# Teacher's Guide:

## Technology

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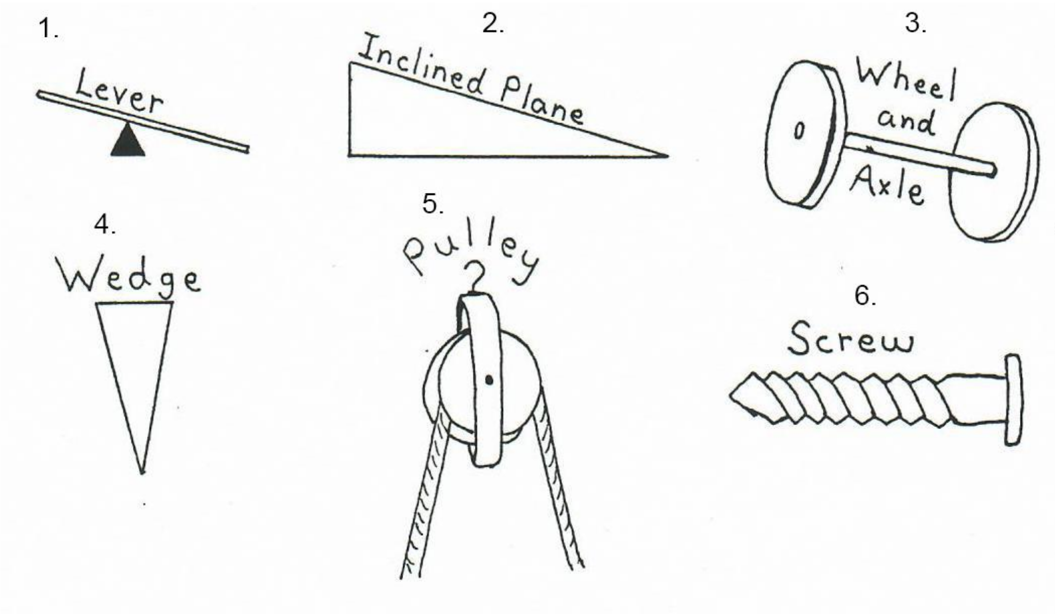
# Technology

## Section I: Mechanical Advantage

Objective: Students will learn about the mechanical advantage provided by both simple and complex machines and can complete a related activity.

# Mechanical Advantage

A machine is a type of tool that makes work, such as lifting or moving things easier. There are six basic types of simple machines: 1. the lever, 2. the inclined plane, 3. wheel and axle, 4. the wedge, 5. the pulley, and 6. the screw.




Simple machines can work alone or can work in combinations. If two or more simple machines work together, it creates a complex machine**,** which combines their individual work properties.

Reed Gold Mine required a great deal of heavy work using several different types of machines. Without the use of both simple and complex machines, work would have been much harder on the miners, and increased amount of time to complete the daily tasks required at the mine.

The effectiveness of a machine can be determined by calculating the mechanical advantage. This can be used to see how much easier a job has become as well as how much help one situation compares to another. The formula for mechanical advantage is:

$$\text{Mechanical Advantage} = \frac{\text{Load}}{\text{Force}}$$

For instance, if a rock weighed 100 pounds and it took 50 pounds of force to lift, the mechanical advantage would be “2” because 100 ÷ 50 = 2. If the same 100-pound load could be lifted with a force of 25 pound, then the mechanical advantage would be “4” because 10 ÷ 25 = 4. The higher a number is for the mechanical advantage, the easier it has become to do the work.

# Wheelbarrow Activity

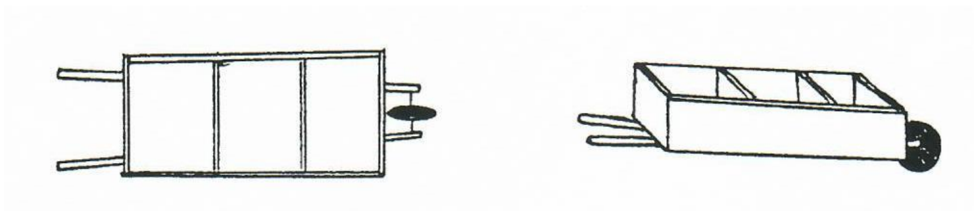
This activity will demonstrate the how placement in a wheelbarrow to see if it affects the mechanical advantage of the machine. A wheelbarrow is a complex machine, made of a wheel and axle and the end of two levers.

