# An Archaeologist's Guide to Mining Terminology

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*The authors present a glossary of mining terminology commonly used in Australia and New Zealand. The definitions and useages come from historical and contemporary sources and consideration is given to those most frequently encountered by archaeologists. The terms relate to alluvial mining, hard rock mining, ore processing, and coal mining.*

There are literally thousands of scientific and technical terms which have been coined to describe various aspects of the mining and processing of metalliferous and non-metallic ores. Many terms have a wide variety of accepted meanings, or their meanings have changed over time. Other terms which used to be widely used (e.g. those associated with sluice-mining) are seldom used today. The use of some terms is limited to restricted mining localities (often arising from Cornish or other ethnic mining slang), or they are used in a sense that differs from the norm; for instance, Henderson noted a number of local variants while working in mines at Reefton on the West Coast of New Zealand.[1]

In the nineteenth century mining engineering was a particularly innovative field, especially with regard to ore treatments and processing machinery. The more innovative mining companies upgraded their plant periodically, while others persevered with outmoded equipment and systems or stuck with techniques which were in vogue when their plant was established. Research for this glossary has highlighted regional differences in mining technology and techniques.

The following lists have been compiled by the authors to assist archaeologists (especially those involved in site recording) to:

- recognise physical features and often long obsolete machinery components on historic mining sites;
- encourage the use of established or well-defined terms to accurately describe machinery and site features to avoid confusion;
- enable the more accurate interpretion of mining methods from the surviving field evidence;
- facilitate more accurate coding of mining site types for the purposes of comparative analysis and research, and management;
- assist in understanding terms frequently cited in contemporary mining literature.

The cited terms are restricted to physical features or machinery associated with mining, ie potential archaeological features. For convenience, they have been allocated into four groups, viz. terms associated with:

1. alluvial mining and associated technology and landforms;
2. hard rock mining and associated technology;
3. ore processing or processing machinery;
4. terms specifically associated with coal mining.

Some equipment and techniques are common to both alluvial (particularly deep lead) and hard rock mining. These include items associated with tunnelling, water supply, motive power, and ore crushing and treatment. They reflect similar means of overcoming common problems. Where terms have multiple meanings and are associated with different aspects of mining, e.g. tailings, they are cited, where appropriate, in each group; otherwise they are cited in the category they most specifically refer to. The authors have attempted to cover all the terms associated with mining and ore-processing, and the resultant modified landforms and relics which are likely to be encountered by or to be of relevance to field archaeologists working in mining regions particularly in New Zealand but also in the wider Australasia. Significant examples, regional variants, the date of introduction of technological innovations, and specifically New Zealand usages are also noted. Related terms and terms which are defined elsewhere in the text are printed in italics.

While many of the terms will be familiar to Australian archaeologists, the authors have not specifically examined Australian historical mining literature nor attempted to incorporate the numerous terms associated with Cornish-type mining and copper refining in Australia. An unpublished glossary of these terms by Jack Connell and some other useful Australian mining references are cited in the bibliography.[2] Although manganese and copper mining in New Zealand (on Kawau Island c.1841–1842) predates any other form of mining, by any standards it was small scale and never likely to amount to much because of the small size of the ore bodies, the distance to markets, and problems associated with smelting the ore.

## TERMS ASSOCIATED WITH ALLUVIAL MINING

**alluvial gold**: gold found in alluvium, ie riverine or estuarine deposits of sand or gravel. Alluvial denotes the material has been washed and transported by water.

**amalgamating tables**: refer processing section.

**auriferous**: having gold content.

**banjo/banjoing**: (the term *banjo* is also applied to a short handled shovel) This method of alluvial goldmining was used extensively on the Hill End and Tambaroora fields in New South Wales.[3] The method involves the excavation of a circular hole in a creek bank into which washdirt is stockpiled ready for washing. Next a trench was dug between the stockpiling-hole and the creek (or water-hole). This created a banjo-like feature, hence the derivation of the term. The stockpiling hole was always dug at a slightly higher elevation than the trench. The latter was lined with rocks or housed a wooden sluice box. The method of washing and recovering gold involved using a gold pan as a ladle to splash water up the trench and into the stockpile to wash some of the washdirt down the trench. In practice the lighter dirt was supposed to be carried down into the waterhole or stream while the heavier gold was trapped in the stones or in the sluice-box laid in the trench. Despite the presence of many Australian miners in New Zealand during the first goldrushes in Otago, banjoing is not mentioned in the New Zealand mining literature and any field evidence of it has long since disappeared.

**beach lead**: concentration of fine gold in old marine sediments (usually consolidated and buried). Beach leads are often some distance from modern shorelines and at different heights (see *blacksanding*).

*Fig. 1: A portable gold table being used for blacksanding at Charlestown, West Coast, South Island, New Zealand. Note the wooden flumes in the background (Department of Conservation collection, Westland).*

**bedrock**: in alluvial mining parlance, the hard rock underlying alluvium. Often the richest auriferous deposits were located on the alluvium/bedrock interface.

**blacksanding**: a form of mining restricted to the West Coast of the South Island. Blacksand mining (*blacksanding*) commenced belatedly when it was realised that the extensive black magnetic ironsand beaches of the West Coast contained rich deposits of fine gold (often in *beach leads*). The presence of gold in worthwhile quantities within sea-beaches is relatively uncommon on a worldwide level. *Blacksanders* often employ small wheeled sluice boxes which can be readily moved along a beach (Fig. 1). See Hooker for description.[4]

**blasting**: in some hydraulic claims, a small tunnel was excavated at the base of a work face and a number of kegs of powder introduced and ignited. The resultant blast was intended to loosen the washdirt and save a considerable amount of water which would otherwise be required to break down the face. Blasting was principally employed during dry seasons or in dry locations to save water because much more water was required for breaking down banks than for washing the freed dirt.

**blocking out**: removing washdirt by driving or shafting down to a lead and excavating a gallery (which was usually timbered up and large stones stacked to support the roof).

**bonanza (*jeweller's shop*)**: small alluvial leads (or patches of ore) of exceptional richness.

**bottom**: an indurated layer below an auriferous alluvial deposit. Often the bottom and bedrock are one and the same (see *false bottom*).

**bucket elevator**: a manually operated or more typically powered continuous chain of buckets used to raise washdirt for further processing.

**California pump**: in their simplest form California pumps consist of an elongated wooden trough along which a canvas, rope, or leather belt could revolve between two wooden wheels at either end of the box. Tight-fitting wooden slats were attached to the belt. When the lower end of the appliance was placed in water and a crank handle attached to the upper wheel was turned manually, water was elevated from the lower level and discharged into a flume at the upper end of the pump. The term is also used to describe a pump made of tin cans attached to an endless belt, ie a crude bucket elevator.

**cement**: a tough conglomerate composed of rounded or angular fragments of rock and black sand cemented by iron oxide. The gold was usually freed from the cement by first crushing it in a battery.

**claim**: an area of land which has been pegged and legally assigned to a miner or mining company (by virtue of a license or miner's right) to work for a specified period. A claim was generally smaller and cheaper but less secure than a mining lease.

**cleaning up**: see *washing up*.

**cradle**: a simple but effective manually operated device used by diggers to separate gold from washdirt by means of a rocking motion. Cradles were an advance on the basic gold pan (see *panning*) and were much faster to use than a pan.

**crevicing**: the recovery of gold, usually by picking and scraping, from crevices in bedrock or the indurated bases of stream beds.

**dam (mining dam)**: a structure of earth, masonry, concrete or timber built across a watercourse to impond water, usually for alluvial mining purposes such as hydraulic sluicing. As opposed to *reservoirs* which are water storages created by either excavating a depression or by erecting an earthen, wooden, concrete or masonry structure usually on a flat terrace. Incoming water was usually fed in by water races, and delivered to work sites by either races or piping. In practice, in New Zealand at least, there was virtually no distinction between dams and reservoirs. Wardens Courts were responsible for issuing dam licenses which encompassed any structure for storing water for mining purposes. Reservoirs tends to be used for the storage of potable water supplies.

**dead man (holdfast)**: a log or similarly shaped object used for anchoring or manipulating gold dredges in rivers or ponds, or in terrestrial situations for manoeuvring devices such as winches or cranes used for shifting large boulders (they probably had many other applications on the goldfields). 'Dead men' were usually buried in a trench at right angles to the direction of pull, in locations where there were no conveniently sited trees or boulders which could be used for the same purpose.

**deep leads**: ancient alluvial deposits often buried beneath a considerable thickness of non-auriferous strata. They are usually worked by sinking a shaft from which tunnels are driven onto the leads (see hard rock mining definition).

**ditch**: see *race*.

**dredging plant**: usually used in reference to plants designed to recover gold-rich tailings (the discharge from mine batteries) which have accumulated in rivers, harbours, estuaries etc. The plants combine two different gold recovery technologies, alluvial dredging (bucket or suction) to recover tailings discharged into the waterways from upstream quartz batteries,

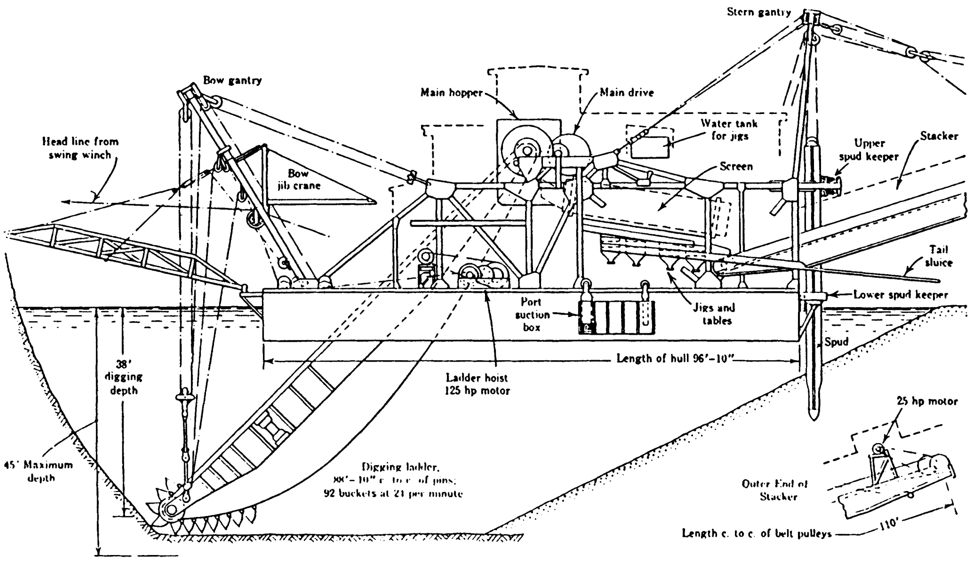


*Fig. 2: Cutaway view of gold dredge (Peele 1941:579).*

and hard rock gold recovery treatments, notably the cyanide process, to recover the bullion from the dredged tailings. Four dredging plants have operated in New Zealand, Judd's at Thames, a small operation at Coromandel, and the two gold dredging operations in the North Island on the Ohinemuri River (Ohinemuri River Syndicate's, and the Waihi-Paeroa Extraction Co.). The site of the latter, the fifth largest producer on the Ohinemuri field, has considerable interpretation potential.

**drift/drifting**: loose alluvial material. Mining into it was called *drifting* (see hard rock mining definition).

**dry-blowing**: a way of separating grains of alluvial gold from sand on arid Australian goldfields. The dirt was dropped from a height, enabling the wind to blow away the lighter dust but not the heavier gold particles.

**elevator pond**: (see *hydraulic elevating*) the depression remaining (usually water-filled) following hydraulic or bucket elevating.

**face**: the work face in an alluvial claim.

**false bottom**: a consolidated and usually non-auriferous stratum on which alluvial gold is concentrated, beneath which there is one or more lower beds of washdirt, the lowest being the true bottom.

**flume/fluming**: wooden channelling used in conjunction with water races to convey water to a claim. Typically fluming built on wooden trestles was used to span depressions or was anchored to rock faces to bypass sheer slopes. In the absence of plentiful timber to build fluming to bridge gullies (e.g. in Central Otago), water race builders were obliged to go the long way, ie follow the hillside contours to maintain height (see *siphon*).

**fly-catching/fly-catchers**: the placing of gold-tables in the bed of a stream below the outfall from a sludge channel. It is estimated that no more than 60 per cent of the gold was captured by claim owners, some 40 per cent escaping with the tailings discharged down sludge channels. Much of the escaping gold was caught in the *fly-catchers*. Restricted to ancient beach-lead working areas on the West Coast, e.g. Charleston, Addison's Flat.

**fool's gold**: iron sulphide (pyrites) commonly found in quartz, coal measures and altered rocks. Often mistaken for gold by the uninitiated, it is virtually valueless. In the past it has been used as a source of sulphur.

**fork/stone forks**: there were two main types: a long-handled multi-pronged fork was used to clear stones out of *tailrace* boxing, while a sturdy two-pronged fork with the tines bent at right angles to the handle was used to clear stones from tailraces.

**gauge box**: a wooden or steel vertically sliding plate which enabled (by specific positioning of the plate) a measured flow of water to be directed from a supply race into a claim head race (see *head*).

**gold dredge**: vessels (consisting of one or more pontoons) on which various forms of dredging equipment were mounted in order to extract auriferous gravels from river beds, and later river margins and terraces (Fig. 2).[5]

- **spoon dredges**: floating platforms on which a large 'spoon' (composed of a steel hoop and a rawhide bag) was mounted. The spoon (later made with a strengthened lip to provide a better cutting edge) was attached to a pivoted arm which was lowered into the water to scoop up a load of the basal gravels, then winched back on to the dredge.
- **current wheeler**: small dredges which employed paddle-wheels to turn an endless chain of buckets. First used on the Molyneux (Clutha) in 1868. As current wheelers were restricted to locations where there was a strong current they were soon superseded.
- **suction dredges**: although suction is an effective means of dredging fine material, suction dredges generally proved unsuccessful on the goldfields; the suction pipes continually clogged with stones, and the high specific gravity of gold often resulted in everything but the gold being lifted. Suction dredging on sea-beach claims also proved to be inefficient, because invariably there was either too much sand or too much water.
- **steam-powered, continuous bucket dredges**: the first steam-powered (self-powered) bucket dredge, the *Dunedin*, began operating on the Clutha River near Alexandra in 1881. It proved far superior in terms of gravel extraction and gold recovery. The type soon became the mainstay of the industry here and overseas. Steam-powered dredges were able to work into river banks, greatly expanding the scope of dredging operations. The development of the steam-powered bucket gold dredge is recognised as New Zealand's greatest contribution to alluvial gold winning technology (see *tailings elevator*).
- **electric-powered bucket dredges**: a later development; essentially the same gold recovery technology as the steam-powered dredges, but electrical power enabled the construction of more powerful dredges and considerably lowered operating costs. The first electrically driven dredge was established on a claim in the upper Shotover River, Otago, in 1894 by the Sandhills Goldmining Co.

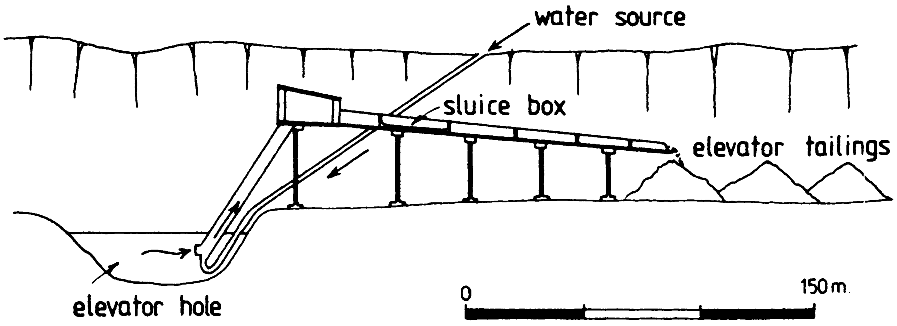


*Fig. 3: Simplified diagram of a hydraulic elevator in operation (Ritchie 1986).*

– **water-powered bucket dredges (hydraulic dredges)**: generally used to describe dredges on to which water was piped aboard and used to drive *Pelton wheels* to power machinery including the excavating buckets. The lack of sufficient water power (head or fall) limited the use of hydraulic dredges, although they were used extensively in some areas, e.g., Waipori and Cardrona. Some dredges combined sluicing and mechanical excavating to enable them to progress into alluvial deposits.

**gold tables**: broad slightly inclined flat tables (often mounted on wheels) covered with plush (matting) over which fine gold bearing beach sands were washed to recover the gold content.

**ground sluicing**: a basic method of alluvial mining whereby auriferous terrace margins were broken down by directing low pressure water over them (free running water diverted from a headrace) to assist their breaking up with bar and pick. The dislodged materal was then sluiced, ie directed through channels to sluice-boxes in which the gold was trapped in riffles.

**gutters**: incised ancient stream channels in bedrock or older alluvium which tend to trap and concentrate alluvial gold into distinct leads and consequently provide rich pickings. Gutters usually underlie later alluvial deposits.

**head**: a measure of water flow and volume. When water was sold to claimholders, a charge was made at so much a head for so many hours. A head was approximately 1 cubic foot per second (cusec) and was measured by an outlet gate of specific size (see *gauge box*) at the point where a branch race to a claim drew water from a main supply race. A raceman was employed on main supply races to turn water on (ie divert water) to specific claims as required, to patrol the system looking for any defects and to undertake repairs.

**hurdy-gurdy wheel**: similar in appearance and operation to a Pelton wheel or similar impact wheel. The term is sometimes used synonymously in reference to *Pelton wheels*. The original hurdy-gurdy wheels had flat buckets cast into the circumference of the wheel. They were designed for using high head pressures. Large hurdy-gurdy wheels were sometimes connected through gearing to derrick-hoists and used to lift heavy boulders on hydraulic claims.[6]

**hydraulic elevating**: In 1880 J. R. Perry introduced hydraulic elevating while working in Gabriels Gully in the Tuapeka district. Elevators employ the Venturi hydraulic principle whereby energy released by the expansion of high pressure water discharged through a narrow pipe and a specially shaped orifice (a *Venturi*) creates a powerful suction which lifts material (water and basal gravels) up a larger inner pipe so that they can be passed through sluice boxes to recover the gold content (Fig. 3). Elevators (bucket and hydraulic) were used where there was insufficient fall (ie the ground being worked was too deep to allow the disposal of tailings). Sometimes they were used in series to elevate washdirt from deep workings. They were mainly used on the Otago goldfields, most notably at St Bathans. The large boulders common in West Coast fluvio-glacial gravels were more than most elevators could cope with, although hydraulic elevating was also used to a limited extent on the West Coast beaches (see Ritchie for description of field evidence of elevating in the Upper Clutha area).[7]

**hydraulicking (hydraulic sluicing)**: a mining technique in which a jet of water is directed against an alluvial deposit to break it down. The method, developed in California in 1852, was introduced into New Zealand by Californian diggers initially using canvas hoses. The introduction of steel pipes (made from riveted sections) and cast iron monitors (moveable nozzles) in the 1870s lead to high pressure sluicing superseding the earlier method. The method did away with much of the pick and shovel work involved in ground sluicing and was the only practical means of mining deep deposits. Hydraulic sluice workings usually have steep working faces (compared to ground sluicing) because the water was directed upslope to undermine the work faces.

