

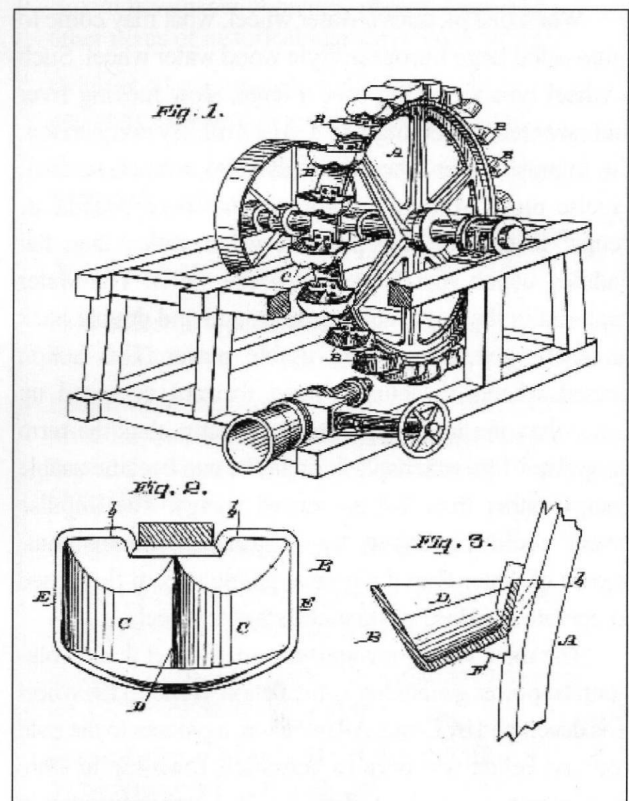
POWERING THE MINES THE IMPULSE WATER WHEELS

by *Bonnie Miller*

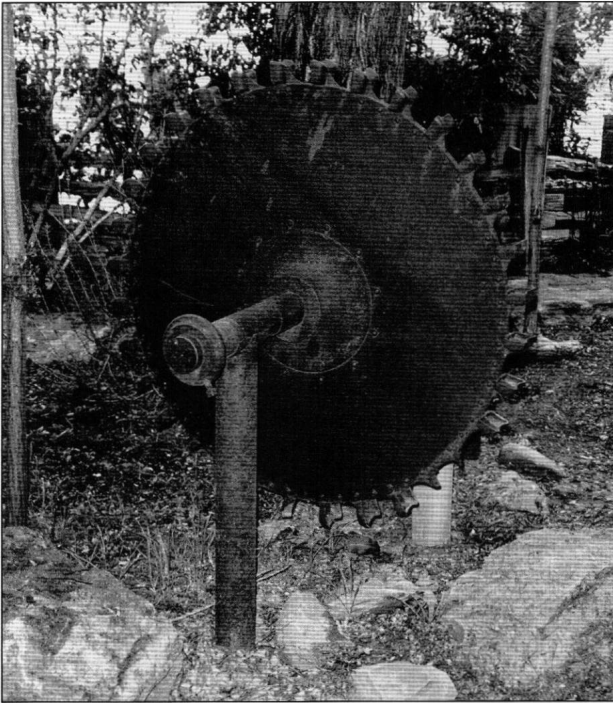
Gold mining has always been a process of capturing and developing natural resources. Numerous inventions and industrial developments came from the inspirations of miners. An example of an evolved use of resources that exemplifies that theory is the development and use of the impulse water wheel. The impulse water wheel garnered the strength of California's water to operate the machinery that processed the ore that bore the gold.

With the advent of the industrial revolution, machinery began to take the place of extensive manual labor. As gold mining became automated, the demand for power became more important. The new machines required power to operate, which was not always readily available in remote mining locations. Remote mines depended on steam engines, which in turn depended on fuel to keep burning. The steam engines had voracious appetites, and the fuel sources were exhaustible. What was abundant in California was fast moving water from the mountainous streams. Equipment fueled by water, using a water wheel, was quickly developed by the enterprising pioneers.

The mechanical power of falling water is a proven tool that has been used for many centuries. A water



Patent drawing for the Pelton Wheel, circa 1889



The 48 inch Pelton Wheel on display in the Jail Yard.

Photo by Bonnie Miller, 2002

wheel uses the energy of the falling water to convert it to a mechanical rotating motion along its shaft. The rotation of the shaft can be used to do work or generate power. The innovative water wheels that were developed in the west are known as “impulse” wheels.