Materials:

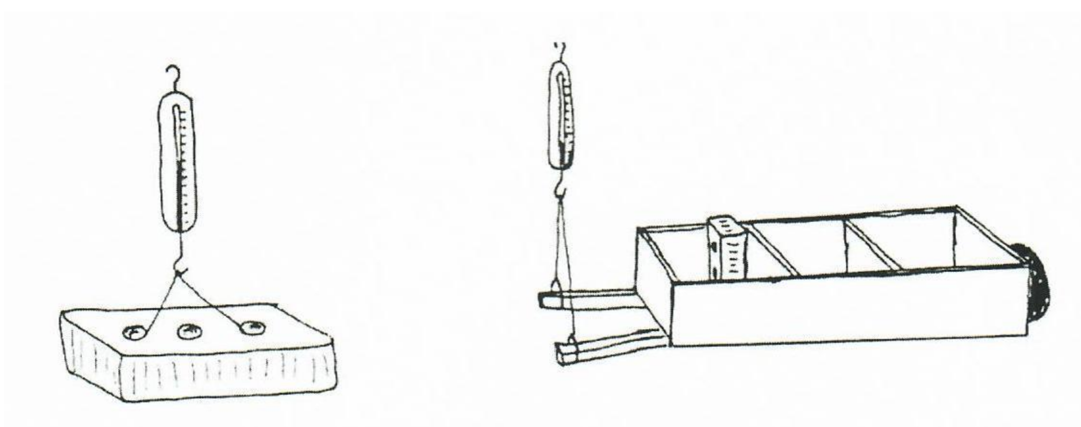
- Calculator
- Spring scale
- Wheelbarrow
- Heavy objects to weigh

Note: The formula to determine mechanical advantage is load ÷ force.

Divide the wheelbarrow into at least three sections. The more sections, the more data can be collected.



Using a spring scale, weigh the load you will be placing into the wheelbarrow. Then place the load into each section and use the same spring scale to measure the force needed to lift the handles.

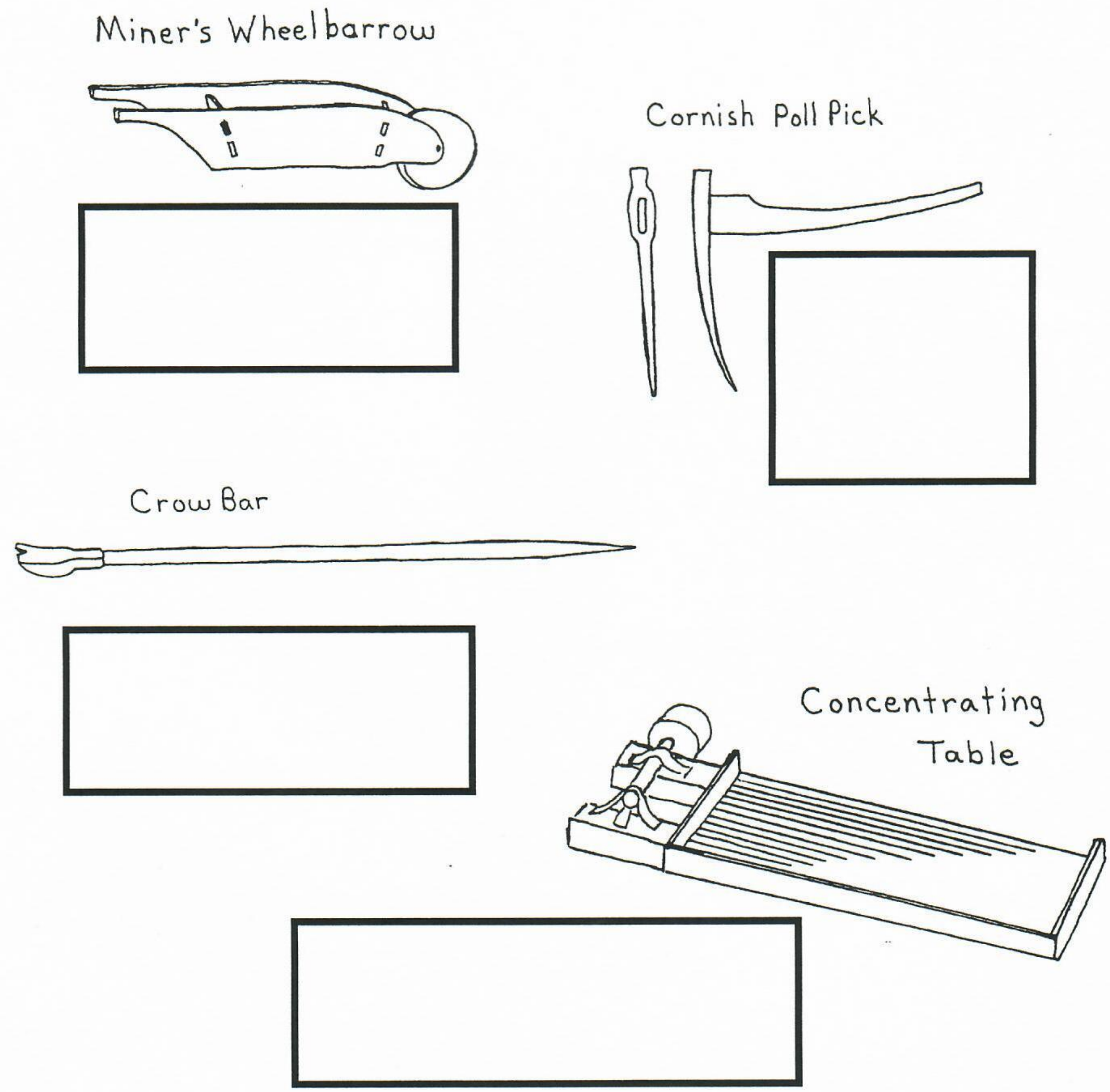


Calculate the mechanical advantage each time and see if it makes a difference where the load is placed in the wheelbarrow. How would a wheelbarrow be designed to give the greatest mechanical advantage?