**iron pipes**: first used in California, they rapidly superceded the canvas hoses used prior to that.[8] In 1856 a San Francisco company commenced the manufacture of wrought iron pipes for hydraulic mining, so their use was well established prior to the onset of sluicing (c.1870) on the New Zealand goldfields. Gradually a whole range of pipe sections, elbows (bends) and associated components, e.g. gate valves, were developed. The pipe sections could be hot riveted into standard lengths (hence the presence of a smithy on many alluvial claims), and each unit joined by connecting flanges.

**koura**: Maori term for gold. A transliteration of the English term.

**lead**: (pronounced leed) a well-defined bed of auriferous wash-dirt in a terrace or stream bed.

**long tom**: essentially a trough (*sluice box*) for washing the gold from auriferous gravels, first used in California in 1850. They were the next step up from a cradle enabling the working of larger claims and a better recovery percentage. They were usually worked by two men. Washdirt was shovelled into an inclined wooden trough about 4 metres long with a uniform width of c.450 millimetres mounted on a frame or legs. Water was powered in at the upper end while the material was agitated with a shovel. Large stones were picked out, while the rest of the material passed over a grating at the lower end. Fine material dropped through onto a series of riffles arranged like those in a cradle while the rest of the material was discharged out the lower end. Usually Long Toms were placed at the edge of a creek which swept the tailings away.

**monitor (giant nozzle, sluice gun, nozzle)**: device consisting of a pivotable steel barrel with interchangable brass nozzles for directing high pressure water brought by pipeline onto a sluice-face for the purpose of breaking it down and passing the material through *sluice boxes*. In practice, it seems the terms *monitor* and nozzle are frequently used synonymously, but

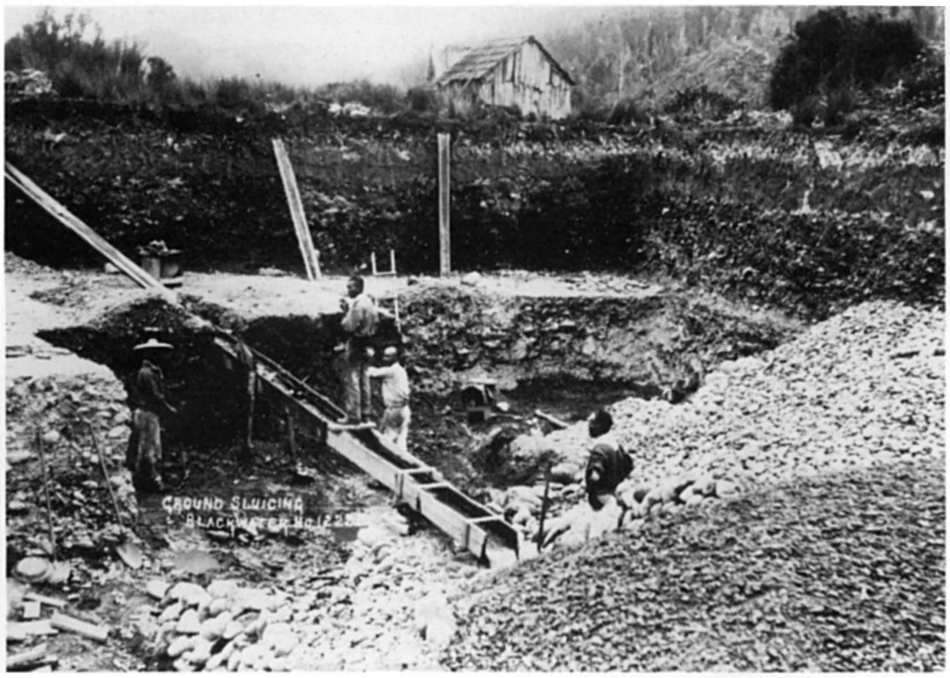


*Fig. 4: Chinese paddocking claim at Blackwater, West Coast South Island, New Zealand. The photograph shows the overburden stripped off, auriferous gravels being shovelled into a long tom type box-sluice, and waste rock stacked behind the work face (Department of Conservation collection, Westland).*

strictly speaking the latter term refers to the interchangeable brass fittings on the end of a monitor. The name was probably derived from the swivel-firing Civil War gunboat of the same name. Invented in California in 1853, monitor technology was further refined over the next 20 years.[9] The most powerful nozzles were known as Giants. They could be swivelled without interrupting the water flow. The development of a built-in deflector was an important innovation. Prior to then it was necessary for one or more men to move a monitor manually backwards and forwards, or up and down with considerable exertion and often coupled with danger to the operators. The deflecting device enabled one man to easily handle the largest Giant. Men who operated monitors/nozzles were described as nozzlemen.

**nugget**: a large piece of alluvial gold, as distinct from a lump or mass of gold embedded in solid rock.

**paddock/paddocking (stone to grass)**: (1) an excavation made for procuring washdirt in shallow ground; (2) a wooden bin or area for the storage of wash dirt; (3) to *paddock a claim* meant to work it systematically by means of a series of small, shallow pits, or alternatively to excavate out the whole mass leaving a large square pit (Fig. 4). In flood-prone areas on the West Coast, ground was *paddocked*, the aim being to get as much wash-dirt as possible out and stored above the known flood level, so that washing could proceed if the river rose. On the West Coast the phrase *stone to grass* was used to describe the act of getting ore out and stockpiling it in a paddock.

**panning**: the use of a fossicking dish or gold pan to test or recover alluvial gold, usually in the gravels of river or stream beds. The first gold pans, hand-forged by local blacksmiths, appeared in the 1840s in the United States.

**Pelton wheel**: the Pelton wheel was the culmination of a 30 year quest to design a better *water wheel.* Prior to the invention of the Pelton wheel all kinds of curved buckets (attached to the rims of water wheels) had been tried to utilise water flows more effectively. Louis Pelton of Comptonville, California, conceived the idea of a wheel lined with buckets with vertical fins which split the water delivered through a high pressure nozzle on impact. His patent wheels had considerable advantages over conventional water-wheels and rapidly gained favour. They were much smaller, more readily transportable, able to be driven with a much smaller volume of water, and had easily replaceable parts. Companies in New Zealand and elsewhere obtained the right to manufacture them and they soon became the predominant water-powered means of driving machinery on the goldfields.

**placer mining**: a term of Spanish origin used extensively in North American literature to describe the mining of alluvial deposits; essentially a synonym for alluvial mining. Placer/alluvial mining involves using water to wash (alluvial) gravels to recover gold and/or other heavy metals such as platinum and tin. As water flows over gravels (placed in devices such as *cradles, long toms*, or *sluice boxes*), dirt and the bulk of the lighter non-auriferous material are washed away, while the heavy metal particles (e.g. gold) sink to the bottom and are trapped behind *riffles* which are periodically cleaned to enable the gold to be recovered.

**pothole mining (potholing)**: see *tailings, pothole.*

**puddle**: process of soaking alluvial gravels to break down the sticky clay content.

**puddling machine/puddling site**: a machine designed to agitate gold-bearing gravel to get rid of heavy clay, which is washed away in water. Puddling was used extensively on some of the Australian goldfields where heavy clays were a problem. The configuration of a horse-powered *puddler* site is similar to that found on a horse-powered *Chilean mill* site. It consists of a circular trough excavated in the ground around which a horse drags a pair of rakes which stir up auriferous gravels placed in the trench and cause adhering clay to be washed off. Like a Chilean mill roller, the rakes in a puddler are pivoted at a central point obliging the horse to walk continuously around the perimeter of the puddling trench.

**race (water race)**: an aqueduct or channel (usually open) for conducting water to or from a mining site. Large water races from a permanent source were called supply races. Typically water would be drawn from a supply race or a local water source and stored in holding dams from where it would be conveyed by head-races to individual claims. Tail-races, usually boxed with *riffles* in the upper section and paved with wooden blocks or flat rocks in the lower reaches took the finer water-borne tailings (*sludge)* from claims to where it was discharged onto lower lying ground or more frequently into existing water-courses and rivers. Races are called *ditches* in American mining literature.

**reservoir**: see *dam.*

*A stoning tray being used to remove excess rock rubble from a operation, West Coast, South Island, New Zealand (Department of Conservation collection, Westland).*

**riffles/ripples**: bars or cleats on the bottom of a *cradle, Long Tom, sluice-box* or tail-race for catching alluvial gold. *Ripple* is believed to be of Australian origin and was used to describe the cleats on *amalgamating tables*.

**rock-sluices**: large sluices or tail-races were frequently paved with stone because of its greater durability than wood. Rock-sluices were very effective gold-catchers but were much more difficult and tedious to clean-up. However, this aspect also made it much more difficult for thieves to steal gold (ie clean-up) from the sluices when they were unattended at night.

**rotary screen**: see *trommel*.

**siphon**: piping used to convey water over an obstacle or across a depression and deliver it to a lower level by means of atmospheric pressure. The availability of iron pipes from about 1890 revolutionised *race* building. Previously it had been necessary to go around, or span gullies with expensive *fluming* on trestles. Iron pipes could be laid directly on trestles (in lieu of fluming), but the construction of siphons down one side of a gully and up to a race (at a slightly lower level) on the other side was the preferred means of conveying water across depressions.

**sludge (channel)**: viscous mud or silt-laden water. Under the mining legislation in New Zealand, the government could gazette that certain rivers were deemed to be sludge channels, in which case miners could apply for a right to discharge sludge from alluvial or hard rock mining directly into them. All the rivers on the South Island West Coast were designated sludge channels. The Ohinemuri River is the predominant North Island example. Sludge channel was also used to describe major *tailraces* (often constructed by the N.Z. Government to facilitate mining). Mining parties paid a 'channel-fee' allowing them to discharge sludge and tailings into a particular sludge channel. On the Kumara goldfield it amounted to about 30 per cent of what the miners were paying for water drawn from the Government races. The short, often high-capacity tailraces from battery sites to a nearby river are also sometimes described as sludge channels.

**sluice**: see *hydraulic sluice*.

**sluice box**: a long trough with a loose bottom on which there are *riffles* or holes. The *washdirt* (conveyed in flowing water) is passed through the box where the gold and other heavy metals is trapped in the riffles or falls through into the false bottom section. *Long Toms* were essentially portable sluice boxes.

**sluice face**: essentially a work face; artificially created terrace-faces created by sluicing away terrace margins.

**stone barrow**: a low slung wheelbarrow used to cart away large boulders which would otherwise have blocked or damaged a *tailrace*, or move them from any other inconvenient location.

**stone trays**: a steel tray something like a modern dragline bucket which was suspended from a horizontal aerial ropeway (Fig. 5). A secondary rope enabled the tray to be raised or lowered, or moved along the main rope. At the work face, the tray would be lowered to enable large stones to be stacked in it. It was then raised and run out along the main rope to a dumping area, where the tray was tripped, depositing the stones well away from the work area. Two *tailing* forms result from this technology: *conical* and *linear mounds*.

**stoning out**: removing large stones from a *tailrace*, usually by means of a stone-fork.

**surfacing/surfacer**: West Coast terms associated with *blacksanding*, describing the working of sea-beach claims, and the diggers who worked them.

**tailings (alluvial)**: the solid waste from alluvial mining operations. Finer material was usually washed into adjacent watercourses. Cobbles and boulders remained either within the claim or adjacent. Tailings are often the dominant feature on old alluvial mining sites. Their form is directly related to the topography, the nature of the substrate, the position of the washdirt, the depth of overburden, the water supply, the available head, the manner of the water's application, and the lay of the land with regard to dumping the waste material. The arrangement of tailings is an indicator of mining techniques used and available technology.[10] Alluvial tailings can be grouped into three basic categories: *hand-stacked, mechanically-hydraulically stacked*, and *dredge tailings* (the latter being a specialised form of the second category). Hand-stacked tailings tend to be neater and smaller in area than those deposited mechanically or hydraulically.

Almost without exception tailings were stacked on worked out or waste ground unless there was no alternative such as when a claim was started. At this stage it was often necessary to elevate (usually by means of an inclined tramway) large volumes of heavy cobbles out of the workings and stack them on virgin ground. Such tailings are likely to be indicative of the first working on a particular claim. Understandably these unworked areas are often worked by later mining companies. This pattern is well illustrated on the Kumara goldfield on the West Coast where the high percentage of large boulders in the alluvium necessitated their stacking initially on virgin ground to facilitate the working of specific claims.

**tailings (alluvial, hand-stacked)**: see Ritchie 1981 for a full discussion.[11]

- **parallel tailings**: visually the simplest form of tailings, consisting of parallel rows of handstacked cobbles and boulders usually aligned at or near right angles to a river or stream. Sites of this type seldom exceed 100 by 150 metres in area and the stone rows are usually less than 1.5 metres high. They are frequently located right on the edge of a riverbank. A variation of this form, *curved tailings*, is essentially similar. The stacked rows are curved but still parallel to one another.

- **box tailings**: this form of tailings is a variation of the parallel type, but differs in that the rows of stacked cobbles are contained in a *box* which is formed by either unworked ground, or more usually, a row of stacked tailings across the lower (and frequently the upper) end of the workings. The box arrangement appears to be an improvement on the simple parallel method of working because all the gold-bearing *sluice* water would have been channelled through one end *tailrace*. There are several good examples of this type in the upper Clutha valley.
- **herringbone tailings**: tailings of this type, if neatly stacked, are generally considered to be the most interesting form because of their symmetry. The characteristic 'herringbone' pattern was produced by hand stacking of cobbles and boulders uncovered within terrace gravels during *sluice* mining operations. The stones were stacked in parallel lines at angles to a central *tailrace*, the working face encroaching from the lower end of a claim. This offered the minimum impediment to the sluice water flow which carried the gold-bearing sediments down the tailrace and through a *sluice box* where the gold was trapped, while the rest of the material discharged into a watercourse or formed fans below the workings. Because cobbles and boulders tended to block the tailraces and trap the gold before it reached the sluice box, the stones were hand stacked into rows to enable the system to work as efficiently as possible. Once a retaining wall was formed, cobbles and coarse gravels were forked behind the wall. Retaining walls are an important feature of virtually all forms of hand-stacked tailings. They were erected in any situation where it was necessary to contain the tailings and prevent them from impeding the tailrace, and in confined situations, e.g. one claim above another, where there was no place to dump the waste rock except within one's own claim.

  Herringbone tailings frequently consist of several herringbone compartments separated by ridges of largely unworked material along which the water was distributed in pipes. Herringbone tailings are often very extensive and represent a huge investment in terms of human effort. They are generally associated with ground sluicing or low-pressure hydraulic sluice workings into river terrace gravels. Some of the best examples in New Zealand are in the vicinity of Cromwell.
- **fan tailings**: this type are a cross between parallel tailings and the herringbone form. They were constructed on ground which contained less coarse material than that in which herringbone formations are frequently formed. Fan tailings are derived from both ground and low-pressure *hydraulic sluicing*. The fan patterns were created by the miners hand-stacking the cobbles and boulders (freed from the terrace gravels) in rows converging on a single point in the *tailrace* where *riffles* were located to trap the gold, whilst the spoil was washed to lower ground or into a nearby river.
- **blow down tailings**: tailings of this type result from a system of *sluicing* known as *blowing down* (Ritchie 1981:55). The introduction of the method is credited to a Russian miner. Subsequently it has been used for the working of wide stretches of poor alluvial ground in Central Otago. Its greatest application has been in the Cromwell area where it was introduced before 1880. The method differs from ordinary ground or hydraulic sluicing, which begin at the lowest point of the ground and were worked forward on a rising bottom. In the blow down system, a main *tailrace* was excavated across the base of a slope to be worked. A side gutter was then extended up one or both boundaries of the claim. Water was conveyed to the top of the claim by race or pipeline and sluicing commenced by working downslope. A strip of ground about 3 metres wide was thus worked either side of the gutter which acted as a channel for the loosened material to be carried down the tailrace. This process was repeated, so that the ground was cut away in parallel slices. Workings of this type are typically located along old terrace risers.
- **amorphous tailings (hummocky tailings)**: catch-all terms to describe stone tailings with no coherent patterning. At first glance this type appears to be the result of indiscriminate stacking of cobbles in low mounds or heaps during sluicing operations. A closer examination usually reveals shallow winding channels threading between the mounds and leading to a low point where presumably a sluice box was located. Amorphous tailings are typically located on river margins and on ground with minimal fall, the pattern often being in part attributable to the uneven surface of the basal material or bedrock.
- **small claim tailings (pothole tailings)**: the term *pothole mining* was coined by Ritchie to describe the principal method of gold working during the early days of the nineteenth-century goldrushes in Central Otago.[12] During this phase the miners concentrated on working the stream and river beds, which were divided into individual claims measuring 24 by 24 feet (7.23 by 7.23 metres) per miner. The miners dug into the gold bearing gravels with pick and shovel and raised the gravel with the assistance of a *whip* or a counterbalanced lifting arm. The gravel was then panned or *cradled*. The resulting tailings reflect the mining method. As a consequence the creek beds and surrounding low ground became dotted with hummocky circular and oblong mounds, occasionally separated by water channels. Although the individual claims were small, when numbers of such workings were established in close proximity, e.g. at Gabriels Gully, the aggregate was quite extensive. Excellent surviving examples of this type can be seen in the flats of the Bendigo Creek near Cromwell, a legacy of the 1862–1865 rush there, and on the Lisle-Denison goldfields in Tasmania.[13] Despite the fact that large tracts of riverbeds were worked this way, surviving examples of the type are uncommon. The former tailings have been obliterated by freshets or later mining ventures.

**tailings (alluvial, stacking mechanically assisted)**:

- **finger tailings**: this form of tailings results from the dumping of tailings from trucks (*skips*) in more or less level mounds or rows radiating from a point source, such as the head of a *tailrace* where the *sluice box* was located or at the head of an inclined tramway (refer definition). The lines reflect the pattern of dumping, the tracks being extended along each ridge as it was formed. A shallow depression marking the line of the tram tracks and remnants of tram track often remain along the crests, and the tracks often pass through cuttings or depressions.
- **radial fan tailings (descending)**: formed in locations where adequate fall and space allowed. Due to the steep fall, large cobbles and small boulders could be washed down through the *tailrace*. Often a slight indentation on the crests marks where the boxing was situated. The latter was extended or radiated as required.
- **conical tailings**: where stone tailings have been dumped from a point source either at the head of an incline *tramway* (horse- or water-powered), or from a *stoning tray* which was anchored to a single central point, the resultant tailings form distinctive conical mounds. There are some fine examples on the Kumara goldfield on the West Coast. The object of the exercise was to minimise the ground covered with tailings.

- **linear mounds**: linear formations of contiguous conical mounds created by the deposition of stone tailings dumped from a *stoning tray*. As the anchor points of a cableway (from which a stoning tray was suspended) were progressively shifted as *sluicing* advanced, the tailings tended to fall in linear mounds with undulating crests often at right angles to the *sluice face*.

**tailings (*dredge*)**: dredge tailings usually consist of extensive series of overlapping mounds of coarse tailings (cobbles and boulders) discharged from gold *dredges*. There is a marked difference in height and patterning between 'early' and 'late' dredge tailings. In 'early' dredges the larger coarse material passed through the screen (see *trommel*) and via a shoot over the stern of the dredge. The fine material was often discharged on top of the coarse material resulting in low undulating mounds. The larger 'later' dredges created high parallel concentric rows of tailings superimposed on the sinuous course that the dredge worked. After the advent of the *tailings stacker* or *elevator* in 1894, dredge tailings were able to be stacked 20 metres or more high.