When one pictures a water wheel, what may come to mind is the large European style wood water wheel. Such a wheel typically hung over a large, slow moving river and powered something like a grist mill. By comparison, the impulse water wheel was (usually) a much smaller, precise piece of metal equipment that bore buckets or “cups” to capture high pressure water, rather than flat paddles which merely deflected the water. The water captured in the cup would swirl around and double back on itself, generating more usable power. This action caused wheels to actually burst forward or speed up faster than the incoming stream of water, thus the term “impulse.” The water splashing in the cup became usable energy rather than lost as wasted energy. The impulse wheel could be driven by a stronger, mountainous, stream of water than the typical gentle stream flow used to operate standard wood paddle water wheels.

The most widely recognized water wheel that revolutionized power generation is the Pelton Wheel. This wheel was developed by Lester Allan Pelton, a pioneer to the gold country. Pelton was born in Vermilion Township in Ohio on September 5, 1829, and received his early education in a one-room school house. Like so many other young men,

at the age of twenty he, and about ten acquaintances from his community, went to California to seek their fortunes in the gold fields in 1850. Pelton found himself with friends in Sacramento and began his first work in the California gold environment selling fish to miners. Pelton was not really interested in mining himself, but recognized that the business of mining was supported by numerous other businesses. Over the next ten years he made his livelihood in a variety of jobs including carpenter, tinsmith, and millwright. He followed the miners and moved to new locations with the new gold strikes, and provided much needed skills to support them.

There are two legends that describe what inspired Pelton to invent his powerful wheel. One legend has it that he was observing a cup style water wheel when the shaft slipped, causing the paddles to be misaligned under the water stream. The skewed cups split the water stream and caused the wheel to burst forward as though given an even stronger push. This observation led Pelton to experiment with the flow of water against the cups on the wheel. He found that if the water stream was split in the cup, it would double back on itself twice as often, and then the energy of the water was actually enhanced yet more by the doubled swirl of the water in the cup.

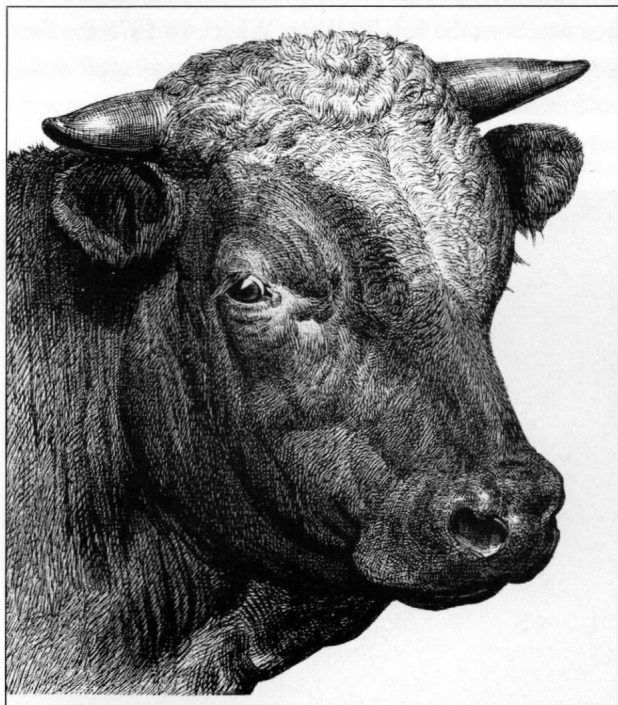
The other, more interesting legend, claims that while Pelton was living in Camptonville, one day he was chasing a stray cow from his landlady’s yard. He threw water at the cow and struck it in the nose. The water split at the two nostrils, swirled in the nose, and then exited in a spurt of water. This powerful swirl of the split water gave him an idea. He experimented with water wheels using double or split cups similar to the nostrils of the cow rather than the typical single-cup of an impulse wheel. The double or split-cup shaped paddle was far more efficient than the flat paddle or single cup, and the wheel ran much faster. Whether this version of the invention is true or not, what is indisputable is the fact that the split cup design clearly resembles the nose of a cow.