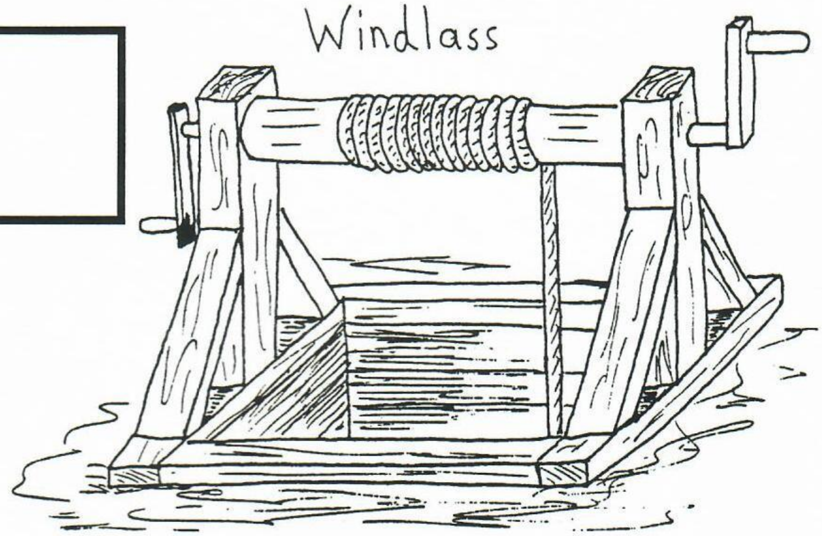
# Miner's Tools

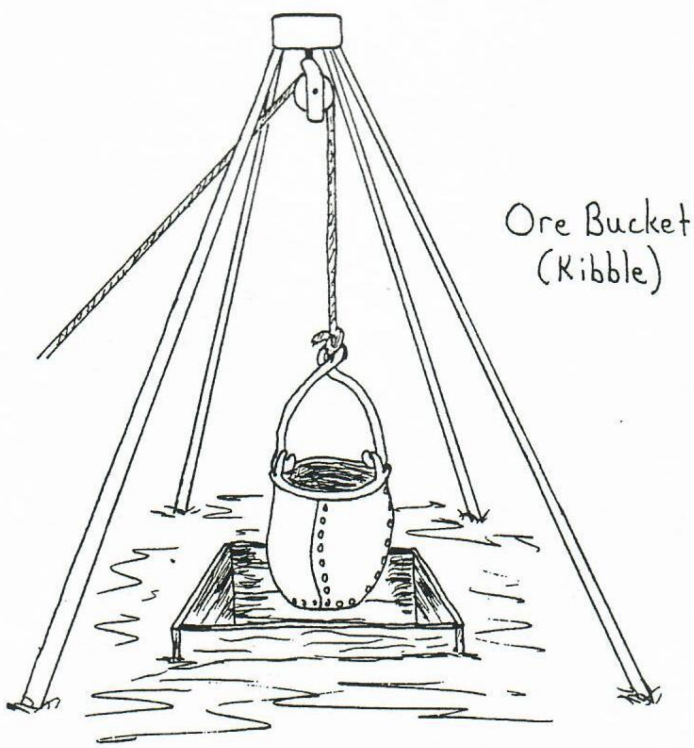
Shown below are sketches of some tools used at Reed Gold Mine during the 1800s and early 1900s. Which simple machine or combinations of simple machines can you find in each one? Write your answers in the box beside each miner's tool.

Screw    Inclined Plane    Wheel and Axle    Pulley    Lever    Wedge



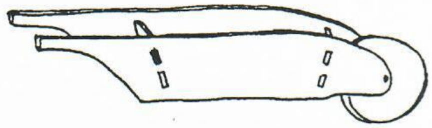
screw inclined plane wheel and axle pulley lever wedge