**tailings stacker (*elevator*)**: a device credited to Cutten Bros Engineering, Dunedin in 1894 for stacking *dredge tailings* well aft of a dredge. Prior to this innovation dredge-masters were constantly frustrated because the excavated spoil tended to flow back under their dredges and thwart their operation. Tailings stackers, essentially an endless belt on a huge gantry, enabled tailings to be stacked in high mounds well clear of the stern of a dredge, in so doing creating the distinctive winding tailing patterns.

**tailrace**: a channel or aqueduct for conveying dirty water and tailings away from a mine site. Usually the *sluice boxes* or *riffles* were placed at the head of the tailrace.

**tailrace tunnels**: tailrace tunnels (also commonly described as *sludge channels*) were used extensively on the West Coast to facilitate working claims on the fluvio-glacial gravel terraces, e.g. at Shamrock Creek and on the Kumara goldfield.[14] The lack of fall in these locations thwarted *sluicing*, so long inclined tunnels were driven from an adjacent valley (e.g. the Taramakau valley) to facilitate drainage and remove *tailings* from the work area. The tailrace tunnels which came in under the areas to be worked were accessed by one or more shafts which served as drain-holes and enabled the miners to sluice down to the level on which *leads* of alluvial gold were concentrated. Because there was no working space in the claims initially, the gold saving boxes often had to be installed in the head of the tunnels and maintained there until space had been created outside the tunnel portals. The fall was particularly important, the more the better because it enabled larger tailings to be discharged through a tailrace. Large boulders encountered whilst driving the tunnel, or blocking the races were always problematical. Before mining commenced each day (ie before the water was turned on) it was usual practice for someone to check the tailrace for blockages. The full length of tailrace tunnels were boxed so that the water-borne tailings would not scour the tunnel-surfaces and cause collapses. The waste material was usually discharged on to the valley floor or into a river at the lower end.

**trommel (rotary screen)**: a powered rotating cylindrical sieve, of various sizes, for cleaning and sizing auriferous gravels or ore. The development of trommels is perhaps best exemplified by their role on the steam powered bucket *dredges* developed in New Zealand in the 1880s for recovering auriferous gold. Trommels (usually called screens on gold dredges) constituted an important part of the gold saving apparatus and were a major component of the machinery (a few dredges employed vibratory screens). Spoil brought up by the bucket-chain was discharged into the upper end of the trommel. As the material moved down towards the lower end it was sprayed with powerful jets of water from a pipe located in the centre of the screen. The gold bearing wash fell through the about 1 centimetre diameter perforations on to goldsaving tables on either side of the screen. Large rocks and any material that did not fit through the perforations moved to a shoot at the stern of the dredge where it was discharged into the river, or in the case of later dredges it was lifted by means of an elevator and stacked well clear of the dredge (see *tailings, dredge* for further details). Trommels mounted on wheels or steel runners for manoeuvrability are an important element of modern day alluvial gold recovery plants.

**tunnelling**: see definition in hard rock section.

**turbines**: water-powered turbines were essentially further developments of the conventional water wheel and the *Pelton wheel*. A turbine consists of a fully encased rotor driven by the impact of water fed on to it through a pipe; the energy output being related to the pressure (the head) and the volume of the water. Turbines generate considerable speed and power but low torque, consequently they were generally not suitable for powering stamper batteries because too much gearing down was required. They also require a consistent water supply to work efficiently; even a small amount of wear greatly reduces a turbine's efficiency.

**washdirt (pay dirt):** the auriferous portion of alluvial deposits (gravel, sand, clay or cement).

**washing up (*cleaning up*)**: the process of collecting the material (gold, other heavy metals and sand) trapped in *tailrace riffles* and separating the gold from the other heavy metals.

**water balances**: a variation of the self-acting tram technology (see *incline tramway*). Water balances worked in the opposite manner. A ballast tank full of water going downward would haul a loaded truck upward. When both had been emptied, the truck, being heavier, would return to the bottom for refilling. Because the tank usually took a long time to fill, jigs (incline tramways) were generally preferred.

**water right**: historically, an authority granted by Warden's Courts to draw a specified amount of water from a *race* or stream for mining purposes. Water rights were eagerly sought after and keenly disputed in the Warden's Courts. They were granted directly to claimholders and to companies which specialised in supplying water to miners.

**water wheels**: overshot water wheels were the most universal motive force on the goldfields. They were used to drive a wide range of equipment including pumps, winches, *stamp batteries* and mills, and electric generating plants. Water wheels ranged from 5 to over 20 metres in diameter and were generally over a metre wide. Some were able to be driven forwards or backwards by moving the water outlet fore or aft of top-dead-centre. When used in reverse water wheels enabled material, e.g. pulp in treatment plants, to be elevated from one level to another. In New Zealand they were then termed elevators or elevating wheels; whereas they were called raff or raft wheels in Australia. Water wheels (made mainly from timber) were preferred for their simplicity, economy and reliability. Machinery was sometimes driven directly off the central shaft but usually the energy was transferred via a circular toothed rack bolted towards the circumference of the wheel. This engaged gearing on an intermediate shaft via which pulleys and drive-belts transfered the power to a battery or other machines. Although waterwheels continued to be used, they were gradually superseded by *Pelton wheels* and *turbines*.

**windsail**: a canvas sail suspended from a pole adjacent to a shaft to divert fresh air into the shaft. Used on the arid Australian goldfields.

**wing dam**: low barriers usually made of stone or timber for either deflecting a stream so that it erodes its own banks, or for the purpose of dewatering a portion of the stream channel so that it can be worked in a dry state.

## TERMS ASSOCIATED WITH HARD ROCK MINING

**adit (*drive* or drift):** a horizontal or gently inclined tunnel driven from the surface (typically into a hillside or outcrop) for the purpose of intersecting or mining an ore body (Fig. 6). Adits were also driven to intersect shafts for the purpose of dewatering. Adits are usually driven with a slight inclination to enable laden mine trucks to run downhill and out of the mine. The empty truck is then pushed back up to the work face. A slight slope also enables ground water to drain out of a mine.

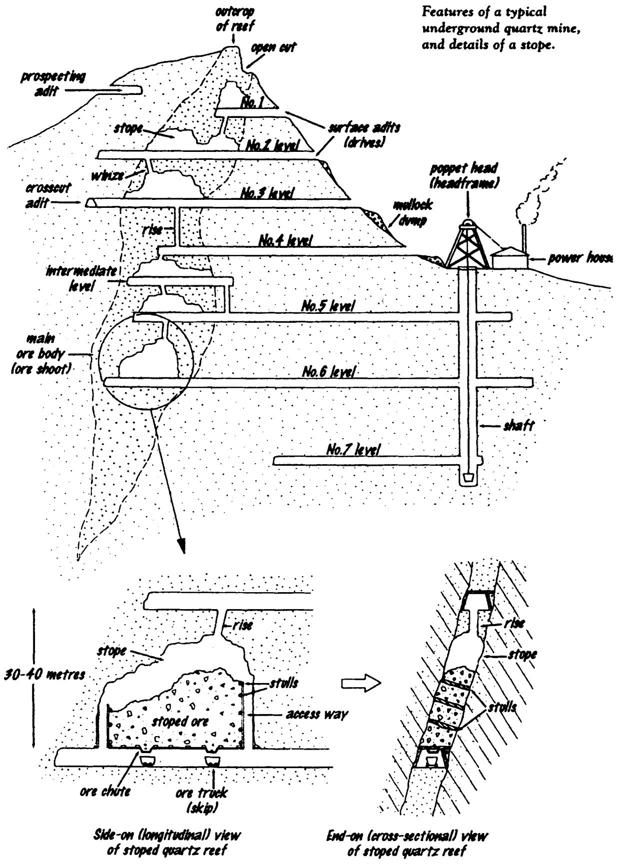


*Fig. 6: Features of a typical underground quartz mine (Moore and Ritchie 1996:34).*

**aerial ropeway (aerial tramway):** a large-capacity, very economical system for conveying ore or coal from a mine to a processing or storage facility. Transport is effected by means of steel buckets (or aerial *skips*) suspended by carriers fixed to an endless steel rope strung along pulleys on pylons. The buckets were usually filled manually from a chute at the upper end and emptied automatically at the lower end. Aerial tramways were generally considered superior to self-acting inclines in most situations. Aerial systems required minimal surface preparation, could traverse undulating terrain more readily, and required much less maintenance. Aerial ropeways are called 'flying foxes' in Australia; in New Zealand, 'flying fox' is used to describe a device principally used for crossing rivers. They consist of a seat or cage suspended from a pulley which runs along a cable stretched across the river. The user pulls the cage across by hauling on ropes suspended below the cableway.

**air receiver**: large elongated riveted steel vessel used to hold compressed air at a pressure of 90–100 psi. Like boilers they had to be certificated and have a number stamped on them. If this number can be located the history of the receiver (and therefore part of the site's history) can be traced through Ministry of Transport boiler records. Air receivers were commonly sited in a small building near a mine entrance. Compressed air (the *air-feed*) was typically delivered via pipes to underground workings at 90–100 pounds per square inch and used to drive *rock-drills*, mechanical loaders, hoists, ventilating fans, and other machines, where it was not feasible to use, or where there was no provision for electricity. While the efficiency of compressed air is very low (c.20 per cent), it was very versatile energy form and assisted in ventilation, particularly in *dead ends*.

**air shaft**: a shaft specifically driven to connect with underground workings to provide ventilation.

**attle**: *mullock*, ie waste rock. A Cornish term still used in South Australia to describe mullock and/or crushed waste rock, usually associated with copper mining.

**anticline**: the arch of a fold within strata.

**back**: the overhead ceiling or roof of a *stope*, *drive* or *crosscut*.

**backs (back reef):** proven ore reserves in a mine. Also used in reference to the thickness of ore above a particular point underground.

**beam engine/pump**: the steam-powered beam engine (or bob engine) was developed in Britain in the first half of the eighteenth century for dewatering mines. Over the next 100 years numerous refinements were patented. One variant, the Cornish beam engine, was used extensively in tin mines. Beam engines consist of a large lever (5 to 15 metres long, ie the beam or bob) which transmits the motion imparted by a piston to either a connecting rod or pump rod or both. In the 1840s the technology was transferred to the South Australian copper mines and on to the goldmines of Victoria.[15] The Western Springs pump at MOTAT, Auckland, is the most notable surviving beam engine in New Zealand. Other former notable examples were employed at the Kawau Island copper mine, and on the No. 5 shaft at the Martha mine, Waihi. Substantial remnants of the distinctive Cornish pumphouses still survive at the last mentioned locations. Australian mining engineers developed a variant of the beam engine in which a centrally pivoted arm supports beams on either side of it, as opposed to the usual situation where the beam is pivoted from its centrepoint. A fine working example of an Australian engine can be seen at Sovereign Hill, Ballarat, Vic.

**bearers (timber bearers):** heavy horizontal beams, sometimes hitched into the rock walls, used to support the timbering in a shaft, or support superimposed sets. Shaft bearers were usually installed every 30 feet.

**Blondin**: the name given to various forms of aerial cableway. The term is derived from Blondini, the famous tight-rope walker. Blondins were principally used for open-pit working, especially for conveying solid blocks of stone from quarries to other sites. The Blondin erected by the Coromandel Granite Co. to convey granite from their quarry to their wharf at Paritu is a notable (but now demolished) New Zealand example. Blondins usually required at least one massive set of sheerlegs or a pylon from which a heavy counterweight was suspended to keep the cable taut under load. Typically the cradle or carrier ran out along a near-horizontal wire until it hit a stop, which tripped a mechanism which automatically lowered the suspended load to the ground. Blondins were often powered by electricity produced by a *turbine* located on a nearby watercourse.

**blow**: large section of *reef* exposed on surface and usually worked by *open cast* methods.

**bob wall**: the front wall of a Cornish engine house, usually about 1.5 to 2 metres thick, on which the *beam* (bob) was hinged by a gudgeon (hinge pin).

**bonanza (*jeweller's box*):** small patches of *ore* or alluvial leads of exceptional richness.

**brace**: landing platform on a *headframe* to which *ore* and *mullock* are raised; usually the same height as the mullock dump and mill entrance.

**buck reef**: name given to large quartz *reefs* in which there is little or no gold or silver.

**cage**: the car or carrier used to hoist men and materials up and down a *shaft*.

**caps**: heavy timbers placed horizontally on top of one or two vertical timbers (*props*) to support the roof of a *drive* or tunnel (see *sets, lath, sill*), or *bord* (see coal mining terms).

**chamber**: (1) a large cavern excavated as part of underground workings for the placement of pumps, engines, *winding gear* and other machinery; (2) the loading area adjacent to the *shaft* on each mine level; known as a plat (derived from German) in the U.S.A. and Australia.

**chute (shoot)**: a channel cut in rock, or constructed of timber, via which *ore* was passed from a higher to a lower level in an underground mine, or outside it, e.g. from an *adit* portal to a ground tramway.

**collar**: timbering, steelwork, concrete or masonry erected around the entrance to a *shaft*, usually about the first 3 metres from the ground surface to a *headframe brace*, to reduce the risk of things falling down and prevent fretting of the entrance.

**collar height**: the height of the entrance(s) to an underground mine (specifically one accessed by a *shaft*) above sea level.

**Cornish pumphouse**: (see *beam engine/pump, engine house*) Distinctive tall structures which housed Cornish beam engines used for dewatering mines. The shell of the most notable Cornish pumphouse in New Zealand is preserved adjacent to the Martha mine at Waihi, while others survive at the copper mines at Moonta and Burra in South Australia, and at the Duke of Cornwall gold mine at Fryerstown, Victoria.

**costean**: a trench dug into the ground surface to find and expose quartz *veins* or *ore* bodies.

**country rock**: a rock mass enclosed or intersected by *lodes, veins*, or *reefs*. Commonly the predominant rock type found in a particular area.

**cribbing**: close setting of timber supports, used in locations where the *country rock* is soft or very wet.

**cross-cut**: a tunnel driven across the course of a *reef.* As *shafts* were sunk to new levels, cross-cuts were excavated to cut the reefs approximately at right angles, after which driving was commenced in both directions along the reef. Further crosscutting continued until the farthest reef was opened up. Usually rises were cut to upper levels from long cross-cuts to ensure adequate ventilation. Cross-cuts were also made to connect *adits* on the same level.

**deep leads**: mineral *veins* at great depths in a mine (alluvial or hard rock) worked by 'deep sinking', ie excavating deep shafts.

**development work**: tunnelling (driving), shaft-sinking and associated work undertaken to gain access to *reefs* in order to commence *stoping* at various levels.

**dredging plant**: see definition in alluvial section.

**drifter drill**: a heavy pneumatically driven drill used for driving in hard ground (Fig. 7). Drifter drills are mounted on a vertical steel column which is wedged between the roof and floor of a *drive*. As the face advanced, the drill was periodically repositioned.

**dip**: the inclination of strata or a *vein* measured from the horizontal at right angles to the strike. Sometimes expressed as so many feet horizontally per so many feet vertically.

**dolly pot**: colloquial name for a mortar and pestle used by prospectors in the early days to powder pieces of *ore*, which they then panned to recover the gold. If the gold was very fine they sometimes roasted the specimen on a shovel to burn out sulphides, then powdered it and mixed it with mercury. The resulting *amalgam* was then heated in a *retort* which vapourised the mercury leaving the gold behind.

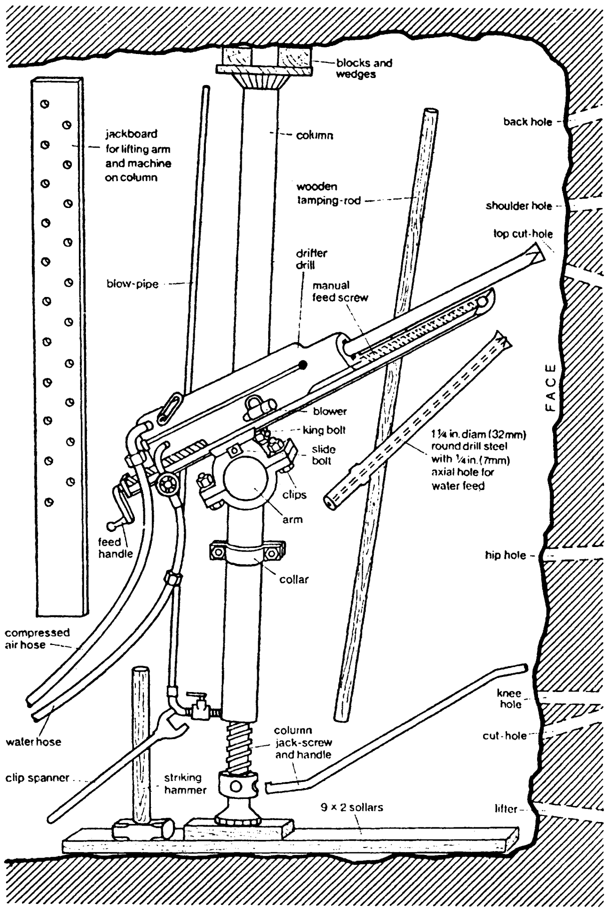


*Fig. 7: Drifter drill rigged for drilling (McAra 1988).*

**drive**: (sometimes called a *drift* or *adit*) a horizontal or slightly inclined underground tunnel which is excavated (drifted, or driven) along the course of a *vein*. Drives (and other forms of mining tunnels) have the following recognised features — a roof, floor, face (work face), and walls (side walls). 'Driving north' refers to a tunnel being driven in a northerly direction.

**dump**: see *mullock dump*.

**dyke (dike)**: an intrusive, often parallel sided, body of igneous rock which cuts through pre-existing strata. In the Thames mining area they were also called *hard bars*.

**engine house**: a structure for housing mine *winding*, hauling, and pumping engines. They are more likely to be called pump-houses, if pumping was their predominant purpose, or boiler-houses if they housed boilers. The masonry ruins of the engine/pump-house (built in 1848) at the Kawau Island copper mine site is a notable New Zealand example while good examples are found in South Australia at Burra and Moonta. The terms engine-house, pump-house, winding-house, and boiler-house are often interchanged, depending on the interest or emphasis of a particular writer, e.g. all of these terms are used in reference to the Kawau Island structure mentioned above. The brick boiler house at the Big River mine on the West Coast is a notable example of that genre.

**face**: the working face of a *drive* or *adit*; ie the part to be excavated next.

**fault (joint)**: a sheer plane or fracture zone in a rock mass where there has been displacement of the sides relative to one another. There are several kinds of faulting.

**filling shaft**: (see *gloryhole*) a *shaft* from the surface via which fill was conveyed or dropped to backfill *stopes*. They usually leave deep circular depressions.

