8 1	37,400 2 11	173,463 7 1	7½%	215	13,640	51,832 0 0	4 1 1
Kumara Sludge-channel ...	2,853 14 3	5,957 11 5	†3,103 17 2	17,200 12 6			114	251	957 19 0	...
Nelson Creek	1,071 19 2	1,173 10 4	†101 11 2	...	90,721 4 8	...	59	2,179	8,334 13 6	2 7 4
Argyle	480 8 5	382 6 5	*98 2 0	...	14,711 3 11	About ⅝%	19	600	2,280 0 0	1 16 5
Mikonui	100 0 0	...	*100 0 0	...	25,644 9 6	In construction	...	...	...	...
Totals	14,655 11 11	10,028 17 0	*4,626 14 11	...	304,540 5 2		509	19,691	74,884 8 6	2 5 6

* Profit. † Loss.

HENRY A. GORDON,
Inspecting Engineer.

[*Approximate Cost of Paper.*—Preparation, nil; printing (1,500 copies), £89 5s.]

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