# Miner’s Tools Answer Key

Miner’s Wheelbarrow



2 Levers
Wheel and Axle
Screws

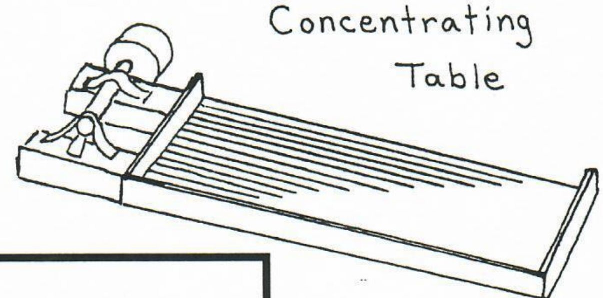
Cornish Poll Pick

Lever
Wedge
Screws

Crow Bar

Lever
Wedge

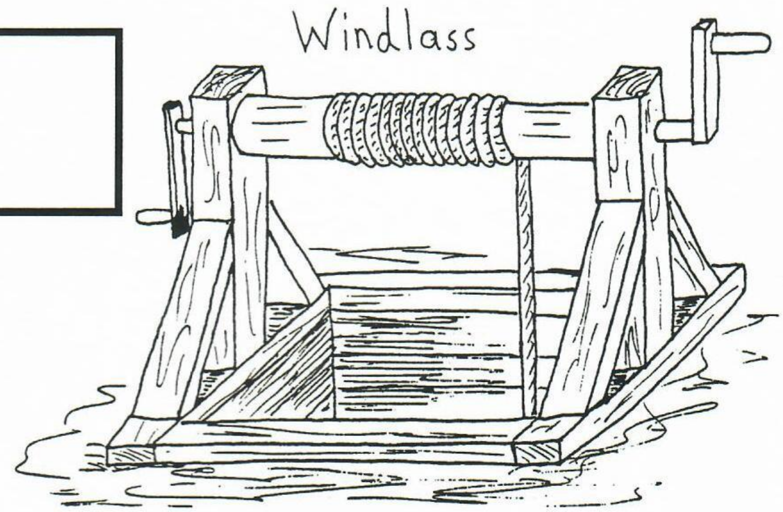
Concentrating Table

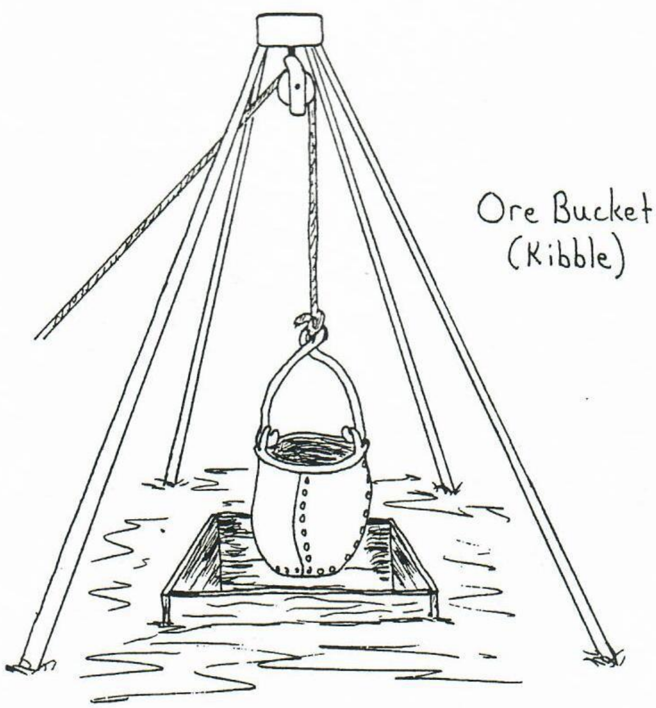


Inclined Plane
Wheel and Axle
Screws

screw inclined plane wheel and axle pulley lever wedge

Lever
Wheel and Axle
Screws




Pulley
Screws
Wheel and Axle

# Technology

## Section II: Mining Technology

Objective: Students will learn about several of the most common forms of mining technology, from the simple pan to the complex stamp mill and can complete a related activity.

# Mining Technology

The miners at Reed Gold Mine used various forms of technology to trap and separate the gold, including chemistry, complex grinding machines, and gravity. The mining process ranged from simple items such and pans to complex stamp mills that crushed quartz while mixing with water. Miners learned how chemical compounds like amalgams could be used to catch smaller flakes of gold which would normally escape the collection methods used at the time.

The simplest technology used by miners was the pan, which may have been an ordinary cast iron frying pan with a broken handle in the early days. The miners knew by working dirt and water together the gold would naturally settle at the bottom. Part of this process is caused by the heavy density of gold, but also the effect of gravity. The lighter material, which gravity does not have as strong an influence, will wash away with the water, leaving the heavier material in the pan. Gold was generally the densest material found along Little Meadow Creek, along with iron. Both would be found together in the bottom of the pan.

Modern pans incorporate a series of ridges and sharp angles to help trap gold, keeping in the pan even with fast shaking back and forth. This allows the lighter material to be washed out at a faster pace, allowing more dirt along the creek to be checked through the day.

As gold mining expanded, larger devices able to move dirt faster were developed, including the cradle rocker and log rocker. Both required a constant source of water, so they were positioned beside a creek or fed water through a series of flumes running downhill.

The cradle rocker was designed after a baby's wooden cradle used during the 1800s. Half-circular pieces of wood were attached to the bottom, and a long handle to rock it back and forth. The top of the rocker had a section with a metal grate to shovel in the creek dirt. The bottom of the rocker had baffles or sections of wood to help catch the heavier material from washing out the end facing the creek. A thick cloth would be placed along to the bottom as well to collect heavier material, which could be removed by squeezing or wringing out over a bucket. While developed in the 1820s – 1830s, cradle rockers made from wood and later metal were used in gold mining for over 100 years, through the 1940s. Some miners still use similar equipment today to work through the dirt.