**footwall (*stepwall*)**: the mass of rock on the underside of an inclined fault plane or vein of ore.

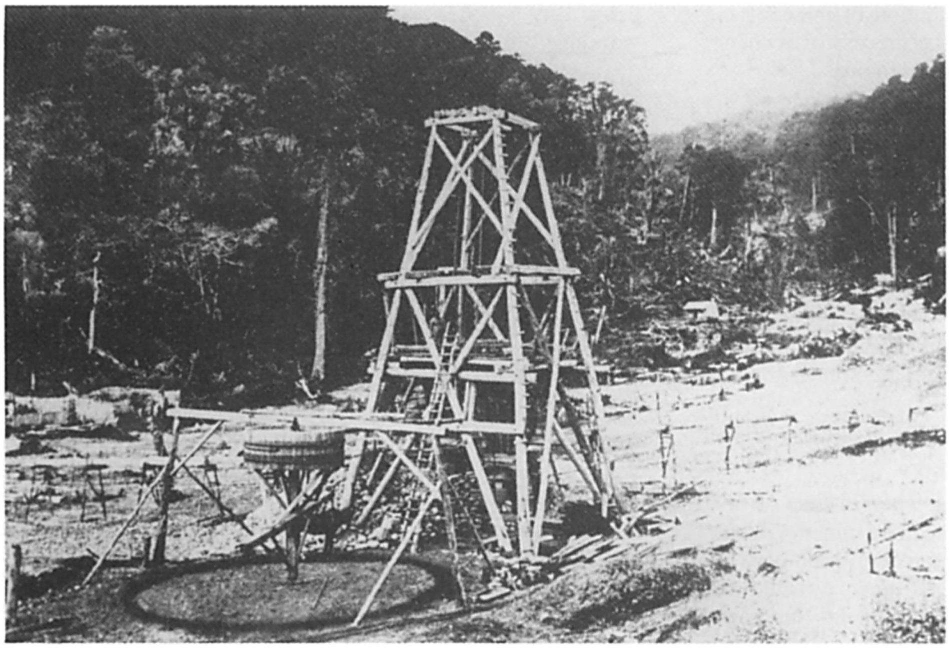

*Fig. 8: Horse-powered whim and poppet head adjacent to a deep lead shaft mine at Ross on the West Coast, South Island, New Zealand (Department of Conservation collection, Westland).*

**Francis turbines**: high-volume water-driven *turbine* used to power machinery.

**gadd**: a small rock wedge or chisel.

**gallery**: sometimes used as a synonym to describe a level or *drive* in a mine, but usually more often refers to a *stoped* area within the above.

**gangue**: usually used to describe non-metallic or low-value metallic minerals in an *ore*, which are considered waste.

**gloryhole**: an *opencast* excavation into which *ore* and/or rock was dumped, then taken by level and shaft to the surface for treatment, or to *stopes* where it was used for backfill.

**gossan (*oxidised zone*)**: oxidised rock overlying a sulphide body (see *sulphide zone*).

**gouge:** to mine only the richest portion of a mineral deposit.

**hammer and tap**: rock-drilling process usually involving two men, one being responsible for holding and periodically rotating a hand-held percussion steel drill, while his mate intermittently struck it with a heavy hammer to promote the drilling action.

**hanging wall**: mass of rock above an inclined fault plane or *vein* of *ore* (see *footwall*).

**hard bars**: see *dyke*.

**headframe**: also known as *poppet heads*. The steel or wooden framework erected over a *shaft* (Fig. 8). They had to be strongly built to withstand the weight of the load being lifted and the lateral stresses on the head sheave (the massive narrow grooved pulley over which the steel winding rope ran). Consequently their design evolved over time.

**hoppers (*paddocks*)**: *ore* holding bins in both above- and below-ground situations. *Stamp* hoppers in large mills held sufficient ore for 24 hours operation.

**incline**: (1) an inclined underground passage (see *incline shaft*). Sometimes described as a decline. (2) a sloping embankment on a rail or tramway.

**incline shaft (*underlie* or *underlay*)**: a principal entrance to a mine sloping at about 45 degrees to follow the dip of an *ore* body.

**incline tramways (self acting, jig)**: there were two basic systems employing two parallel sets of tram-tracks and utilising the weight of a loaded truck going downward to pull an empty truck up an adjacent line. This was achieved either by a a single rope running round a bull wheel at the upper end of the incline, or two ropes wound in opposite directions on to a winch drum, so that one was wound in while the other was paid out. Usually the top truck would be loaded from a storage bin above it, and discharge automatically when it reached the bottom. Then the process would be reversed. Usually inclines only had three rails, the middle one diverging to let the trucks pass. The inclines on the Wairongomai goldfield near Te Aroha are probably the most notable surviving examples in New Zealand.

**jackhammer**: a hand-held percussive drilling machine used mainly for down-drilling, e.g. foundation holes, or shaft-sinking, in mines.

**jig (self acting *incline tramway*)**: see above.

**kibble (kibbal)**: (derived from German kubel, a bucket) a wooden or steel barrel-shaped container used to haul ore or water up from a mine. Usually used on small scale mining ventures in association with a windlass. Larger capacity kibbles, known as 'sinking kibbles', were used in conjunction with poppet heads to sink main shafts. The barrel shape minimised the catching of the lip on the sides of the shaft.

**lagging**: secondary timbers placed behind the main timber supports in a shaft or drive to hold back rubble or loose country rock.

**laths**: heavy timbers placed horizontally along the sides of a tunnel or *drive* between the outer surface of the *props* and the walls to prevent rock (or coal) falling inwards.

**leader (feeder)**: A small *ore*-rich *vein* extending from a larger one.

**levels**: Underground mines are established as a series of horizontal workings or levels which are usually numbered from the surface down. In mines developed on quartz veins, the levels varied from c.20 to 100 vertical metres apart. The levels are connected by vertical shafts or steeply inclined passages (see *rise* and *winze*). In some mines sub-levels were established. They were termed *intermediate levels* and usually prefixed by the level number beneath.

**lode (*reef*)**: part of an ore zone or rock mass containing several veins spaced closely enough so that they and the intervening rock can be mined as one unit by driving, or stoping if the lode is steeply inclined.

**magazine**: a secure ventilated structure or locker used for storing explosives.

**mineralisation**: the presence and distribution of minerals in *ore*. The term is also used to describe the process or account for the presence and distribution of minerals in ore.

**moil**: a heavy pointed steel bar used for driving shot holes in soft ground.

**mucking**: removal of blasted-down *ore* from a face or *stope*. The men and machines who do this work are called 'muckers'.

**mullock**: an old Cornish mining term used to describe the waste rock from a mining operation. Whereas the *ore* is stockpiled and treated to recover minerals, mullock (*attle* in South Australia) is the barren material which is deemed not worth treating. It is usually dumped in radiating heaps below a mine drive, or the *shafts* accessing underground mines, or used to backfill *stopes*.

**notches (hitches):** indentations excavated in the roof or walls of a mine drive to secure supporting timbers.

**open-cut (opencast):** method of mining where a *lode* or ore body outcrops at or near the surface and can be mined without resorting to underground methods. With modern machinery to efficiently remove the overburden it is now possible to opencast mine to much deeper levels than in the past. Commonly used to mine stockwork systems.

**ore**: a natural mineral deposit of various elements. The term is usually used in situations where at least one element is a sought-after metal, e.g. gold. An ore-body (ore reserve) may be worked if tests indicate that there is enough metal-ore in it so that it is economically feasible to work.

**outcrop**: a location where a *lode, reef*, or stratum is exposed on the natural ground surface.

**oxidised zone (*gossan*):** the upper part of an *ore*-body which has been altered by oxygen and weathering, usually with the loss or chemical modification of some of the *mineralisation*. cf. *sulphide zone.*

**paddock (*hopper*)**: box-shaped wooden ore storage bins (also see alluvial mining definition of *paddock*).

**paddocked ore**: stored or stockpiled ore.

**Pelton wheel**: the invention of Louis Pelton of Comptonville, California, the Pelton wheel was the culmination of a 30-year quest to design a better water wheel. Pelton designed a wheel with small replaceable cups or buckets regularly spaced around its outside circumference. It was driven by a high pressure jet of water (usually under a head of 80 feet or more) which struck the buckets, turning the wheel and the shafting attached to it. Pelton wheels (many were manufactured in Thames, others were manufactured and imported from Australia, England, and the United States) were widely used in the early days of goldmining to drive batteries and provide a cheap form of power. The speed, therefore the power of a Pelton wheel, could be regulated by a deflector (if fitted) or by adjusting the incoming water flow.

**picked stone**: rich pieces of ore, e.g. quartz picked out for showing gold or *assaying*.

**plat**: see *chamber*.

**popper drill**: a relatively light drill mounted on pneumatically-operated telescopic leg; used for boring holes in an upward direction (see *drifter drill*).

**portal**: surface entry to an *adit* (drive) or tunnel. In mining, the term is usually used in reference to the main entrances to underground mines, or the timbered or masonry entrances to adits/drives.

**poppet head**: see *headframe* (poppet head is distantly derived from puppet, ie. a thing manipulated by lines from above).

**powerhouses**: the buildings at a mine or battery where the main switchgear and controls were situated. Originally the term applied to actual on-site generating equipment such as producer-gas plants, or coal-fired steam turbines.

**prop**: any wooden post or support used in underground workings.

**propylitic alteration**: rock altered by hydrothermal action and containing minerals such as calcite, chlorite and quartz, the latter often being auriferous.

**prospecting trench (*costean*):** a trench excavated in an outcrop or rock mass with a view to prospecting or locating a reef.

**pump-house**: a building housing pumps for dewatering a mine. The ruins of the Kawau copper mine's engine/pump-house and the Martha mine's Cornish pumphouse at Waihi are the two pre-eminent surviving examples in New Zealand, while good examples can be found in South Australia at Moonta and Burra.

**quartz**: a hard dense form of silica commonly occuring as veins in country rock. Quartz veins or reefs are of economic significance if they contain large concentrations of desired minerals such as gold, silver, or mica. As quartz is the ultimate source of most alluvial and reef gold, exposed quartz reefs are sought and sampled to ascertain the presence of gold, other sought minerals and their concentrations.

**rake/rakeline**: a rake refers to a string of ore-trucks hauled by a mine locomotive or horses. The Waihi Gold Mining Company's Waihi-Waikino rakeline is the pre-eminent example of its type in New Zealand.

**raise (rise):** a vertical shaft excavated upwards from a lower passage.

**reef**: often used synonymously with *lode*. Prominent concentrations of quartz (or other mineraliferous) veins within country rock.

**rising**: upwards excavation (a *rise*) involving the use of strongly built compartmentalised timber-structures known as *sets* which served as a working surface and temporary ore bin. Rises were about 2.5 metres by 1.2 metres in section and might extend from one level to another (c.50 metres) or from a *stope* to the level above.

**rock-drills**: a generic term for a range of compressed air-driven drills used to bore holes for explosives.

**sets**: pre-cut timber frames used for propping the sides and roofs of drives. Typically sets are placed 4 feet apart. More sophisticated square-frame sets were used to provide working surfaces during *stoping* (see *rising*).

**shaft**: a vertical or near vertical passage to provide access from the ground surface to underground levels, or from one level to another. The shafts of established mines were usually timbered (especially in unstable ground) and usually subdivided into three sections. Typically two were used as winding compartments/ haulage ways for lift cages (or a bosun's chair), and the third contained a ladderway as well as drainage or ventilation piping etc. The division of the shaft into two or more compartments also created an uneven airflow (the air rising in one section and sinking in the other(s) which assisted ventilation and helped prevent the formation of foul air (air with little or no oxygen).

**shaft collar (*collar height*):** the height of the entrance to a mine shaft above sea level or a local datum. The *collar* refered to the framework around the neck of the shaft.

**shoot (chute)**: see *chute*

**sill**: heavy timbers set into the ground or floor of a tunnel or drive to hold supporting legs (*props*) apart. The use of sills is generally restricted to areas where considerable pressures are present on the sidewalls of a tunnel. A sill is also a geological term used to describe a mass of igneous rock intruded between other rock types.

**sink, sinking**: the processs, usually aided by explosives, of excavating *shafts* for access to lower levels in mines.

**skimps**: a Cornish term for tailings, only used in South Australia.

**skip (ore skips, handcarts, trucks)**: small rail-mounted, side or end-tipping ore carts used for conveying *ore* or *mullock* from a workface to the surface of a mine. The men who pushed them were called truckers. The ore buckets attached to aerial ropeways are known as buckets or aerial skips (see *aerial ropeway*).

**sludge channel**: see definition in alluvial section.

**stationary engine**: term covering all types of steam engine mounted on a foundation to provide a fixed energy source for pumping, winding, and driving machinery.

**steels**: the rods or drills used for boring holes with the aid of a pneumatic drill, or a hand drill operated by a sledge hammer in the case of the *hammer and tap* method. Explosives are then placed in the holes and detonated to break out the work face and advance the drive or shaft.

**stock, stockwork**: *country rock* containing so many fine *stringers* or veinlets that it may be more economical to excavate and crush all the rock rather than the veinlets alone.

**stope**: an underground excavation from which *ore* is extracted, usually above or below a *drive* or working level. The process is called stoping. Once the ore body has been removed the resultant chamber is sometimes described as stoped out. The shape of a stope, which is often inclined, depends on the width, height and extent of an ore body. Timber *sets* are used to provide working platforms when stoping steeply inclined reefs or lodes (see *stulls*). Stopes were often backfilled with *mullock*. This material is described as stope-fillings.

**strike**: the direction or bearing of a seam, vein, fault etc with a horizontal surface at the point of intersection. The strike of the country rock is usually mentioned in relation to the angle of *dip* of a vein.

**stringers**: fine and often convoluted offshoots of the main metalliferous reefs (approximately synonymous with veinlet).

**stulls**: wooden props cut to fit and placed across a *stope* to prevent the side walls from collapsing or sloughing off, or to support a platform for the ore to land on when *overhand mining*, ie mining upwards from a particular level, as opposed to *underhand mining* (ie excavating downwards from a floor level).

**sulphide zone**: the unweathered, usually larger and deeper part of a mineral deposit. The *ore* in a sulphide zone is usually harder and more difficult to treat than that in the *oxidised zone* near the surface.

**sump/sumphole**: the base of a mine shaft where water accumulates and from which mine water is removed by pumping or a drainage *adit*. Sumps at the base of a shaft also enabled them to be drained by the use of specially designed *bailing buckets*. These were lowered down a shaft using the winder. When the bucket reached the water-filled sump, its base opened automatically, allowing it to fill. On lifting the base closed, enabling a full load of water to be brought to the surface where the bucket was triggered again and its contents released into a drain. Also see *sump* in processing section.

**tailings**: from hard rock mining, refer definition in processing section.

**tram/tramway**: narrow gauge lines (c.450 to 600 millimetres) with a level or gentle downhill gradient along which trucks would be pushed one at a time by a miner, or pulled in rakes of half a dozen or more by a horse, depending on weight and distance. The act of hauling ore away from a stope is called tramming or *trucking*. Aerial ropeways are sometimes described as aerial trams.

**tributers**: miners who work a section of an ore body belonging to a company on their own account, and pay as royalty a percentage of the value they recover. Tributers were often allowed to work sections of mines that were no longer viable for companies.

**trucking**: the loading of ore from *stopes* or elsewhere in a mine and its transport to processing sites. When *trucked*, ore is conveyed in wooden or steel *trucks* (*skips, tubs*). See *tramway*.

**tunnel**: the term tunnel originates from Cornish miners who referred to an *adit* or *drive* as a tunnel. Strictly speaking an adit does not become a tunnel until it is driven through a rock mass, e.g. a ridge or an ore body, enabling free passage through it.

**tunnelling**: essentially the same as *driving*. The excavation of tunnels/adits to gain access to leads in alluvium, or to enable haulage, or the passage of water (in *races*) through consolidated ground or hard rock. The roofs of tunnels through weak ground were generally supported with timber props. Some timbers, e.g. red beech (on the West Coast) were favoured because of their tendency to talk, ie make distinctive squeaking noises when nearing the point of collapse.

**underlie (or underlay)**: Australian terms for an *incline shaft*.

**vein (*lode*)**: a general term for a narrow body of ore with depth and length but relatively small thickness.

**whim (whimsies)**: strictly speaking any device for winding up a rope, but normally used to describe a vertically mounted winding drum (powered by a horse walking round it) used for raising ore from a mine. As the horse moved a rope passing over a pulley suspended above the shaft gradually wound on to the drum, which in turn elevated the suspended load. Field evidence of the existence of a whim is usually in the form of flat circular areas (c.10 to 15 metres in diameter), often marked by a shallow circular depression where the horse walked, and occasionally timber or steel remnants of the winding drum at the centrepoint. Whims were also used for hauling ore up or down *incline tramways*, and for lifting pumprods out of shafts when servicing *Cornish engines*. Two whims of unconventional form were used for hauling coal to fire steam boilers at the Ajax quartz mine neer Reefton on the West Coast. The archaeological evidence indicates the winding drums were positioned in an excavated well beneath the horse track, rather than above the horses as is the more usual situation.

**whip**: a structure containing a pulley mounted over a shaft. A rope running over the pulley was attached to a horse. When the horse was led away from the shaft, it pulled suspended loads up the *shaft*. The term is also used to describe a counterbalanced pole used to lift *washdirt* or sterile material from small alluvial workings.

**winch**: used for hoisting materials and *winze*-sinking. Usually powered by small, reciprocating, compressed-air engines.

**winding engine/gear**: steam or electric engines installed adjacent to the main shafts in underground mines to raise and lower the cages which conveyed men and materials to the various levels. Since the lives of the miners depended on the winders, they had to be maintained to a high standard, and the drivers had to be certificated. Many winding engines had two winding drums, so that one cage counterbalanced the other. Substantial remains of winding gear on old mining sites in New Zealand are now limited to the Big River and Inglewood mines (Murray Creek goldfield) on the West Coast. In Australia examples survive on the Croydon goldfield in Queensland.[16] See also definition of *engine house*.

**windlass**: a wooden roller with a crank at one end mounted over a *shaft*. When the crank was turned it wound up a rope attached to a *kibble* and consequently lifted the latter out of a shaft.

**winze**: a generally small-section vertical or steeply inclined *shaft* or passage excavated from one level to another in underground workings usually along the line of a reef. Winzes do not reach the surface, and were usually excavated downwards from an upper level to a lower one.

## TERMS ASSOCIATED WITH PROCESSING ORE TO RECOVER THE METAL CONTENT

**agitation**: generally refers to the agitation of *slimed* ore in various forms of agitation vessels (such as *vats* or *B & M tall tanks*), either to keep it in suspension or to circulate or oxygenate it, particularly with regard to dissolving the precious metal content. Compressed air was used to agitate pulverised gold-ores because it increased the efficiency of the cyanide amalgamation process (see *cyanide process*).

**alloy**: a compound mixture of two or more metals.

**amalgam**: when mercury (quicksilver) is added to finely crushed quartz containing fine gold it creates a mixture (an amalgam) of gold and other precious metals which are then separated, usually by *retorting* off the mercury.

**amalgamating**: process by which fine gold was recovered by passing it over mercury-coated, copper *amalgamating plates*. The fine gold amalgamated on the plates laid on tables (see *amalgamating tables*) extending out from the mortar boxes below the *stamps* in batteries, or extensive tables erected on beach sluicing or *blacksanding* sites. The gold was periodically collected by retorting the amalgam. Amalgamating was also done to some extent in grinding pans, e.g. *Berdans* (Fig. 9).