Pelton spent the next several years experimenting with and perfecting a design. In 1878 his first wheel was used in the Mayflower Mine in Nevada City. But he wasn’t the only inventor developing a water-driven power source for mining. There were in fact several manufacturers of water wheels but certainly the most widely known impulse wheel of the gold mining era is the Pelton Wheel. Other names of wheels were the Francis, Donnelly, Knight, Tyson, or the Banki/Michell. Sometimes miners affectionately referred to their early water wheels as “hurdy gurdies,” although this wasn’t a

brand name. Other types of later water wheels were the Doble, Turgo, crossflow, overshot, undershot and the breast design, which all captured the energy of water in their own unique ways.

By the early 1880s Pelton felt he had perfected his design and he began peddling his invention with little sales success and a lot of competition in the market. Mines had to be innovative to continue to process their ore effectively. The more efficient the process, the greater the profit, so generally they were open to new innovations that could improve their operations. The Idaho Mining Company of Grass Valley wanted to buy one of the new water wheels, so in 1883 they staged a competition between various manufacturers. The informal competition made history, in that it proved the magnificent efficiency of Pelton's design. His wheel produced power at the rate of efficiency of 90.2%, an unheard of success. His next three competitors only attained 76.5%, 69.6% and 60.5%. After the success of the competition, sales grew rapidly. In 1888 Pelton and some partners formed the Pelton Water Wheel Company in San Francisco and began to mass produce his impulse wheels. It wasn't until the following year before Pelton got around to patenting his invention on August 27, 1889.

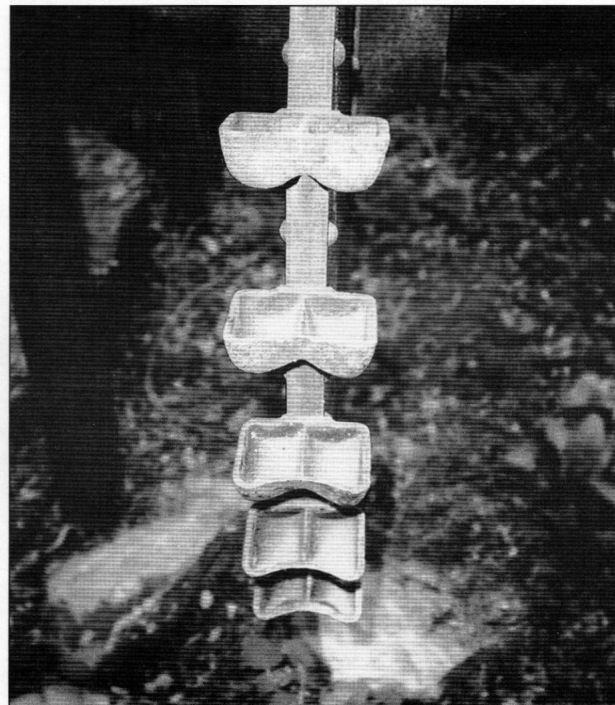
In the more florid language of the day, in his patent application Pelton described the invention as:



“My invention consists, essentially, in a novel construction of the buckets into which the water is discharged, so that the stream of water is divided into two parts by a central ridge or apex which directs the current of water into the curved bottoms of the two halves of the bucket, from which it passes out over the flaring or divergent sides of the bucket, so as to escape smoothly and utilize the full reactionary force of the escaping stream in addition to the direct force of the impinging jet.”

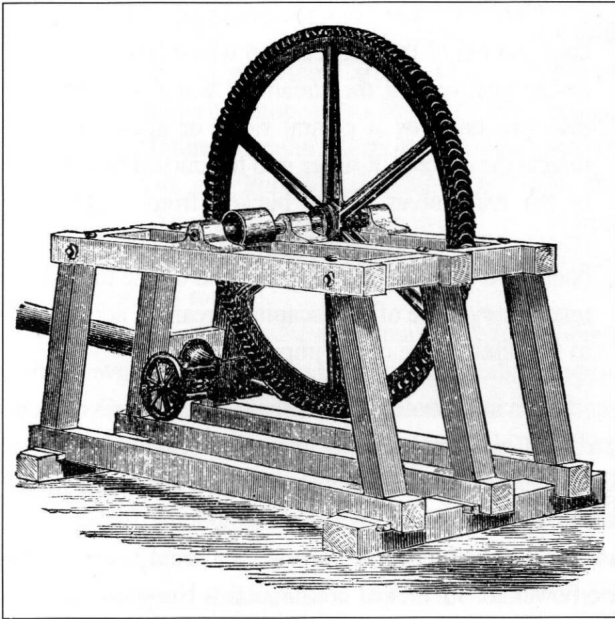
Pelton immediately saw the power industry revolutionized with his improvements to the impulse water wheels. Their first application was to provide power to the mines such as to operate heavy hoists or stamp mills. Besides their use in powering mining operations, they could produce electric power for municipal consumption. Historians believe that by 1893 the use of hydroelectric power was prominent throughout the west, and the age of hydroelectric power was in full operation in the western United States. Prior to World War I, more than forty percent of the country's electricity was supplied by hydroelectric power.