The log rocker, so named because the first designed used hollowed out tree logs, were designed to be used in multiples, with miners standing on a board and shifting side to side to mix the water and dirt together to make the mud. These began to replace cradle rockers by the 1870s and 1880s as the primary way to sift through large areas of dirt along a creek bed. Water would be fed through a flume and feed each of the rockers. The bottoms would have wooden ridges, cloth or even copper plates coated with mercury to trap the gold. The front of the rocker would be open or have slats to let the water run through, emptying into a small box to trap any smaller gold pieces.

At many North Carolina gold mines, both cradle rockers and log rockers were operated by women who were employed by mines as "sandwashers." In addition to operating rockers, women and girls also panned in search of gold. Enslaved women also searched for gold—though they were not paid to do so.

# Chilean Mills and Arrastra Stones

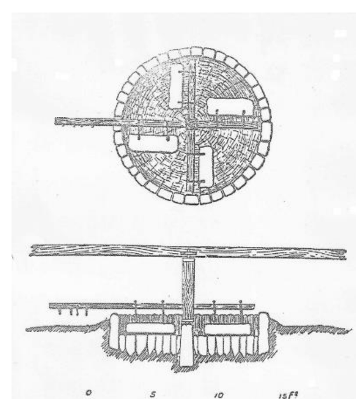
By the 1830s, miners at Reed Gold Mine and other North Carolina mines started using Chilean Mills and Arrastra Mills to crush the quartz and use mercury to extract the gold. How the Chilean Mill came to North Carolina remains a mystery, but this mining apparatus became the most common way to extract gold from quartz by 1830. The basic function involves a heavy base with one or two upright round stones slowly rotating and pulverizing the quartz while mixing with a solution of mercury and water. The gold became trapped by the mercury, which was later removed by heating this mixture in a retort, or large still.

The Chilean Mill that was used at the Furniss Mine in Cabarrus County, photographed in 1971. Notice how the upright stones would have turned inside the base to crush the quartz.

The October 27, 1829 edition of the *Western Carolinian* newspaper gave a fairly accurate description of Chilean Mill operation:

A large stream of water constantly runs into the tubs and keeps them full; the ore [crushed] from the stamp mill is…put in…the quicksilver. Each [runner] stone has two motions—one rolling around on its edge, turning on its axis; the other directly askew, as it is carried round by the shaft; thus greatly agitating the water, and giving it a motion like a whirlpool. The gold settles to the bottom…and is taken up by the quicksilver, forming an amalgamation…while the earthly and ferruginous particles float away…The water runs off from the [base] down an inclined plane, or a kind of spout 2 or 3 feet in width, the bottom of which is lined with skins…for intercepting and securing any of the finer particles of gold which have escaped the mercury in the tub…

Chilean Mills were operated so the stones would turn approximately 6 to 10 revolutions per minute. Too slow and the waste products would not wash away, too fast and the gold would wash out of the tub. The water had to be fed into the base at the right speed as well to keep it functioning properly. In contrast, Arrastra Mills had a crushing bed made of flat rocks between 8 and 12 feet in diameter where large rocks would be dragged across the surface in a circular motion. The Arrastra Mill did not need the large source of water like the Chilean Mill, and therefore made better use of the mercury and recovered up to 25% more gold.



The Arrastra Mill drawing is from: *Mines, Mills, and Furnaces: Industrial Archaeology in Wales*. D. Morgan Rees, 1969. The Arrastra stones would still move in a circular pattern across the flat rocks.

Power was originally supplied by mules or horses, but by the 1850s had been replaced with steam power. Reed Gold Mine had both Chilean and Arrastra Mills located in 1854 Engine house, and Chilean Mills along Little Meadow Creek for easier processing of gold. Both types of mills were used extensively in North Carolina mines through the 1850s, with some mines using them into the 1880s.

# Stamp Mills

Stamp Mills, large machines crush quartz by raising and lowering a heavy metal crushing “stamp” against another metal shoe, had been used in North Carolina by the 1850s. Originally, most of the stamp mill was wooden, but by the 1880s everything was metal except for the main frame to hold everything in place.