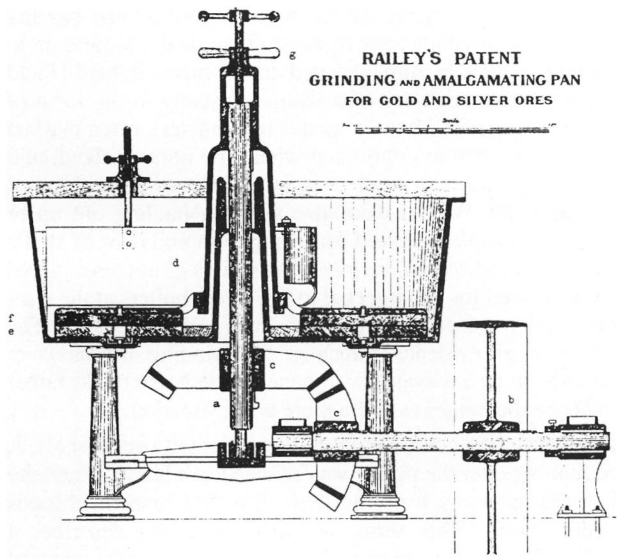


*Fig. 9: Diagram of Railey's Patent Grinding and Amalgamating Pan for treating gold and silver ores (Annual Journal of the House of Representatives 1887 Vol.1, Section C5, opposite p. 72).*

**amalgamating tables (gold tables, or *tables*)**: surfaces covered with copper or Muntz sheeting (see *Muntz metal*) for amalgamating gold particles with mercury. Those associated with *stamper batteries* were relatively small whereas amalgamating tables associated with beach sluicing claims (particularly on the West Coast) were often quite extensive. One at Charleston was 102 feet long and covered with 816 square feet of copper sheeting (Faris 1941:177). Small mobile tables using either plush or copper amalgamating plates were used for *black-sanding* (see definition in alluvial section).

**amalgamating drums**: mostly used on West Coast alluvial claims to assist in the separation of extremely fine gold and *blacksand* trapped on blanket tables. This material together with a quantity of mercury would be put into a drum mounted on an axle and rotated by means of a small overshot or *Pelton wheel*. Several hours of turning would ensure the gold amalgamated with the mercury and could later be retorted.

**arrastra**: the most elementary form of crushing plant. Earliest forms consist of boulders (mullers) dragged round a paved circular gutter by a horsedrawn swinging arm. Later they consisted of fixed circular pans in which crushed ore was further ground by powered revolving weights together with mercury (for *amalgamating*) and water. *Chilean mills* and *Berdan pans* are slightly more advanced devices based on the same principle. Arrastras, used extensively in the United States, seem to have found little favour in Australasia. There is no record of the usage of horse-drawn arrastras in New Zealand and few reports of their usage in Australia.

**assay**: the process of determining the gold and silver content of ore. Usually about 400 grams of pulverised ore was melted with fluxes in a crucible-furnace, then the resultant lead button was cupelled (see *cupellation*) in a *muffle-furnace* until all the base metals were absorbed or vapourised. The bead which remained consisted of gold and silver. This was weighed and the silver *parted* in hot nitric acid which was then poured off, leaving just pure gold. This was reweighed, the difference being the weight of the silver fraction. The quantities were calculated in ounces, pennyweights and grains per ton.

**B & M tanks (*tanks, conical tanks, pachucas*)**: tall tanks (usually made of steel, sometimes concrete or wood) used in the cyanide process (Fig. 10). Compressed air was forced through the conical bases of the tanks creating a powerful air-lift which agitated and aerated a charge of finely crushed ore (*slimes* or *pulp*) and potassium cyanide for about five days (see *agitation*). The tanks were designed and patented in 1902 by C. F. Brown, General Manager of the Komata Reefs Gold Mining Company near Paeroa. The concrete and steel remains

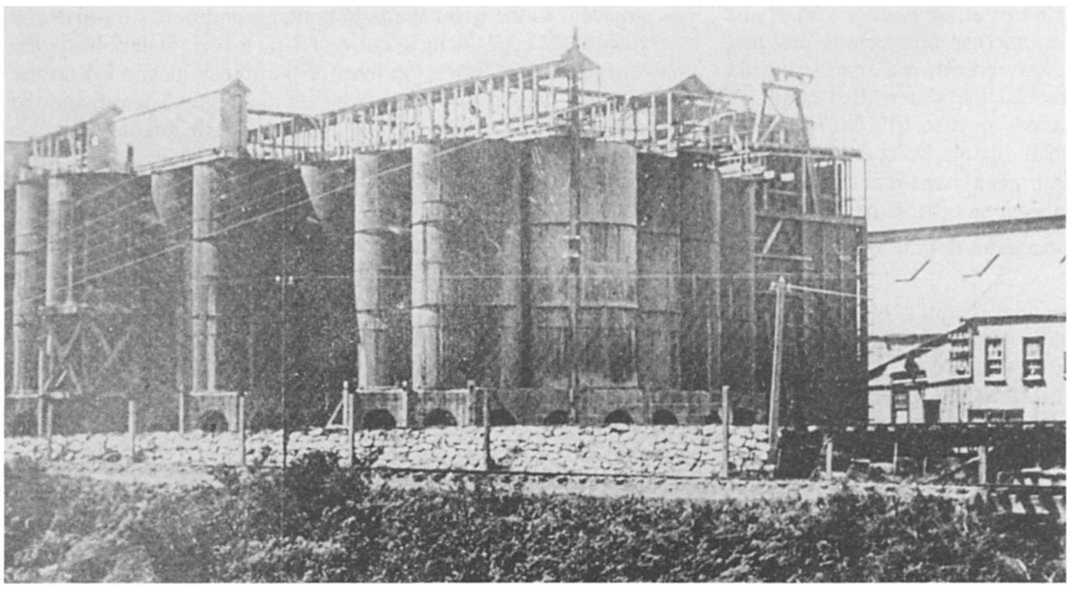

*Fig. 10: Pachuca tanks (also known as Brown agitators, after the inventor, or cyanide agitation tanks) at the Victoria battery site, Waikino, North Island, New Zealand (N. Ritchie).*

of the B & M tanks at the Victoria battery site, Waikino, and the concrete tanks at the Union battery site at Waihi have been classified B by the New Zealand Historic Places Trust.

**ball mill**: used to describe cylindrical mills where the length is less than or roughly equal to that of the diameter (see *tube mill*). Initially developed for relatively coarse grinding, when used in conjunction with *classifiers* they were often employed for fine grinding. The ore, usually wet but sometimes dry, was pulverised by the action of steel balls (from 1 to 4 inches in diameter initially) tumbling within the revolving cylinder supported on hollow trunnions. The feed was fed in through the trunnion at one end and discharged at the other either by overflowing, or through powered discharge gates.

**base metal**: general name for chemically reactive metals such as lead, copper and zinc, as opposed to the precious or 'noble' metals such as gold and platinum, which are less reactive.

**battery**: see *stamper battery.*

**beneficiate**: the processing of ores to regulate the size of the product, remove unwanted constituents, and improve the quality, purity or *assay* grade. In essence, the *concentrating* and preparation of ore for *smelting*.

**Berdan (pan)**: a frame-mounted inclined revolving cast iron basin between 0.6 and 1.25 metres in diameter containing a heavy steel weight (sometimes a piece of stone was used) known as a muller (Fig. 11). The slow revolving action causes the muller to finely grind the ore, particularly concentrates. Berdan's 'Gold-ore Pulveriser, Washer and Amalgamator' was patented in new York in 1852. Early models were over 2 metres in diameter, were heated, and had multiple mullers. Berdans became popular for fine grinding after *cyaniding* was widely adopted. Mercury was added to the Berdans to form an amalgam with the finely ground gold (ie they could be used for either grinding or *amalgamating* or both). Berdans were commonly erected in parallel in the larger crushing *batteries*. They were widely used in New Zealand until early this century and their remains are relatively common on old mining sites. The series of seven mounted Berdan pans at the Invincible mine site near Glenorchy in Central Otago is one of the finest existing examples in New Zealand.

**Blake crusher**: to reduce the cost of pulverising ores to a minimum, *rock crushers* (either *jaw* or *gyratory*) were employed to crush the ore initially, as these were the most economical machines that were available for this purpose. Various machines were used in New Zealand including Giant, Dodge, Lamberton and the Blake-Marsden, but for efficiency, economy, and durability, the latter (the 'Blake-Marsden Pulveriser', more commonly known as the Blake crusher) was widely recognised as the optimum machine. Blake-type crushers were reciprocating-action machines, which crushed ore by direct pressure between a fixed plate and a swinging jaw. They had one major disadvantage compared with gyratory crushers in that the latter produced a more consistent size product which was the ideal for further processing. Gyratory crushers were also less prone to getting feed blockages.

**blanket tables**: after crushing (in a battery) the *pulp* (finely crushed rock and ore) was passed over either *amalgamating* or blanketing tables, or both sequentially. Blanket tables were similar to amalgamating tables but were surfaced with plush or carpet 'blankets'. The heavy metal content settled or was trapped in the weave. The blankets were periodically removed and washed in tubs to recover concentrates. Most of the blankets used in N.Z. mills were manufactured by the Mosgeil Woollen Mills near Dunedin, especially for mill use. The material cost 12 shillings per yard (2 yards wide) and had to be replaced every three months.

**blanketings**: heavy metals trapped in the blankets on *blanket tables*.

*Fig. 11: A row of seven berdans at the Invincible mine site, Rees Valley, central Otago, South Island, New Zealand (N. Ritchie).*

**blast furnace**: the origins of blast furnace technology are obscure but they are generally thought to have been developed in what is now Northern Europe before AD 1400. Many innovations and associated terminology (beyond the scope of this glossary; refer chapters on iron and steel in industrial archaeology texts) have occurred in blast furnace technology over the ensuing centuries, one of the most notable occurring in 1709 at Coalbrookdale, Shropshire, when Abraham Darby perfected the technique of smelting iron ore with coke, rather than charcoal. Blast furnaces enabled much greater quantities of iron and other metals to be produced because they could be charged continuously with ore and charcoal or coke which was fed into the top of the furnace and gradually descended through it. In the process water and other volatiles were driven off in the upper section, and the ore was reduced to flowing metal. The efficiency of the process was greatly enhanced by blowing air into the furnace (originally by bellows) because it reacted with the charcoal/coke and increased the rate of the reduction of the ore. Earthy impurities fused to form a slag, which together with the molten metal was funnelled down into a hearth in the base of the furnace, where the denser metal accumulated at the bottom with the slag overlying it. Periodically the molten metal could be tapped off and cast (see *pig iron*).

**blister copper**: produced in a *converter* during the last stage of a conventional *smelting* process, blister copper, 'the end product of smelting copper sulphides, consists of a black blistery porous *matte*. This nearly pure copper requires refining before it can be used commercially.

**blowers**: powerful fans used to create the jet of air injected into blast furnaces.

**buddle**: name given to a range of devices which use a sloping surface to separate particles of different densities from a slurry. The most common form, known as a round buddle or round table, used the centrifuge principle and a circulating water flow in addition to gravity. The water sprays washed the finely ground metal residues and other impurities into *launders*, but the separation was achieved by gravity. They were often used for reprocessing *tailings* discharged from battery sites. One buddle could concentrate the ore from ten *stamps*.

**bullion**: commonly used to describe bars of semi-refined gold or silver. Sometimes used in a more specific sense, e.g. gold bullion or silver bullion. The term is also used as a general name for the metal product of a smelter, e.g. lead, cast into ingots or bars. Bullion usually requires further refining before it can be used commercially.

**calcining**: same process as *roasting*.

**Chilean Mill**: the earliest form of Chilean Mills likely to be found on Australasian goldfields consist of a circular trench around which a large steel capped wheel was pulled by a horse, in so doing crushing quartz placed in the trough. A similar technology is commonly used for pugging clay in the brickmaking industry. The crushed quartz dust was washed away while the heavier freed gold particles accumulated in the base of the trough from which they were periodically recovered. Traditional Chilean mill sites are quite common on some of the Australian goldfields, e.g. Victoria. The authors are unaware of the existence of any traditional Chilean mill sites in New Zealand. Modern Chilean mills are ore-milling machines consisting of a revolving iron pan in which ore is crushed by two vertically mounted wheels which revolve against the base of the pan.

**chlorination**: usually refers to the Freiberg chlorination process by which metals are leached out of crushed ore in a chlorine solution. The process was developed by Carl Plattner in 1858.[17] Barrel chlorination, in which bleach powder and acid were added to a cylinder of crushed ore, was the most common method. Although chlorination was used extensively overseas (especially in the United States), it was soon dropped in favour of cheaper pan *amalgamation* technology, and eventually completely superceded by the advent of the *cyanide* process. Only one company in New Zealand is known to have used chlorination. In 1898 Progress Mines Ltd. at Reefton on the West Coast established a chlorination plant but only used it for a few years before adopting cyanidisation. The latter technology had many advantages over chlorination. The cyanide process enabled the recovery of silver and other metals which could not be achieved with chlorination. The latter process required one tonne of chemicals (mainly bleaching powder) to treat about 14 tonnes of ore, whereas one tonne of cyanide and zinc would treat 100 tonnes of ore. The chlorination process also required pre-roasting of the ore, necessitating the installation of furnaces and the purchase of fuel.[18] The Newbury-Vautin chlorination process was widely used in Australia. Chlorinated tailings are a brick red (ferric oxide) colour.[19]

**classifiers/classifying-boxes:** a wide variety of machines used to separate (classify) the coarser particles of *pulp*. In larger plants classifiers were arranged in successive groups, each refining the pulp a further step. Classifying processes are often alternated with *concentrating* processes in a mill because concentration works more efficiently with particles of uniform size.

**cleaning up**: periodic collection of gold trapped on blanket tables, or other alluvial gold catching devices, e.g. from *stamper battery* mortar boxes where cleaning up referred to the recovery of concentrates from sands; also used to describe the periodic separation of *amalgam* from, for example, the copper plates on *amalgamating tables*.

**coke**: (see *coke* in section on coal mining). the usual and preferred fuel for base metal smelting. If coke was in short supply, coal, firewood and charcoal were sometimes used in smelters.

**complex ores (mundic, refractory, or pyrite ores):** ores containing several mineral sulphides and requiring a series of treatments to separate and recover the precious metal portions.

**concentrates**: processed finely-crushed ore containing a mixture of metallic sulphides and heavy desired metals such as gold and silver (see *concentrating*).

**concentrating**: the process of separating the heavy fraction of the pulverised ore from the lighter material. Machines for concentrating were called *concentrators. Wilfley tables, jigs*, and *buddles* were three of the main types of concentrators used in New Zealand.

**concentration**: refers to methods used to increase the proportion of economic metal by pre-crushing ore and mechanically discarding the barren rock particles before *smelting*. Concentration is usually done with base metal ores to reduce the volume of material that has to be smelted and consequently lower smelting costs.

**cone separators**: large diameter cones (c.15 feet in diameter) used to separate (ie classify) the coarse and fine fractions of pulverised ore (sand and *slimes*) after the concentrates have passed over *Wilfley tables*. The lighter fraction was lifted by an upcurrent of water through the inverted cone and creamed off via an annular *launder* around the top perimeter. Larger particles were washed out via a nozzle in the bottom of the cone into intermediate sand vats, where they drained, prior to being shovelled into larger concrete sand-treatment vats (usually in a tank shed).

**conical tanks**: see *B & M tanks*.

**converter**: a machine, usually a steel cylinder which can be rotated to different positions for charging, pouring *slag* and pouring metal, which is employed in the last part of the copper smelting process. Converters are lined with firebricks which are consumed in the process and have to be replaced regularly. The process involves mixing molten copper *matte* produced in a blast furnace with silica. A powerful air blast is blown through the mixture for an hour or so until the copper sulphide is oxidised to copper metal. The products produced in a converter are *slag* and *blister copper*, the latter having a copper content of 99 per cent or more.

**crucibles**: pots for melting or smelting substances in a furnace. Usually ceramic .

**crusher**: various machines for breaking down rock by crushing it. See *Huntingdon mill, jaw crusher, Blake crusher, roller crusher*. Three stages of *crushing* are generally recognised-primary crushing employing *jaw crushers* or stonebreakers; secondary crushing employing batteries (*stamps*); and tertiary crushing or grinding using *Berdans* and other grinding machines.

**crushing rolls**: pairs of powerful steel rollers used to crush ore and *flux* to a uniform small particle size before the material goes into a *smelting* furnace. Particularly used prior to the smelting of base metal ores to increase the efficiency of the smelting processs.

**cupel**: a small ceramic bowl made of special heat resistant clays used for refining gold. The process known as cupellation (see *assay*).

**cupellation**: part of the process of *assaying*.

**cyanide process**: the McArthur-Forrest cyanide process was patented by Scottish chemists in 1887. The patent rights were held by the Cassel Gold Extraction Company. In 1889 the first actual field test in the world was conducted by New Zealand Crown Mines Company at Karangahake on behalf of the Cassel Company.[20] The introduction of *cyaniding* on a commercial scale was a revolutionary world first, enabling low grade ores to be worked profitably and 90 per cent of the gold and about 50 per cent of the silver to be recovered from all grades of ore. The methodology gave a tremendous impetus to the Ohinemuri mines. Within a few years it was widely adopted by many goldmining companies in New Zealand and overseas. It was first used in Australia in 1892, but became especially popular after the patent rights expired in 1897 (in which year the New Zealand government acquired the patent rights from the Cassell Company). In the basic process, finely-pulverised ore (less than 200 mesh size) is submitted to the action of a dilute potassium cyanide solution (by percolation through it) for approximately five days in a tank. The pregnant cyanide solution was then drawn off (by vacuum filtration in more advanced plants) and passed through wooden boxes where the gold and silver content precipitated (as a black sludge) on zinc shavings, after which the solution was recirculated. Later it was found that the process worked more effectively if compressed air was used to agitate the solution, oxygen and water being an essential part of the process. Many of the larger northern mills in New Zealand, e.g. the Crown and Victoria, did most of their gold-saving by cyaniding.

The cyanide process enabled so much extra gold to be recovered that it became economic to re-process old tailings. In Australia virtually all the old tailings were re-treated about the turn of the century, and many were done again in the 1930s. These episodes often represent the most conspicuous evidence on gold mining sites. Cyanide tailings are a characteristic bone-white colour. Timber work within cyanide tailings tends to preserve very well but iron corrodes rapidly.[21] The advent of the cyanide process also made it economical to dredge riverine and marine areas where tailings from batteries had been discharged to submit them to cyanide treatment. See dredging plant.

**cyanide tanks (leaching vats):** wooden, steel or concrete tanks used for containment of *pulp* undergoing cyanide treatment.

**distributer**: a multi-armed device (similar in principle to a giant garden sprinkler) which distributes *pulp* evenly into *cyanide tanks.*

**dressing/to dress**: process of sorting ore into its various components, usually by mechanical means, e.g. *vanners* or *Wilfly tables*.

**Dwight-Lloyd sintering plant**: a plant designed to roast lead ores before *smelting*, consisting of an endless belt which slowly carried pallets of ore through an ignition furnace and then under a strong air blast to oxidise the sulphur before discharging automatically.

**dwt**: abbreviation for pennyweight. A pennyweight equals 24 grains. 480 grains equal one troy ounce.

**Edwards Roaster**: a roaster developed in Ballarat, Victoria, about 1897 for the continuous roasting of gold ores. It consisted of a long steel chamber heated by a furnace beneath, in which a thin layer of crushed ore was agitated and moved along by mechanical rabbles. On the Chillagoe goldfield in Queensland and at other Australian mines Edwards roasters were used to treat lead ore sulphides.