Pelton's factory was destroyed in the 1906 earthquake and fire. Despite the setback, he remained determined and rebuilt the factory in the same location where it continued to produce the huge hydroelectric wheels into the 1920s. Pelton's wheels were sold all over the world, although his best customers were always right here in the



The nose of a cow was said to inspire Pelton to re-design the shape of the cups on an impulse water wheel.

Left photo courtesy internet image. Right photo by Bonnie Miller, 2002



The Knight Wheel, from the book *Supplying the Mining World*

California Gold Country. Pelton never married, he lived out his remaining years in Oakland, and he passed away on March 14, 1908. A monument to Pelton's accomplishments is on display in Camptonville, California along with one of his original water wheels. Another is on display in the Smithsonian Institute in Washington D.C.

All of the above-described history leads one to believe that Lester Pelton was "The Father of Hydroelectric Power," as he has been credited. What most people do not realize is that Pelton's inventions were preceded by another. Everyone thinks of the Pelton as the first efficient water wheel, but...

In 1866 a millwright in the mines near Sutter Creek named Samuel Knight invented a water wheel that operated with water under pressure. Knight was inspired by watching the powerful hydraulic mining that washed away hillsides of earth in search of gold. The water was held on higher ground in a penstock system which allowed the water to be delivered, with the aid of gravity, at a high level of pressure. The water's pressure is measured in feet of "head." The higher the head, the greater the pressure. Knight felt that a powerful stream of water aimed at the water wheels could speed up the process, and he was right. It was Knight who developed the idea of the water wheel with a bucket capturing the pressurized water, acting on impulse, thus the "impulse" wheel. When a high head of water was available, the impulse wheel was the best choice.

Knight is credited with *inventing* the impulse wheel, whereas Pelton is credited with *improving its efficiency* dramatically. Pelton actually conducted his experiments on a Knight Wheel. The greatest competitor to Pelton was the

Knight, and the Pelton and Knight wheels dominated the market. Amusingly, users who preferred the Pelton design often disliked the Knight design, and visa versa. Fans of one type of wheel were very loyal to that brand. The rivalry between the two types of water wheels was similar to the vehemence that Ford vs Chevrolet experiences today.

Locally, the Knight was the preferred wheel, although the Pelton became the more efficient model over time. This loyalty to the Knight was probably due to a sense of local pride, as the Knight was developed and manufactured nearby in Sutter Creek, whereas the Pelton was from "up north."

Samuel Knight's background as a Gold Rush pioneer was similar to that of Pelton. Knight also worked in a variety of jobs, lastly as a ship's carpenter before abandoning that career and trying his luck in the gold camps. He worked at a variety of mines and mine construction sites throughout Amador and Calaveras Counties where he began to experiment with the designs of water wheels. In 1866 he, along with several other innovators of the day, was attempting to perfect the wooden bucket water wheel. In 1868 he made a wood wheel, but with metal buckets. It was at this time that he began to experiment with the shape of the bucket. And unlike others, he also experimented with the delivery of the water. The hydraulic nozzle that fed the water to the wheel was also modified by Knight. By 1872 the curved cup and the perfected hydraulic nozzle were developed to his satisfaction, and thus was born the Knight Water Wheel. In 1875 the first large scale Knight Wheel of this design was used at the Lincoln Mine in Sutter Creek.



The Knight Wheel, on California Historical Landmark 1007.

Photo by Bonnie Miller, November 2005

The Knight Wheel was made by the Knight Foundry in Sutter Creek. The foundry was originally established as the Campbell, Hall & Co. by Knight and some partners in 1873, but he later bought out the partners and renamed it. They manufactured his water wheel as well as heavy equipment to the mining and timber industries in the Mother Lode. It was here that Knight manufactured the cast iron impulse water wheel that became the forerunner to the Pelton design. Some of Knight's wheels from this foundry were used in the first hydroelectric plants in California, Utah and Oregon. Knight's catalogs stated that over 300 wheels were produced in the 1880s and 1890s, and it was claimed that they powered over 2,000 stamp mills.