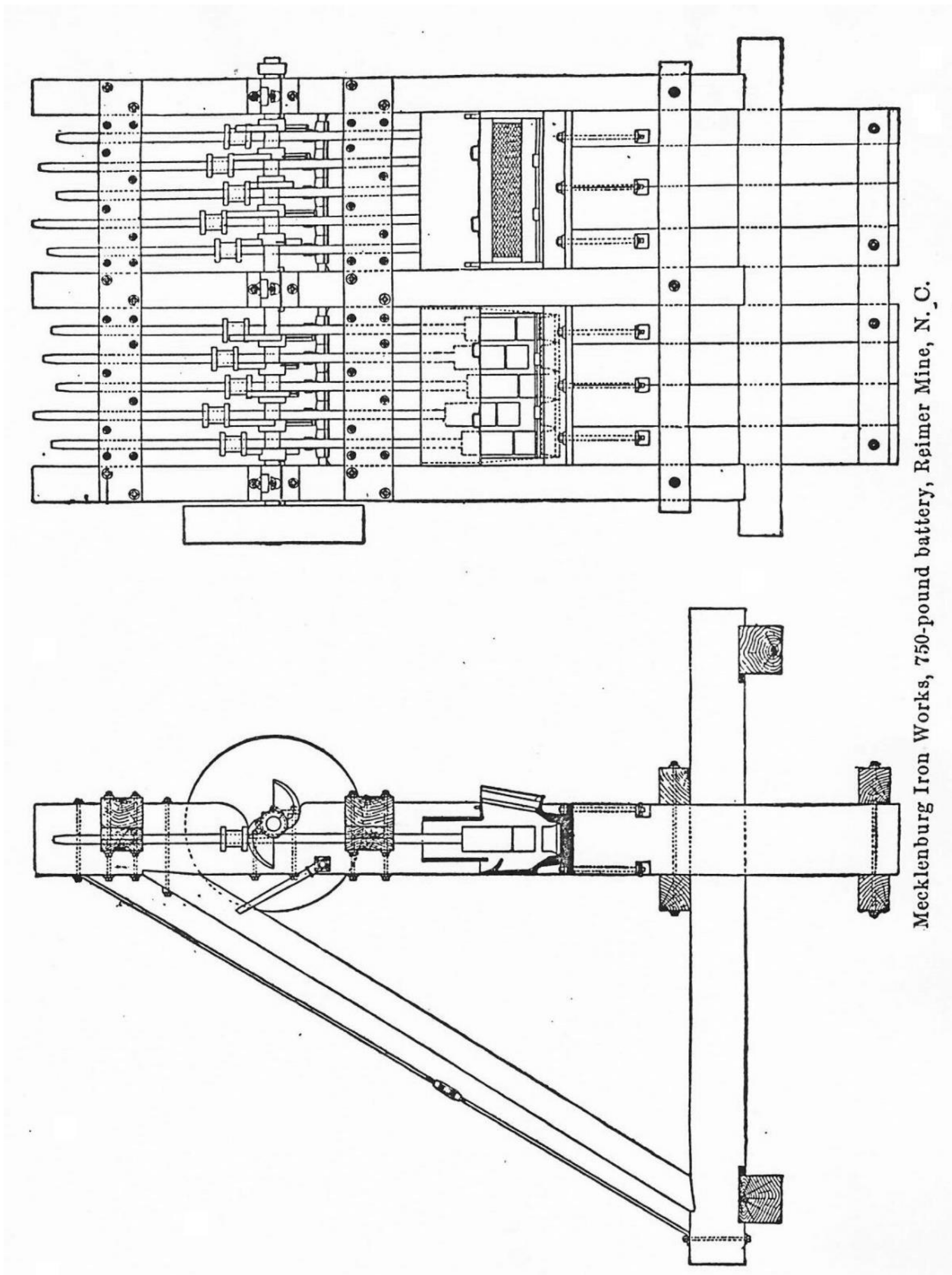
Quartz was taken from the mine, crushed into hand-sized pieces by a jaw crusher, and fed into the hopper on the stamp mill. The quartz then fell from the hopper and the stamps pulverized them into a fine sand. The fine sand was then mixed with water to form a slushy mixture, then forced over apron tables to collect the gold with mercury or drained onto a concentrating table to “shake out” the gold. This was a loud, laborious process, but could generate between $20.00 to $30.00 of gold per ton of quartz processed through the mill. The average 10-stamp mill could crush up to 10 tons of quartz in 12 hours, using 720 gallons of water per hour to keep it running smoothly.

The last stamp mill installed at Reed Gold Mine was built by the Mecklenburg Iron Works in Charlotte, North Carolina. It had 10 stamps, each weighing 750 pounds that would be raised by a camshaft and allowed to free fall against the shoes. Power was supplied by leather belts, called line shafts, driven by a steam engine.

Stamp Mills were the most efficient way to crush quartz to extract gold from the 1880s to the 1920s, but still could not recovery all the gold run through the machine. Smaller flakes of gold would still be washed away with the water, but hopefully collected by the concentrating table. These were noisy machines that required constant maintenance and replacement of parts. The stamps and shoes, made of cast iron, would have to be replaced every 180 days, or six months. The copper plates on the apron tables would have the mercury layer removed every few weeks to process for gold and reapplied to start the process all over again.

Reed Gold Mine kept the stamp mill in operation from 1895 to 1912, when they stopped mining. Other gold mines continued to use stamp mills into the 1930s, due to the amount of gold still processed in North Carolina. Only a handful of original stamp mills can be seen in operation today.

# Reimer Mine Stamp Mill Diagram




The Reimer Mine was located in Rowan County near present day Granite Quarry. This mill was identical to the one purchased for Reed, which was a standard design from the Mecklenburg Iron Works.