**feeder (ore feeder or self-feeder):** a machine consisting of a storage hopper and an intermittently triggered discharging mechanism for feeding a regulated amount of ore (or coal) into a *stamper battery* or other crushing device. Regularity of feed into crushing machinery is critical for the maintenance of a steady throughput, effective crushing, and minimising mechanical wear on the machinery from uneven running. When large quantities of ore piled up in a mortar box, it cushioned the fall of the stamps, impairing their movement and efficiency and occasioned more frequent breakages of the screens. Feeders enable the input of ore into mortar boxes in controlled quantities, the ideal depth above the dies being 1.5 to 2 inches. The term is often used in reference to a Challenge feeder (Fig. 12). in which a circular cast iron plate (about 60 centimetres diameter) mounted in the chute beneath

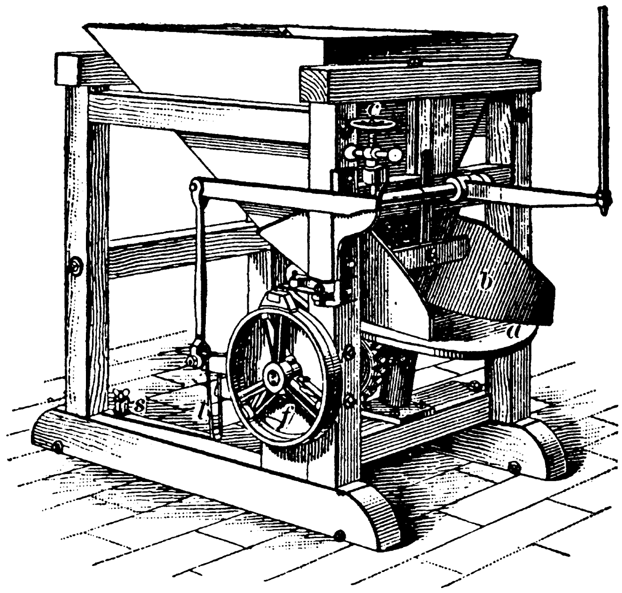

*Fig. 12: A Challenge Ore Feeder, one of a number of similar types of machinery for feeding a consistent flow of ore into batteries and other types of crushing or grinding machinery (Davies 1894).*

the hopper is rotated in short jerks by a bevel gear, actuated by a striking mechanism attached to the battery camshaft, thus spilling the ore on it into the mortar box at regular intervals. When the level of the ore in a mortar box dropped, the stamper shaft tappet would move more distance which by means of the above mechanism caused the feeder to discharge more ore.

The principal self-feeders used in Australasia were the Challenge, Tulloch, Roller and Hendy Improved Challenge suspension feeder. Archaeological evidence of feeders is often difficult to define because the machines consist of many small and not readily identifiable components within a wooden framework. Once the latter has decomposed the steel components are freed and tend to get scattered about a site. There are now few substantially intact feeders on historic mining sites in New Zealand. The Blacks Point Museum battery near Reefton has a working Challenge feeder, as does the Hauraki Prospectors Association battery at Thames. There is a substantially complete Challenge feeder at the Big River mine near Reefton, and remnants of feeders (of unknown type) at the Mount Greenland mine near Ross and at the Brittania mine north east of Westport.

**flotation**: method of mineral separation in which a froth created in water by various reagents floats some finely crushed minerals which were skimmed off, while others sank and were drained off. Flotation, virtually the last word in fine gold saving technology, was undertaken in flotation cells. It was first used on a large scale to treat silver-lead ores at Broken Hill in 1896, and subsequently has become almost universal in base metal plants. It was also extensively used in Western Australia to treat difficult telluride gold ores. Flotation has not been used extensively in New Zealand. A notable example of its use here was in the later plant at the Blackwater mine, Waiuta, West Coast.

**flue**: (1) an enclosed channel for conveying heat (hot air and noxious gases) from a smelter or furnace; a long brick or steel structure (often built against a slope) to produce an up-draught to increase the efficiency of a smelting furnace or oven, or to improve mine ventilation. A flue leads to a chimney (almost always vertical, and also known as a stack or smokestack). Square sectioned freestanding chimneys known as Welsh stacks were used on smelters, and round stacks (known as Cornish chimneys or stacks) were used on boilers (almost without exception for no known reason except tradition); (2) a wooden chute to convey mine water.

**fluxes**:
- chemicals or other substances, e.g. ironstone (ferrous silicate) added to a charge of ore and fuel in a furnace or *converter* to lower the melting temperature and modify the chemical processes occurring.
- chemicals or substances added to an *assay* sample during refining to effect a more rapid fusion than would be possible by heating the mineral alone. Limestone, sodium carbonate, borax, and microcosmic salt were the most commonly used assaying fluxes.

**grizzlies/grizzly-bins**: bins located above crushers in a *stamper battery*. Trucks of quartz were tipped into the bins which had bars (grizzlies) about 2 inches apart at the top; the finer material went through, the coarse material was conveyed to the crushers. Large chunks of rock on the grizzlies were often broken manually with a *knapping hammer*.

**gyratory crusher**: for initial or primary crushing of ore the choice was limited to either *jaw* or gyratory crushing machines, although the latter were often used for secondary crushing after the ore was initially broken down in jaw crushers. Gyratory crushers consist of a circular shell with the inner sides inclined towards a central orifice. A vertical shaft, supported by a spider, passes through the lower opening. The shaft, eccentrically moved at the bottom and equipped with a conical crushing head, crushed the ore between the inclined sides of the shell and the crushing head. The crushing action was continuous and rapid and less prone to clogging up than jaw crushers. Gyratory crushers also produced a product of a more constant size. See *Blake crusher.*

**Huntington Mill**: a roller mill designed for crushing quartz ore by means of vertically mounted rollers in combination with centrifuging. Huntington mills consist of circular cast-iron basins 3 feet 6 inches deep. Inside the basins (two sizes, 3 feet 6 inches and 5 feet in diameter) horizontal rollers were suspended slightly off vertical so that their weight kept them pressed against the rim of the revolving pan. According to Gordon, several Huntington mills were imported from the USA and used in New Zealand but there appear to be few surviving examples.[22] Despite being cheaper and easier to erect than stamp batteries, New Zealand millmen preferred the latter. The first documented usage of a Huntington mill in New Zealand was at Nenthorn around 1890. The Nenthorn specimen is now on display at the Golden Point battery near Macraes in Otago. Huntington mills were not popular in Australia either. Apparently they were considered less durable and not reliable enough for use in remote locations.

**Huntington-Herberlein Plant**: patented plant designed to treat difficult lead sulphide ores. Ore was crushed, mixed with crushed limestone and heated in an air blast in a cone-shaped kettle before smelting in a conventional furnace followed by further treatment in a *converter*. The Chillagoe smelters in Queensland employed a Huntington-Herberlein plant but after problems with the charges tending to clinker into unmanageable masses it was replaced with a *Dwight-Lloyd sintering plant*.

**jaw crusher (jaw breaker or stonebreaker)**: a machine for crushing rock or ore. It consists of a massive rectangular frame with a fixed crushing surface at one end. Ore is crushed by the action of a heavy steel powered plate or jaw which is arranged to swing internally so that it crushes anything between it and the fixed surface. Typically, jaw crushers were designed to reduce ore to chunks 2.5 inches in size.

**jiggers**: vibratory machines for concentrating coarse sand, commonly used in the cyanide process. They consist of two water-filled boxes, one with a short-stroke plunger, the other fitted with a sieve or hopper. The latter contained a finely perforated plate and bedding which caught heavy minerals (such as gold and scheelite) and water and sand were pumped through.

**kettles (separators)**: solid metal vessels used to contain *amalgam* and free mercury after they had been drawn off from *settlers*.

**kilns (roasting pits or ovens)**: prior to 1900 ore was often dried in kilns or pits before crushing. Roasting and drying ore was done for two main reasons — to fracture particularly hard ore before crushing, and/or to oxidise sulphides and make the gold more amenable to *amalgamation* and chemical treatment. Ore roasting was practised in many parts of Australia from the 1850s on. There are two traditional roasting oven designs-deep circular pit ovens (resembling lime kilns), and beehive-shaped ovens (similar to beehive coke ovens). The former are generally excavated vertically into a slope. Short tunnels provided access to chutes in the base of each kiln via which the dried ore was removed continuously. Roughly a ton of wood per ton of ore was required, the wood being loaded into the kiln in alternating 5 feet thick layers with the ore. Pit kilns usually had a capacity of 50 to 100 tons of ore. In New Zealand roasting pits or kilns are unique to the Hauraki goldfield because of the presence of complex ores which made gold recovery very difficult prior to the advent of the cyanide process. In New Zealand fine examples of subterranean roasting pits exist at the Woodstock-Talisman, Victoria, and Try Fluke battery sites. Ore drying and dry-crushing became obsolete after the advent of cyanidation. The quartz dust derived from dry crushing had previously resulted in many deaths from silicosis. In Australia good examples of beehive roasting ovens exist at Maldon, Victoria and Hill End, NSW. Later, patent steel ovens were used, e.g. the Edwards furnaces at Kalgoorlie.

**knapping hammer**: A heavy long-handled hammer, the head of which tapers to a striking face measuring approximately 8 centimetres by 3 centimetres for maximum breaking impact. Used for manually breaking lumps of ore, e.g. large lumps caught on *grizzlies* (see definition).

**launders**: wooden channels used to convey *pulp* from one treatment stage to the next in a *cyanide plant*.

**leach**: to dissolve minerals or metals out of ore by use of a suitable solvent, typically cyanide or chlorine solutions, or acid; also used to describe the use of the *cyanide* or similar processes to recover fine gold from *tailings* dumps by percolation.

**leachate**: liquid that has percolated through soil, rock, *tailings* etc. In old mining locations it often contains very high concentrations of sulphides and other compounds.

**Mackay Pan (Improved Mackay Pan)**: several improved *amalgamating* pans (over and above *Berdan pans*) were devised. The Mackay Pan is notable because it is of New Zealand manufacture (Fraser & Sons, Auckland). It employed a series of cylindrical discs of varying diameters which ground material between them and against the side of the pan.

**matte (*regulus*)**: an intermediate product of the copper smelting process. Matte is produced in a blast furnace, and consists of copper metal, copper sulphides and iron silicates. Matte normally contains 40 per cent to 55 per cent copper and is further refined in a converter.

**milling**: term used to describe the crushing of ore (hence '*stamp mills*').

**muffle-furnace**: a small furnace used for *cupellation* of the lead buttons recovered from the melting of an *assay* sample in a crucible furnace.

**Muntz metal**: a metal alloy consisting of 60 per cent copper and 40 per cent zinc, named after its inventor. The metal was first used on *amalgamating tables* by Thames millmen in 1875 in lieu of pure copper plates, when these were in short supply. It proved a durable and effective alternative especially when poor ore was being crushed.[23] At the time Muntz was readily available from local ironmongers who imported it for

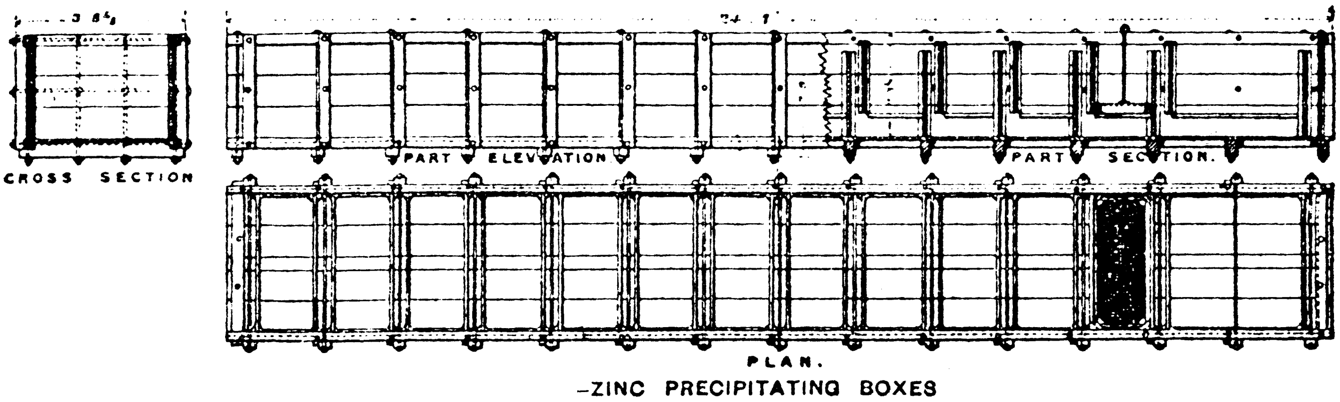


*Fig. 13: Plan and elevation of zinc precipitating boxes (source unknown).*

sheathing vessels' hulls. Muntz metal was favoured in preference to copper by many of the northern mills, e.g. the Victoria at Waikino because the *amalgam* did not adhere so firmly and therefore was more readily descaled (removed) from Muntz plates.

**ore feeders**: see *feeders*.

**Pachuca tank**: Australian term for *B & M tank*.

**pan amalgamation**: this method was developed for treating complex metallic ores, especially those with high silver content (such as those found in the Ohinemuri goldfield). It involved heating *pulp* in large metal tubs (pans) with steam to promote *amalgamation*. There were two main variants of the method: the Washoe process, and the Reese River process. They differed in that the latter involved roasting the crushed ore in a furnace first. After treatment in the pans, the ore was discharged into *settler*s.

**percolation**: a process whereby *pulp* and *cyanide* solution were mixed together in a vat for a specific period without agitation (just allowed to percolate).

**pig iron**: crude iron from a smelting furnace was cast originally in depressions in a bed of sand to produce handleable blocks known as pigs. Pig iron is now made by machines, the size of the pig being determined by the convenience of handling.

**precipitation boxes (*zinc boxes*)**: wooden multi-compartmented boxes which contained zinc shavings onto which the bullion content in cyanide treated *pulp* precipitated as a black sludge (Fig. 13). See *zinc slimes*.

**pulp**: is produced by *stamper batteries* and other ore crushing machines. It consists of finely crushed ore mixed with water, and contains two fractions: coarser sands and *slimes* which are routinely separated for further treatment. See also *spitzkasten*.

**pyritic smelting**: technique of smelting copper ores by utilising the sulphur content of the ore as the fuel, with very little or no additional fuel in the furnace. Requires a powerful air blast for rapid oxidation of the sulphur. Pyrite is an old term for sulphide.

**reduction**: the process of breaking down ore to recover its metal content.

**refining**: the process of extracting impurities (including metals) from gold or other molten metals. The first known refining process was that of cementation whereby plates of gold were stacked in earthen pots surrounded by powdered stone or ceramic dust. The pots were then heated until they glowed red. This was hot enough to enable many of the impurities to seep into the pot walls or the dust but not hot enough to melt the gold. In the sixteenth century inquartation was developed to remove the main impurity in gold, ie silver. The process involved melting gold with at least three times its weight of silver, then granulating the mixture by pouring it into water. The granules were then boiled in nitric acid which dissolved all the silver, leaving the gold.

These two refining methods led to the advent of the chlorine process which was developed in Australia in 1869. The process involved melting gold bullion in clay pots and bubbling chlorine gas through it which reacted with the silver to form chloride which was skimmed off. The silver was then recovered by electrolysis in another vessel. In 1902 the process of electrolysis for purifying gold was perfected and has been widely used ever since. Although the process may take three to four days the end result is gold of 99 per cent or better purity. The process involves immersing plates of gold in a solution of hydrochloric acid in a porcelain cell. The plates are attached with gold or silver hooks on to a series of metal rods which act as an anode. In each cell thick plates of impure gold are alternated with thin plates of pure gold. The latter act as a cathode. The solution is then heated to 60 degrees Celsius and continuously stirred. When an electric current is applied, gold dissolves off the anode plates and precipitates on the cathodes. The silver content becomes insoluble chloride and falls to the bottom of the cell. Other impurities such as platinum dissolve into the solution and can be recovered by other processes.

Refining is the last stage of copper production, raising the purity of the metal typically to 99.6 per cent copper. Copper refining could be done very precisely by controlled smelting but was more usually done by electrolysis. Typically *blister copper* anodes were suspended in a solution of copper sulphate through which an electric current was passed, causing pure copper to be deposited on the cathode.

**refinery**: because of the nature of *refining* and the value of the products, it is often undertaken in structures (refineries) in nearby towns or some distance from the actual mine sites. Typically refineries are secure well-ventilated buildings. Although the interior has been gutted, the Grand Junction mine refinery building at Waihi is a good surviving example of this type of structure.

**refractory**: often used to describe complex ores that are difficult or costly to treat for the recovery of gold and silver. The Karangahake ores were often described as refractory, as were the ores from the Mount Lyell mine in Tasmania.

**regulus (*matte*)**: sulphide rich *matte* usually cast in ingot form after the roasting of copper ores.

**retort**: a heavy cast iron pot in which *amalgam* is heated in a furnace (often in a specialised retort room) to separate the gold and mercury fractions. The evaporated mercury condenses in a cooling tube (which extends from the lid of the retort) enabling it to be recovered and reused. The gold (retorted gold) remains in the body of the retort. After being allowed to cool, the gold was scraped out carefully and weighed, then taken to a bank where it was cast into ingots, *assayed* and paid for according to its value (based on its purity).

**revolving ore-dryer**: see *rotary kiln*.

**roasting (*calcining*)**: the process of roasting, burning or calcining any ore to break it down and burn off or remove problematical or unwanted impurities such as sulphides. As a pre-treatment prior to the smelting of base metal ores, heating the ore and holding it at a high temperature for a time oxidised sulphides and simplified the chemistry of the smelting process. The roasting of hard auriferous quartz made it more brittle and therefore easier to crush. It also burnt out the sulphides, such as pyrites and bismuth, which hindered *amalgamation* and separation of the gold content, and helped to congeal minute gold fragments which otherwise tended to float on the water surface during crushing and amalgamation. Roasting quartz involved heating it to a temperature which was insufficient to smelt the ore. Typically the deep circular kilns used for roasting were loaded thus: a layer of wood was placed on the bottom of the kiln and upright pieces were placed around the sides; then the kiln was built up with alternate layers of quartz and wood; the top was heaped and covered with earth or crushed rock, the object being to obtain a slow combustion of the wood and so avoid intense heat. If properly calcined, quartz is friable, free from slag, and of a white colour streaked with red.

**roasting furnace**: used in some plants to pre-treat sands prior to cyanide treatment.

**roasting (or drying) ovens**: these perform essentially the same function as a roasting kiln or pit but are much smaller and fabricated of steel.

**roasting pit**: see *kiln*.

**rod mill:** see *tube mill*.

**roller crusher**: a machine for breaking down rock or ore by crushing it between one or more steel cylinders. The material to be crushed was fed in at the top and after treatment discharged below. Typically the rollers were mounted horizontally, but the Huntingdon centrifugal roller quartz mill (crusher) (see *Huntingdon mill*) contained three vertically mounted rollers. Roller crushers were used in the Australian copper industry from the 1840s — then usually known as rolls, now Cornish rolls.[24]

**rotary kiln**: a revolving ore dryer, typically consisting of a long steel cylinder (similar in form to that of a *tube mill*). Pulverised ore is fed into one end and gradually moved through the cylinder by its rotation. Heat is directed from a firebox at the lower end through the drying cylinder, in so doing roasting the ore, causing it to break down and burn off sulphides etc. The most notable surviving example in New Zealand is on the Luck at Last mine site near Whangamata, Coromandel. Although the revolving ore dryers have long been removed from the site, the brick fireboxes and flue structures still exist and the general layout of the facility is still apparent.

**self-feeders**: see *feeders*.

**settlers (separators)**: large steel tubs with rotating stirring arms used to separate amalgam from *pulp*; the heavier *amalgam* and free mercury settled to the bottom of the tub where it was drawn off into *kettles*. The amalgam was then retorted (in a *retort* furnace) which vapourised the mercury which was then condensed for re-use. What remained was silver/gold bullion which was refined in a furnace and cast into ingots.

**slag**: glassy or crystalline byproduct (predominantly iron silicates) from the smelting of metallic ores. Typically slag, while still liquid, was discharged outside a smelter where it solidified into hard black masses. At the Kawau Island copper smelter it was cast into blocks and used as a building material. This was also done at the copper smelter in Kapunda, South Australia.

**slimes**: the pulp produced by crushing consists of a coarser fraction known as *sands* and a finer fraction known as *slimes* — while both contain minute particles of precious metals, that in the slimes was largely unrecoverable prior to the advent of *cyaniding*.

**smelter**: a purpose built structure with appropriate furnaces, kilns, or ovens, ventilation, sumps etc. for smelting ores.

**smelting**: the process of extracting a metal from its ores by heating in a reducing environment; the chemical reduction of a metal oxide with carbon monoxide in a furnace. Prior to the advent of the *cyanide process*, mining companies often resorted to smelting *refractory* auriferous ores, which is not normally practical for gold recovery because the high temperatures required for smelting necessitate considerable fuel costs. Smelting is the standard method for treating copper ores. The process involves isolating the metal from the chemical compounds in which it occurs naturally, and heating it to melting point. The higher density of the liquid metal then causes it to separate from the lighter ore. Smelting is usually done in several stages because the chemical reactions occurring during the process need to be carefully controlled.

**smelting furnace**: (technically melting rather than smelting) a small round furnace approximately 1.2 metres high in which the final melting of gold was undertaken prior to pouring it into moulds to produce bullion bars.

**spitzkasten (initial classifier):** a device which was often used before a concentrator. Spitzkastens were shaped like an inverted pyramid and used a downward current to separate the coarse sand fraction from the finer *slimes*.

**stamper battery (stamp mills)**: a mill for crushing ore by means of a sequence of stamping motions achieved by the alternate lifting and dropping of heavy stamps by means of a powered camshaft (Fig. 14, see *stamps*). In New Zealand the term *battery* is commonly used to describe the structure which housed stamper batteries (Fig. 15). In the USA they are usually described as [Californian] *stamp mills*.

The basic design, made of wood, was in use in Roman times. Water-powered wooden stamps are called Cornish stamps in Australia. They were used in the copper mines at Burra and Kapunda from c.1851 until at least the 1870s. The all-metal *California stamp* evolved very rapidly in California from the Cornish stamp in the period 1850–1852, although the

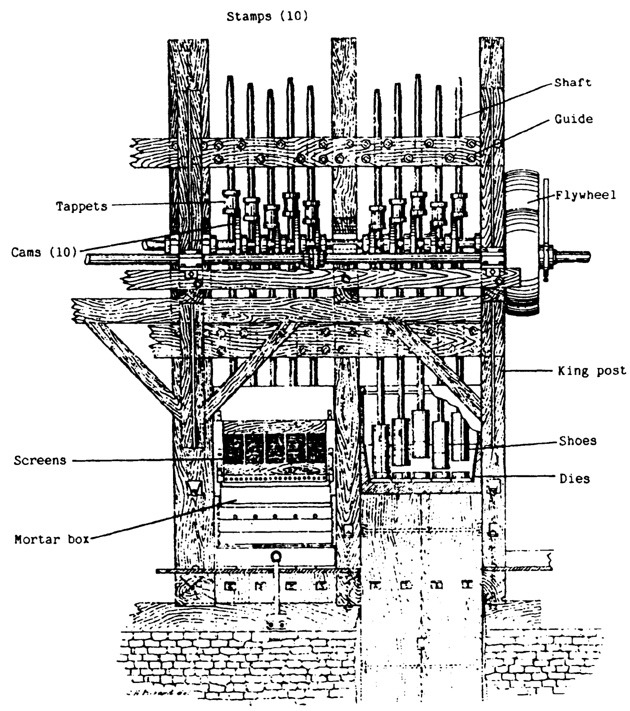


*Fig. 14: A ten head stamp battery showing the main structural features (Gordon 1894 opposite p. 312).*

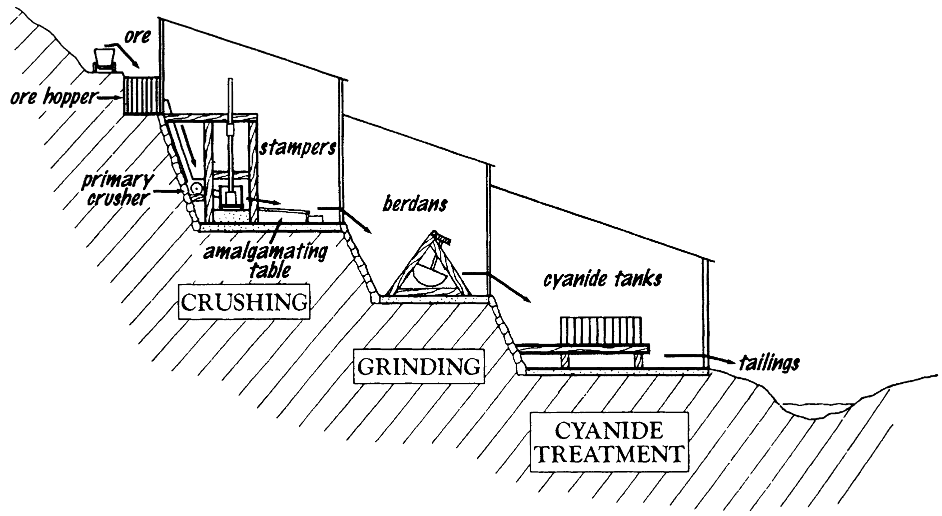


*Fig. 15: Features of a typical (Coromandel, New Zealand) stamper battery showing the three main proccesses: primary crushing, fine grinding, and cyanide treatment (Moore and Ritchie 1996:34).*

first reliable evidence of their use on the Australian goldfields is 1856. The basic design was established by 1860 and they have changed very little since. Descriptions of commonly found stamper-battery components are listed below.

If water was readily available it was generally used as the motive power source. Coal and wood fired boilers were used where fuel was plentiful or in locations where there was limited water. Some of the larger batteries were driven by electric motors and dynamos, e.g. those of the Phoenix Quartz Mining Company at Bullendale, Otago, and the Waihi Gold Mining Company's Victoria battery at Waikino. Stamp batteries were by far the most popular means of crushing ore and cemented alluvial deposits in New Zealand, even though supposedly superior methods had been devised. The American mining authority, H. A. Rickard, considered that Thames (and possibly other) New Zealand millmen used them to crush ores which were not suited for battery crushing.[25] Stamper batteries (mills) were popular because they were relatively cheap, simple, and durable, easy to transport and repair, and readily available. It soon reached a stage where it was hardly necessary to order one from a foundry; there were so many up for sale or lying abandoned on mining sites.

- **cams**: curved arms fixed to a powered shaft (the camshaft) which sequentially raise the stamps in a battery to facilitate ore-crushing. Once raised each stamp free-falls onto the ore contained in the *mortar box* (see definition below).
- **dies**: replaceable hammering surfaces in the mortar boxes in a battery (stamp mill). Those on the Hauraki goldfield were locally manufactured of cast iron, weighed 80 to 116 pounds each, varied in thickness from 3 to 5 inches, and when worn out and replaced weighed 35 to 45 pounds. For every ton of ore crushed the weight of the dies was reduced by 5.5 to 8.5 ounces.[26]
- **guides**: iron or hardwood cross-members mounted between the *kingposts* in a battery. They enable the stamper shafts to move up and down but rigidly control their horizontal movement.
- **kingposts**: vertical wood or pre-cast steel posts which support the stampers in a battery.
- **mortar boxes**: the large cast iron boxes fitted with heavy cast iron dies in which five head (usually) of stamps dropped onto ore or *cement* (see alluvial section) reducing it to a *pulp* which then passed through mesh screens (commonly at the rate of about 7 tons in 24 hours). The crushed material was then usually subjected to further reduction processes including: *amalgamation*, screening, classifying, or further ground (in *Berdans* or other machines). In some batteries mercury was placed in the base of the mortar boxes to amalgamate with freed gold.
- **shoes**: the replaceable hammer heads attached to the base of each stamp shaft in a battery. Each shoe has a protusion which fitted a socket in the end of the shaft. In New Zealand shoes usually weighed 168 to 215 pounds each and varied in depth from 9 to 10 inches. Their weight was reduced by 6 to 16 ounces per ton of ore crushed.
- **stamps (or stampers)**: each battery (stamp mill) was composed of various numbers of stamps usually in groups of five per *mortar box*. Each stamp consists of a shaft with a stamping shoe attached to its lower end, and a *tappet* positioned at about the midpoint. Large battery complexes such as the Victoria battery at Waikino had stamps which weighed 1 250 pounds each. The stamps, driven by a camshaft so they lifted and fell in a particular sequence, (1-4-2-5-3 was preferred in New Zealand), pulverised the ore after it had been reduced initially to 2.5 inch size by crushers. The stamping surfaces (shoes and dies) had to be replaced regularly.
- **tappets**: thimble-shaped components attached to the shafts (*shanks*) of stampers. The tappets were designed to engage the cams on the camshaft which in turn lifted each stamper in sequence.

**stamp sands**: essentially *tailings*, the result of crushing ore in a battery/stamp mill. The fine waste sand fraction of the original ore after its metal content has been removed. Frequently discharged into waterways in the past, or flushed downslope from a battery often creating a distinctive site feature and indicator of the former existence of a battery upslope. This is the material which was reprocessed in *dredging plants*.

**sulphide ore**: usually used to describe lead or copper ores in which the metal is chemically combined with sulphur. These ores were usually difficult to treat and were *roasted* to oxidise the sulphur before smelting.

**sump**: a sink or pit below a smelting furnace designed to retain molten metal. Also see mining definition in hard rock section.

**tailings**: from hard rock mining are the portions of washed, crushed ore (usually in a finely ground state after processing) which are considered too impoverished to treat further, and are discarded (commonly into rivers last century). See *stamp sands*.

**tanks (*leaching vats*)**: an integral component of cyanidation technology. Those used with Cassel cyanidation plant usually had an internal diameter of 20 feet and were initially constructed on the northern goldfields of 3-inch thick heart kauri. Later riveted steel tanks became commonplace. The larger sand vats were square concrete or steel structures.

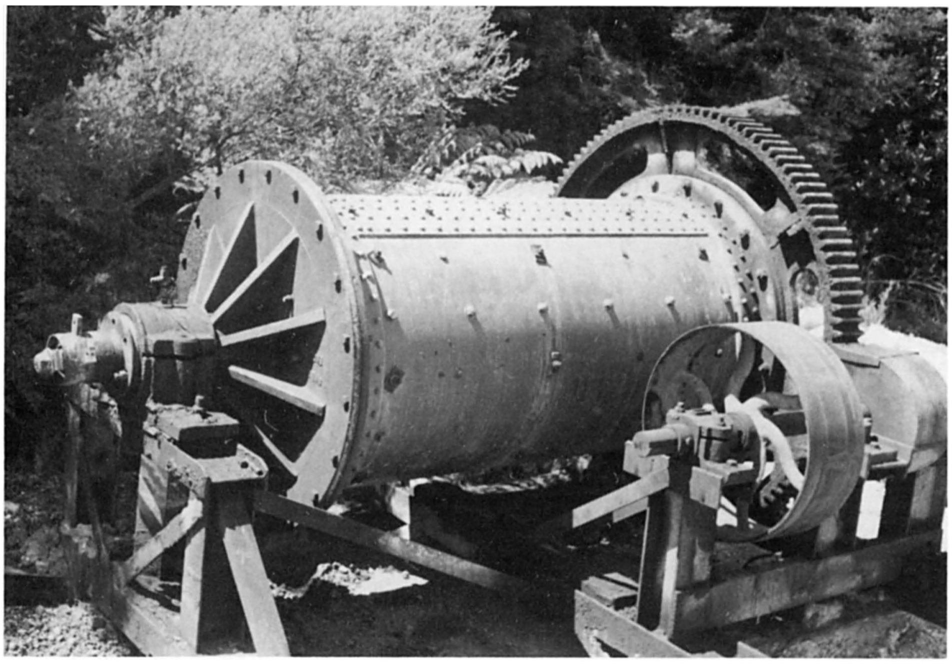

*Fig. 16: A tube mill, one of a range of machines used for grinding ore prior to cyanide treatment (Victoria battery site, Waikino, North Island, New Zealand: N. Ritchie).*

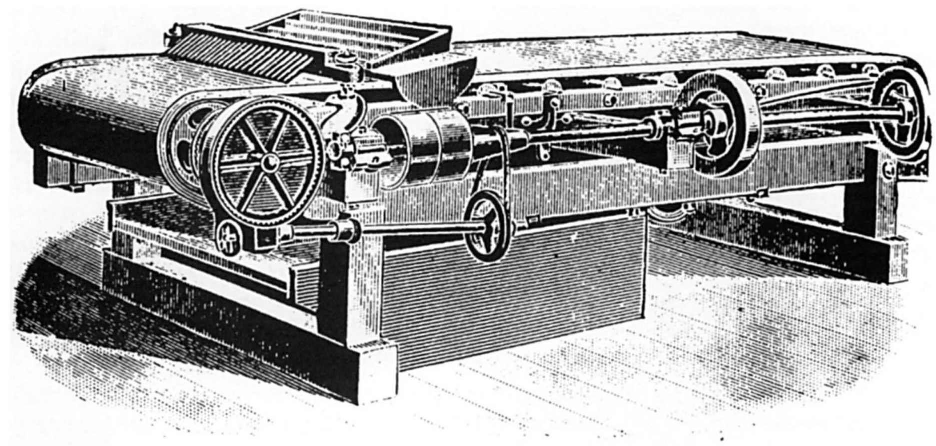

*Fig. 17: A frue vanner (Young 1978:140).*

**tap hole**: a hole near the base of a furnace for the controlled draining of *slag*.

**tapping**: the process of removing liquid *slag* from a furnace.

**tube mills**: mechanically powered rotating cylinders into which middle *pulp* was discharged through a hollow shaft (Fig. 16). Each tube mill was partly filled with imported flints (siliceous concretions) which crushed reduced ore to less than 200 mesh size. If flints were not available steel balls or scrap iron was used. Discarded vestigial flints or rounded pieces of steel are a diagnostic feature around former tube mill sites. Tube mills are similar in principle to ball mills, but differ in that their length is much greater than their diameter; hence they generally have greater capacity and were favoured in the larger mills such as the Victoria battery at Waikino. The tube mills installed in the Victoria were 18 feet long and 4 feet 9 inches in diameter. They were considered a significant technological innovation, proving to be by far the most economical and efficient means of milling the Waihi ores. *Rod mills* are similar to tube mills but differ in that the crushing was achieved by the action of a mass of steel rods (3 or 4 inches shorter than the length of the mill) rather than flints or steel balls.

**tuyere**: ports for injecting air into smelting furnaces, retorts or boilers.

**vanners**: ore dressing (concentrating/separating) machines incorporating a wide inclined fabric or rubber belt stretched between two rollers (Fig. 17). Crushed ore fed onto the belt was carried up the incline, against a current of flowing water which washed away the light waste. The heavy fraction was carried over the end of each belt and collected. Widely used initially, they bowed out to *Wilfley tables* because of the latter's higher efficiency and ability to separate various grades of material for further treatments. Archaeological evidence of vanners is usually in the form of the cast steel ends of the rollers scattered about within battery sites. Frue and Triumph vanners were the most popular models used in New Zealand. To the authors' knowledge, no intact examples of these machines have survived in New Zealand.

**vats**: large wooden or concrete tanks (usually open-topped) in which *cyanide* or other *percolation* treatments were carried out.

**waterjacket blast furnaces**: the standard furnace employed by the base metal industry at the turn of the century was a tall steel structure, rectangular in section, in which ore, fuel and fluxes were charged in alternate layers. Oxygen for the reactions was provided by blasts of compressed air produced by mechanical blowers. Waterjacket blast furnaces incorporated an ingenious innovation, viz. an steel jacket through which water circulated, similar in principle to the operation of a car radiator, to keep the walls of the furnace at about 100 degrees Celsius much lower than the 1000-plus degrees Celsius reached in the interior during smelting.

Consequently waterjacket furnaces lasted much longer than the older brick-lined furnaces which had to be rebuilt regularly as the bricks were actually consumed in the smelting process. After a few hours of firing, molten *slag* and *matte* were tapped at the bottom of a furnace. A furnace with a 50-ton capacity would require 10 to 15 tons of fuel and fluxes. The output would be about 10 tons of matte and 30 tons of slag, the rest of the material being lost or discharged as gas or dust.

**Wilfley tables**: shaking tables invented by Rittinger in 1844 and developed by Wilfley for use in separating (or *concentrating*) the heavy fraction of pulverised ore from the lighter fraction. The main component of each machine is a slightly sloping, often linoleum-covered, table. Wilfley tables have a reciprocating action created by a spring-loaded return which causes heavy particles e.g. gold, aided by a steady water flow, to move towards the end of the table each time it is jerked back by the spring. The material was discharged into a tub or channels (*launders*) via which it was conveyed to the next part of the plant for further treatment such as *cyanidisation*. Wilfley tables were a major advance over *vanners* because they enabled various grades of material to be separated.

**zinc slimes**: a black precipitate containing gold particles formed on zinc shavings in *precipitation boxes* (zinc boxes), an integral part of the *cyanide process*. Slimes were washed in acid (to dissolve the zinc), then dried and *smelted* with *fluxes* to recover the gold. Zinc slimes usually consisted of 56 per cent bullion.

## TERMS LARGELY ASSOCIATED WITH COAL MINING

**back balance**: massive counterweight, commonly a block of concrete, used to maintain tension on a cableway, whether suspended or in the form of an endless rope running over pulleys on a haulage. When a cableway is demolished or relocated, the back balance is often left at the original site. Back balances are an integral part of cable haulage systems used for hauling coal or ore.

**banjo shovel**: large round-mouthed shovel used for loading coal broken from a face. The Brady was the favoured brand in New Zealand mines.

**barrier**: a block of coal left unworked in a mine as protection against flooding, fire, gas, or other danger; or to maintain separate 'ventilating districts' within a mine; or to form a boundary between adjacent mines.

**bars**: see *caps*.

**bath-house**: buildings housing showers and ablution facilities for miners to change, and clean up after coming off their shift. Work clothes were kept in the bath-house through the week; each miner's gear being suspended from the roof to dry. Surviving examples on the Huntly coalfields have a distinctive appearance. They consist of a central room (with a ridgeline ventilator) for changing and clothes storage, with shower facilities in lean-to's on either side. The bath-house at Blackball on the West Coast has a New Zealand Historic Places Trust B classification.

**beehive oven**: used in coke production. Beehive-shaped coke ovens were by far the most common form of coke oven during the late nineteenth and early twentieth century. The construction of the ovens involved specialist brickmaking and laying skills and the end result is visually interesting. Typically they were built in rows back-to-back. This permitted the use of a common flue, conserved heat and generally added efficiency and improved the quality of the coke. The Brunner mine complex on the Grey River near Greymouth contains the best surviving examples of beehive coke ovens in New Zealand.

**bench**: a relatively level underground working floor or surface created to enable the mining of a coal seam.

**bord**: an underground mine passageway made through solid coal by the *bord and pillar* mining method, usually 2 to 5 metres wide.

**bord and pillar mining** (***room and pillar***): a method of coal mining whereby a grid system of roads (*bords*) is established leaving pillars of coal. Most of the pillars can be mined later and the roof allowed to collapse (which in turn often causes ground subsidence). The remaining standing coal pillars are called *stumps*. Evidence of earlier bord and pillar mining is often visible in exposed sections in open-cast mines.