# Stamp Mill Building Diagram

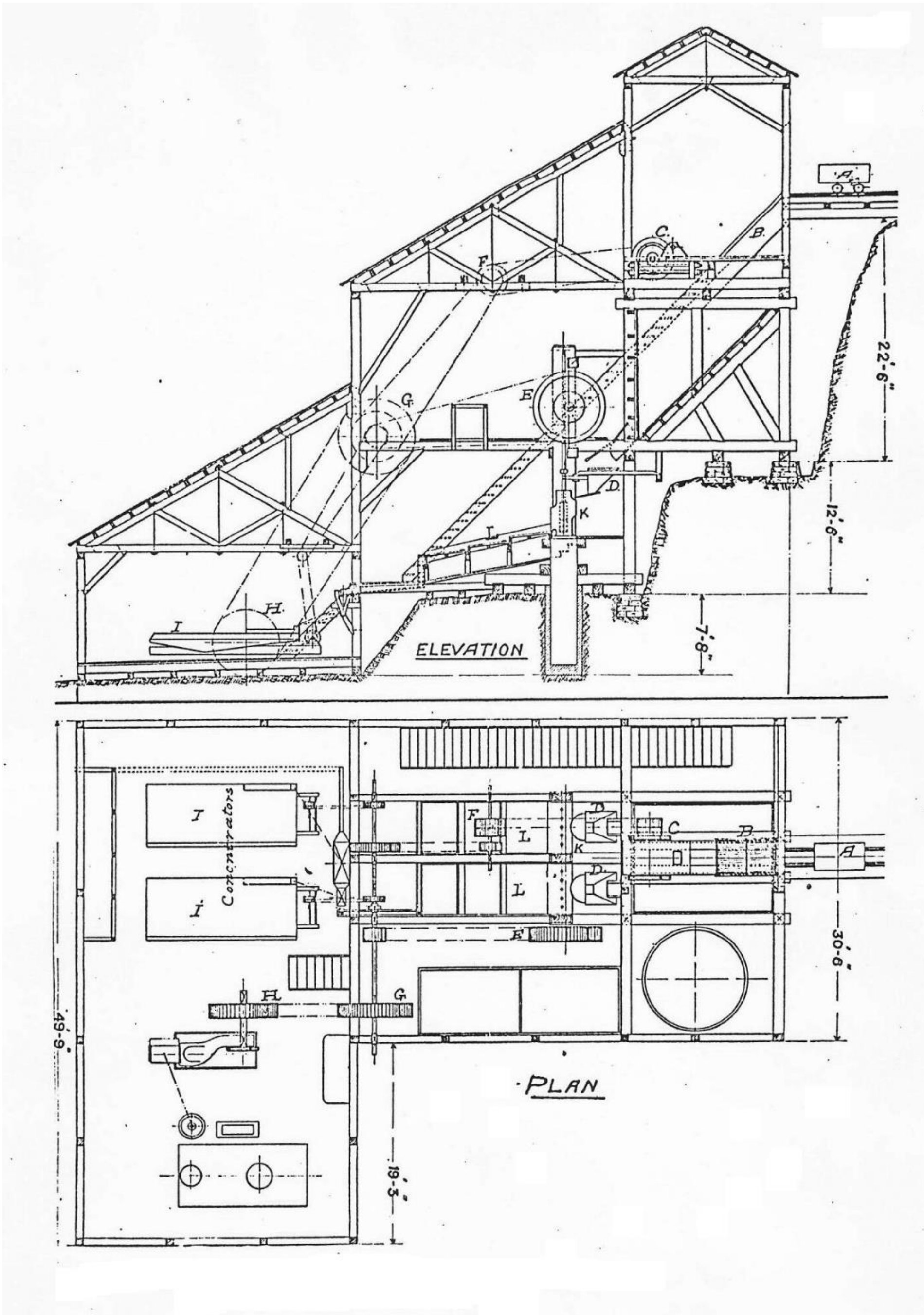



Diagram showing how a stamp mill building used gravity to feed the quartz into the mill, onto the apron tables and finally to the concentrating tables. Similar buildings were located across the U.S. from North Carolina to California.

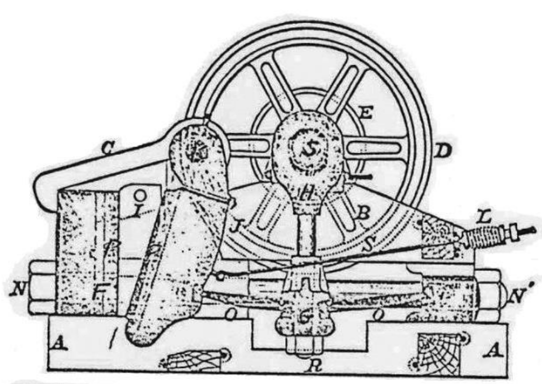
# Jaw Crusher

One of the early issues in underground mining, or lode mining, was how to break the quartz down to manageable size to use in the Chilean or Arrastra mills. Early wooden and metal stamp mills may have been used to crush quartz for processing, but more than likely this was done manually using mine labor. That changed in the 1860s.