**bins**: large wooden or steel coal storage structures usually designed for loading trucks or railway wagons, and usually incorporating *screens* to grade the coal to desired sizes (see screens). On the West Coast *bins* were used for storing coal for many weeks because the ever-changing river bars often delayed the arrival or departure of colliers (coal ships).

**brattice/brattice cloth**: heavy sacking or fire resistant fabric used in a mine passage to confine the air and force it into working areas (*line canvas* or *line curtain*). Brattice material was usually stored in a brattice shed or store near a mine entrance. Also used to exclude ventilation to specific areas, e.g. to control mine heating or fires.

**breaker props**: large wooden props set in a group at a *goaf* edge. They are used to break off the *goaf fall* at a given point and prevent the fall extending along the *roadway* (*bord*).

**briquette**: small ovoid mini-bricks of compressed fine coal or semi-coke bound with coal-tar, pitch or bitumen. Despite much consideration by coal mining interests, it appears only three briquette plants have ever been established in New Zealand. A briquetting works was established at Westport in 1907 to increase the utilisation of slack coal from the Seddonville Colliery but closed in 1912, largely because the pitch used to bind the briquettes made them prohibitively expensive (Morgan & Bartrum 1915:45). In the late 1950s State Coal Mines installed a German-made briquetting plant at Ngakawau but its use was discontinued because the resultant briquettes produced too much smoke when burnt. A briquette manufacturing and carbonisation plant was established by Waikato Carbonisation Ltd at Rotowaro, Huntly coalfield in 1931 and continued in operation until 1985. The defunct plant and its interesting technology are still standing. The New Zealand Historic Places Trust has recently declared the site an historic conservation area. The plant produced briquettes which sold on the New Zealand domestic market under the trade name Carbonettes (see *carbonisation*).

**caps (*bars*)**: heavy timbers placed horizontally on top of one or two vertical timbers (*props*) to support the roof of a tunnel (see *sets*).

**cars**: essentially modern versions of mine *skips* or trucks. Small rail-wheeled wagons designed for carrying coal, ore or waste material underground, and to the surface. Once man-hauled, they are now usually moved by attachment to ropeways, or pulled by small electric shuttle-cars. In the Waikato coal mines *cars* refer to the vehicles used to haul coal from faces to conveyors which take it to the surface. *Skips* attached to ropeways provide transport to the surface for men and equipment only. Some cars are modified for specific haulage purposes, e.g. carting props and caps, or consist of specilised equipment such as winches and pumps, cement mixers, and other equipment permanently attached to bogies.

**carbonisation**: the distillation of coal to produce coke, gas and liquid by-products such as tar and creosote. In 1931 Waikato Carbonisation Ltd established a carbonising plant (a Lurgi Spulgas retort) and auxiliary *briquette* plant at Rotowaro, Huntly to provide an outlet for large quantities of slack coal (fine coal) which at that time was being dumped for lack of a market. The carbonisation plant, the first in the Southern hemisphere, and subsequently the only one in the country, closed down in 1985, but it is still standing (refer *briquette*).

**cavil**: the allocation of a working place to a miner; done by means of a draw.

**cleat**: parallel cleavage planes or partings across coal beds known as the cleat of the coal, along which the coal breaks more easily than in the other direction.

**clipping shed**: an integral part of an endless road haulage system. A shed or location where skips are manually clipped (with individual steel *rope clips*) onto a moving endless rope so that they can be hauled either into or out of a mine. The men involved in this work were called clippers. Chain clips were later replaced by grippers.

**coal-cutter (mechanised)**: a machine for cutting solid coal for a distance of up to 3 metres in front of it (depending on the stability of the roof). The cutter, attached to a boom which can move horizontally or vertically, may be ball or barrel shaped.

**coke**: the solid residue left after bituminous coal has been carbonised. Foundries were one of the main users of the product.

**coke ovens**: ovens designed to carbonise coal and produce coke. There are two main forms: oblong and *beehive*.

**colliery**: an alternative term for a coal mine and its associated structures and buildings. The term seems to have lost favour these days.

**conveyor**: method for transporting coal by means of a series of endless belts (ie a conveyor belt). Rubber conveyor belts are no longer allowed in New Zealand underground mines because safety regulations require modern conveyor belts to be anti-static and fire resistant.

**conventional mining**: a system which is older than continuous mining and employs the cyclical operations of cutting, drilling, shooting, and loading.

**continuous mining**: mining by means of mechanical coal cutting machines (many different types and sizes) which remove coal from a face with rotating cutter blades and load it into shuttle cars.

**creeper/creeper loops**: usually sited at the end of rope-road haulages, creepers are endless chains with hooks which catch on to the axles of skips and pull them around a loop or to a point where they can be manually clipped on to the main haulage again.

**cross-cut**: (1) opening at an angle to a main working or opening; (2) a roadway driven between two parallel roadways to connect them.

**deputy**: person in charge of one section of an underground mine.

**dip (decline)**: usually refers to the gradient of a coal seam. On the West Coast it is sometimes used to describe the point where the main incline intersects other underground mine roads.[27]

**dog-watch**: midnight to 7 a.m. work-shift.

**dolly car**: control car permanently attached to a drift haulage rope. The term *dolly-car* is also sometimes used in reference to *skips*.

**drift**: an inclined access from the surface to an underground coal seam, or from one seam to another. A drift (tunnel) usually contains a *conveyor belt* for hauling coal, and/or a car-hauling system for conveying men and materials to and from the work faces.

**downthrow**: amount of displacement, measured vertically, between the upper and lower portions of a coal seam displaced by a downthrow or normal fault.

**endless rope (rope road)**: a rope haulage using either gravity or a driven cee-wheel to impart motion to an endless rope. Gravity driven ropes utilise the weight of loaded *skips* going down-grade to haul empty skips up. Where a hauler winch provides the motive power empty skips are hauled 'inbye' (inwards by) the inbound motion of the rope which runs around a sheave (pulley) set below the road. Full skips are hauled 'outbye' (outwards by) the outbound motion of the rope. A tension device keeps the rope tight on the cee-wheel (see *return wheel*).

**fans**: prior to the advent of powered fans, mines installed chimneys or flues (and maintained fires) to create a convection draught which drew air up the chimney and in consequence through the mine, e.g. the Blackball mine. From the 1890s onwards, mine ventilation was improved by installing rotary fans to force air through the workings. There were many types. In New Zealand, the Cappel fan predominated initially. They were later superseded by Sirius or *Sirocco fans* housed in concrete or brick structures (see *fan-house*).

**fan-house**: a structure sited at the return airway portal where ventilation *fans* and drive-motors are housed. In some instances fan-houses were built into the *portal*.

**fault**: a break or dislocation in the continuity of a coal seam or rock strata. There are many kinds of fault.

**feeder (breaker feeder)**: equipment designed to aid and control the flow of coal from one system to another, e.g. from a bin onto a conveyor. Optimum flow is achieved by the mechanical breaking of large lumps of coal into smaller pieces and its controlled discharge from one system to the next.

**firedamp**: explosive gases, especially methane, released from coal once it has been worked. To reduce the risk of explosions underground mines have to be continually ventilated by means of huge extractor fans (see *fans, fan-house*).

**flame safety lamp (FSL)**: an enclosed lamp used for measuring the presence of methane, or blackdamp (a mixture of nitrogen and carbon dioxide). Based on the Davy Safety lamp.

**flotation**: a wet process for the separation of coal from waste rock. Coal particles are floated to the surface by either air bubbles in a liquid medium or by chemical froth flotation. The process is not commonly used in New Zealand. It was employed at the Strongman mine on the West Coast.

**gantry**: a structure which carries a coal conveyor from where it emerges from a mine to the top of nearby bins or screens to facilitate their loading. Gantrys are also used on rope-road haulages to maintain a consistent grade.

**goaf (gob)**: an area abandoned and left to collapse usually by removing most of the remaining pillars of coal (see *stumps*).

**haulage**: portal of a *drift* tunnel. The term is also used to describe a specific endless rope system or its alignment or route.

**hauler**: winches driven by electricity, water or steam which provide the motive power for endless rope cableways or other forms of 'overland' haulage systems. Once established 'main haulers' used in coal and ore mining were usually maintained on the one site until the mine closed. Smaller more portable haulers were used in mines to haul materials from one level to another or to the main hauler(s). In the logging industry, highly portable 'log haulers' are routinely used to drag felled trees to skids (ie loading sites).

**heading**: a roadway driven parallel to the direction of cleavage in a coal seam (often at right angles to *bords*). Described as rise headings or dip headings dependent on the grade.

**hydraulic jacks**: used to support the roof during longwall mining. None are presently in operation in New Zealand (see *longwall mining*).

**hydraulic stowage**: the filling of worked out sections of a coal seam by pumping in a slurry of water and sand or rock. The water drains away leaving the residue which tends to consolidate, thus supporting the overlying rock and preventing collapse of the superincumbent strata.

**hydro-mining**: the New Zealand definition of hydro-mining differs from that overseas. In New Zealand it refers to the use of water channels to carry coal from a face to an underground sump from where it is conveyed to the surface. It is the sole means of mining at the Bennydale mine in the south Waikato, where the coal seams are blown then sluiced. Overseas, it refers to the use of high pressure water delivered by a monitor to cut or sluice coal from a face.

**incline (self acting)**: see *jig*.

**jig**: a self-acting incline/endless rope-road, by which full *skips* descending the slope pull up empty ones. Power is only used for braking purposes. Also a device used for removing stone from coal.

**lay-by**: area off the main rope-road where full or empty skips are stationed before being clipped to the rope.

**lamp-room (cap-room)**: a room or building in which miners' cap-lamps are stored and recharged. Typically personal self-rescue apparatus is stored in the same structure.

**laths**: heavy wooden boards placed along the roof and walls between wooden or steel sets to prevent cave-ins. Boards are used because they flex and give early warning of potential problems, such as rock heave or collapse.

**longwall mining**: a relatively modern system of working coal in which *a panel of coal* is extracted on a broad front or long face. The roof is supported by hydraulic jacks (shields) which are moved forward as the face advances.

**mule**: a small locomotive (usually battery or electric powered) for hauling coal tubs.

**open-pit (open-cast, open-cut)**: an open excavation created when coal seams are worked from the surface. Open-pit is most commonly used in New Zealand, open-cast on the West Coast; and open-cut in Australia.

**pig-sty (chocks)**: a method of supporting the roof of a coal seam by stacking props or similar large timbers in horizontal tiers (each alternating direction) so that the weight of the roof is supported on the pig-sty. Pig-stys are used at locations such as intersections and wide openings in underground mines to support the roof (if considered necessary) in the absence of coal pillars.

**pit bottom**: the seam level in a mine shaft or the bottom central junction.

**pithead**: the area surrounding the top of a coalmine shaft or access haulage. The term also encompasses the associated machinery and buildings such as haulers, screens, workshops, battery charging rooms etc.

**props**: solid wooden posts used in underground mines (coal and ore) in conjunction with laths to prop up the walls and sides of tunnels. The props are cut to length as required. Props are usually set under a cap or head board.

**rat hole**: (slang) small mine where coal was worked without regard to any designed layout.

**reserves**: that part of a coal resource which can be economically mined.

**return (air, airway)**: air or ventilation that has passed through underground workings and may contain gas or dust.

**returns**: roadways used for the movement of return air from the face back to the main fan.

**return wheel (carriage)**: the large horizontally mounted pulleys at each end of an endless rope cableway. Return wheels are mounted on a carriage which moves to maintain a constant tension on the cable. The tension is maintained by a *back balance*, a large suspended counterweight located behind the return wheel carriage.

**rib**: name given to the coal walls of a roadway; the sides of coal pillars.

**ripper**: a machine for extracting coal (and soft ores) by tearing the material from a face.

**rising main**: pipes in shaft or drift for conveyance of drainage water to the surface.

**rob**: to extract more coal from pillars previously left for support.

**rolling seam**: a coal seam which has been warped by ground pressures to produce a series of anticlines and synclines giving it a wave-like appearance in section.

**room and pillar**: a system of coal mining essentially the same as *bord and pillar*. A seam of coal is divided into a series of rooms prior to mining and the intervening pillars are left to support the ground above.

**rope-clip**: initially a short length of chain wrapped around the rope and attached to a skip. They developed into portable steel devices to attach (clip) skips to a rope-road. Typically the clips were secured by striking a locking plate with a hammer. This action locked the jaws of the clip onto the rope. Each clip had a steel ring which was used to attach each skip to the cable. In some instances skips were secured by screw-threaded rope-clips.

**rope-road**: see *endless rope*.

**rotary drill**: a drill which operates by rotation rather than percussion.

**seal**: a permanent or semi-permanent closure of a roadway (see *stopping*).

**section**: coal mines are divided into a number of sections or working areas.

**sets**: a complete unit of roof support consisting of *props, caps* and *laths*.

**screens**: usually incorporated in (storage) bins. Substantial wooden or steel structures designed to separate coal into various size ranges for different industrial and domestic uses by passing it over a range of meshes on rotary screens or shakers. Before screening the coal is passed over *grizzly bars* which take out over-sized run-of-mine coal. Coal grades include *slack*, domestic, nuts, peas, fines, and slimes. Slack coal by definition has an upper size limit and is generally used in coal-fired boilers.

**seam**: a layer or bed of coal.

**shaker:** a vibratory screen for separating coal into various grades.

**shearer**: a machine used in longwall mining that uses a rotating action to *shear* the material from a coal face as it traverses along it.

**Sirocco fan**: with the introduction of electricity into mines in the 1890s, high speed motors were soon used to drive small fans for ventilation. During 1898, an Englishman, Samuel Davidson, patented the Sirocco fan which featured a series of small curved blades around the circumference. When tested, the fan had a capacity far ahead of any other fan. The first example went into use at the Pelton Colliery, Durham in 1902. Once collieries realised that Sirocco fans were much more efficient than all preceding fan-types and cost less to construct and run, they gained rapid industry acceptance and were widely used.

**slack coal**: prior to about World War Two *slack coal* was used to describe fine coal for which there was little market. Now it is generally used to describe coal with a specific upper size limit and is widely used in self-feeding coal-fired boilers (see *screens*).

**shaft-mine**: a coal mine which is accessed by shafts rather than inclines.

**skip (truck, *car, dolly-car*)**: a tub-like wheeled container made of wood or steel for conveying coal (or ore). Their capacity varies from about 0.5 tons (when used in narrow seams) to 10 tons in fully mechanised mines (see *cars*).

**slope-mine**: a coal mine which is cut at a 10 to 17 degree angle into a mountainside.

**slurry**: the conveyance of coal, ore, or other solid materials by water either via a pipeline or fluming. One of the most remarkable historic hydraulic systems in New Zealand was established in the 1930s on the West Coast of the South Island. It involved over 3 kilometres of surface and suspended fluming to convey coal from Hunter's Coal Mine to coal bins established on an offshore island (Seal Island) from where it was shipped. In the 1940s 8.5 kilometres of *fluming* (see definition in alluvial mining section) was used to convey coal from the Cascade Creek mine, Denniston to the railhead.

**sooty-back**: a zone of crushed coal along a fault or joint plane. Often prone to collapse.

**spider**: a spiked candle-holder, also used in underground gold mining. The spike can be impaled in mine timbers.

**splint**: coal of inferior quality often containing dirt bands or concretions. Shale splints are the most common.

**sprag**: a piece of timber placed between a prop and the *rib* to prevent the rib falling; a wooden or steel spike placed in skip wheel spokes to prevent the axle from turning and control the rate of descent down grades.

**steel**: a drill rod.

**stone drive (stone-driving)**: a drive (driving) through solid rock to provide access to a coal seam.

**stone dusting**: the spraying of finely ground limestone or other non-combustible and non-siliceous dust onto coal, to reduce the possibility of coal dust explosions.

**stoppings**: a structure (temporary or permanent) built across an underground mine road to control ventilation, to limit the risk of mine fires through spontaneous combustion, or the spread of poisonous or explosive gases. Stoppings also prevent unauthorised access to old underground workings for safety reasons.

**stowing**: backfilling a *goaf* to prevent subsidence.

**stripping**: process of removing coal, often used to describe bulk removal as in open-cast operations; also used to describe the removal of overburden.

**stumps**: see *bord and pillar* mining.

**subsidence**: the deformation of superincumbent strata or surrounding ground (usually evidenced by dropping or slumping) as a result of the removal of a coal seam (or ore vein).

**sump**: a water reservoir in a coal seam; or the bottom few metres of a shaft ('well') where ground water accumulates and from where it is pumped to the surface.

**swing-shift**: sometimes used to describe the rotation of working shifts for different periods of time, but commonly used to describe the 6 p.m. to midnight shift in coal mines.

**tamping rod**: a wooden rod used for tamping shotholes.

**tippler (tumbler)**: a rotating frame used for automatically discharging coal (or other ores) from *skips* or railway wagons. A tippler is usually mounted over a hopper or a conveyor to enable the coal or ore to be loaded into bunkers or onto another means of transport e.g. rail wagons or road transport.

**tramming (trucking)**: pushing full or empty skips by hand; moving mobile machines under their own power is also described as tramming.

**underviewer**: mine manager's chief assistant, in charge of underground work.

**upcast**: a shaft or other mine opening through which air is vented to the surface, after ventilating mine workings.

**ventilation chimneys**: tall (20 metre plus) chimneys built over air shafts. By means of a furnace in the base of the chimney a draught was created which sucked foul air up from the mine workings below. The need for tall ventilation chimneys was superseded by the advent of huge electric fans (see *fan-house*). The impressive round or square chimneys were usually made of bricks. Two of the best surviving examples in New Zealand, relics of the Blackball mine, are located near Blackball on the West Coast of the South Island. Another fine example, although threatening to collapse, still stands on the Tynside mine site beside the Grey River near Greymouth.

**wedge**: a wedge-shaped piece of timber to tighten props in place; steel wedges are also used for anchoring slot and roof bolts.

**wongawilli**: a system of underground mining devised at the Wongawilli mine, south of Wollongong in the Illawara district, New South Wales, late last century. It differs from the traditional *bord and pillar* method in that areas of coal are mined by working in tunnels excavated in a herringbone pattern. The herringbone tunnels are driven off bords. The method enables a higher extraction rate than traditional *bord & pillar* mining. As the coal is worked out the roof is allowed to fall which usually results in surface subsidence. The method is currently being used at the Huntly East mine at Waikato, New Zealand.

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## NOTES

1 Henderson 1917:114.
2 Connell n.d.
3 Drinkwater 1982:75.
4 Hooker 1983.
5 Hearn and Hargreaves 1985.
6 Bowie 1905:185.
7 Ritchie 1981:64.
8 Bowie 1905:49.
9 Bowie 1905; ICS Reference Library 1908.
10 Ritchie 1981.
11 Ritchie 1981.
12 Ritchie 1981:62.
13 Coroneos 1993.
14 Hooker 1982.
15 see Drew and Connell 1992 and Milner this volume for further details.
16 see Wegner 1995.
17 Eissler 1898.
18 Thornton 1982:73.
19 P. Bell pers. comm. 1991.
20 Park 1913.
21 P. Bell pers. comm. 1991.
22 Gordon 1894:315.
23 Rickard 1898:179.
24 P. Bell pers. comm. 1991.
25 Rickard 1898. See Dreadon (1966:13–15) for a detailed account of battery operation and the processes right through to the stage of banking the gold.
26 Rickard 1898:212.
27 J. Staton pers. comm.

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