In the 1850s, a man named Eli Whitney Blake invented a device that crushed stones for roadways. Gold miners adopted it by 1861 to break down the quartz rock at California gold mines. Rocks were dropped in a wedge-shaped space between two iron jaws, one of which opened and closed on the other in short, successive reciprocating motions of about ¼ inch. As the stones were crushed by this motion, they fell lower into the wedge and were again made smaller. Finally, the particles reached the adjustable bottom of the jaws and passed out in the desired size, which ranged between 1" – 2" in diameter. It did not take long for the crusher to break up enough ore for a day's supply for a ten-stamp mill.

The jaw crusher would be located at the highest point of a stamp mill operation, which allowed the crushed rock to move by gravity into hoppers that supplied the mortar boxes and stamps. Otherwise, the rock would be moved by wheelbarrow to the mill to be manually loaded into the hoppers. Power for the jaw crusher was supplied by a steam engine located at the stamp mill. Line shafts, which used pulleys to drive leather belts, would turn the main wheel on the crusher.

The stamp mill currently in operation at the Reed Mine today has a concreate pad for a jaw crusher but does not use one today. The rock used in the mill must be manually loaded in the hopper, which will feed into the mortar box as the machine pulverizes the quartz. The Reed mill has two banks of five stamps, each with a separate rock hopper.




The Blake jaw crusher. *A–A*, lower timber frame; *B*, upper timber frame; *C*, clamps; *D*, flywheels; *E*, pulley; *F*, main frame; *G*, brushes; *H*, pitman half box; *I*, chucks; *J*, spring jaw; *K*, jaw shaft; *L*, spring on spring rod; *N–N*, main tension rod nuts; *O–O*, toggles; *P–P*, jaw plates; *R–H*, pitman; *R*, pitman rod nuts; *S*, main eccentric shaft.

# Technology Vocabulary

- **Apron Table** – An inclined table connect to the mortar box on a stamp mill. Would have amalgamation plates on them to capture any gold that flowed over top them with water.
- **Arrastra** – A rude drag-stone mill for pulverizing ores that contained gold.
- **Camshaft** – A horizontal rotating piece of a stamp mill used to lift the stamps in the air before releasing them.
- **Chilean Mill** – A mill for crushing quartz, by rotating two stone wheels in a circle. Used to extract gold from white quartz.
- **Concentrating Table** – A table that shakes side to side in which finely-crushed ore and water flows downward. The heavier minerals separate from the lighter materials.
- **Cradle Rocker -** A device used for concentrating gold in small-scale placer mining operations. It rocks back and forth separating rocks and dirt from the heavier gold.
- **Crowbar** – An iron bar with a flattened end, used mostly as a lever.
- **Jaw Crusher** - An adjustable machine for crushing quartz to various sizes in order to prepare the quartz to be used at the Stamp Mill.
- **Kibble** – A large cast iron bucket used to lower miners in and out of underground mines and used to also bring the gold enriched quartz out of the mines.
- **Line Shaft -** Power was supplied by leather belts, called line shafts, driven by a steam engine.
- **Pan** – The action that involved washing gravel or dirt in a pan to separate out the gold.
- **Poll Pick** – A single-pointed miner’s pick having a short poll or striking head.
- **Stamp Mill -** A large machine for pounding pieces of ore into a file gravel to separate gold.
- **Steam Engine** – An engine that uses the expansion or rapid condensation of steam to generate power.
- **Wheelbarrow** – A complex machine with a solid bottom using a lever and wheel used to transport material in a mine.
- **Windlass** – A type of winch used to lower buckets into a shaft and to hoist it up.

# Technology Vocabulary Word Scramble



1. RPOAN EABTL ______
2. ARASATRR ______
3. MTSACAHF ______
4. CILAENH ILML ______
5. ECOIGNTNCNATR TEALB ______
6. LCRDEA OKRREC ______
7. RACWROB ______
8. AWJ UHECRSR ______
9. KBLBIE ______
10. LIEN THSFA ______
11. PAN ______
12. LLOP CIPK ______
13. STPAM ILML ______
14. TSMEA INGENE ______
15. OBREWLREAHW ______
16. SIDSLANW ______

# Technology Vocabulary Word Scramble Answer Key



| | |
|---|---|
| 1. RPOAN EABTL | Apron Table |
| 2. ARASATRR | Arrastra |
| 3. MTSACAHF | Camshaft |
| 4. CILAENH ILML | Chilean Mill |
| 5. ECOIGNTNCNATR TEALB | Concentrating Table |
| 6. LCRDEA OKRREC | Cradle Rocker |
| 7. RACWROB | Crowbar |
| 8. AWJ UHECRSR | Jaw Crusher |
| 9. KBLBIE | Kibble |
| 10. LIEN THSFA | Line Shaft |
| 11. PAN | Pan |
| 12. LLOP CIPK | Poll Pick |
| 13. STPAM ILML | Stamp Mill |
| 14. TSMEA INGENE | Steam Engine |
| 15. OBREWLREAHW | Wheelbarrow |
| 16. SIDSLANW | Windlass |