Most of this early innovation was well established before Pelton manufactured his first wheel. Despite the success of the Knight Wheel, after the 1883 water wheel competition in Grass Valley, the Pelton design was providing heavy competition for the Knight Foundry. Fortunately for the foundry, the water wheel wasn't their only product. They produced other heavy mining and timber equipment such as dredgers, pumps, hydraulic engines, and hoists.

This factory was a busy complex of workshops including the foundry with two furnaces, a blacksmith shop and a machine shop. What is most unique about the factory was that it used water power to operate itself. The factory used one of their own 42 inch wheels to drive the main power line shaft, augmented by seven Knight turbines or "water motors" for accessory equipment. The water to power this system drops over 400 feet from a reservoir above Sutter Creek, which is part of the Amador Canal system. The Knight Foundry was the last, and possibly the only, water powered foundry and machine shop in the



Bill Burton and grandson Joe installing the Pelton Wheel display in the Jail Yard, 2002. Photo from the Calaveras County Historical Society archives.

United States, and it operated continuously from 1873 until 1991. Today the foundry operates periodically and provides a unique service to history. It often produces the historic castings required by other historic sites such as architectural iron work for the California State Capitol. The original one-and-a-half story foundry building is still present on Eureka Street today where it is undergoing a complete historic renovation. The Knight Foundry was placed on the National Register of Historic Places and is a California Historical Landmark, as well as a designated historic site by the American Society of Mechanical Engineers.

With the advent of the impulse wheel, mines that had a good source of water were soon generating their own power. They powered their own heavy equipment such as the mills and hoists, as well as lights and ventilation



The Knight Foundry in Sutter Creek today. Photo by Bonnie Miller, November 2005

systems for the underground shafts. Ironically they also were used to power traditional arrastras (drag mills) as well as the modern stamp mills. In Calaveras County, ore from the Tanner Mine in Murphys was processed in an arrastra with a Pelton Wheel using water from the North Ditch. Another arrastra was powered by a Pelton Wheel with water from the Calaveras River near where New Hogan lies today.

In Calaveras County several smaller Pelton Wheels were known to have been used. Old timers recall one operating on Carson Creek in an area that was later inundated by New Melones Reservoir. One operated in the Jesus Maria Creek near the Ponderosa Road south of present-day Highway 26. The Fine Gold Mine in Rail Road Flat used water from the South Fork of the Mokelumne River to obtain power via a Pelton Wheel. Before the Pelton Wheel was perfected, the Maltman Mine in Angels Camp, and the Sheep Ranch Mine each used a wood water wheel.

Today the Stevenot Winery occupies land along San Domingo Creek where the former Shaw Ranch was located. An ingenious member of the Shaw Ranch used captured spring water flowing to the creek to operate a tiny water wheel only seven-and-a-half inches across. This wheel was a home-made affair, of small Knight-like cups welded on to an old pulley. This tiny operation was enough to generate power to operate a string of six-volt lights that lit the main ranch house. It was a reliable enough power source that it continued to provide the only electric power to the ranch house until public power was brought to the area in the 1950s.

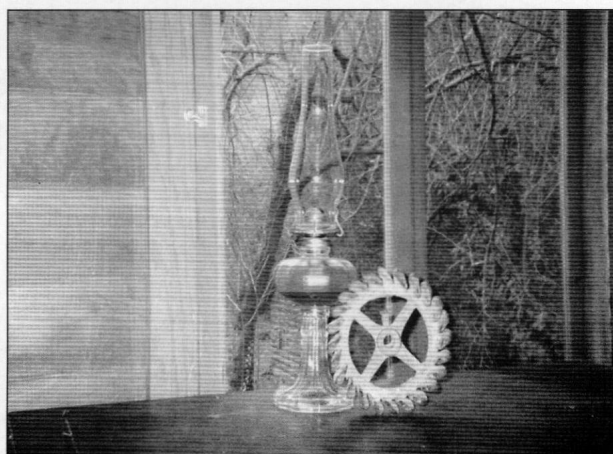
The Utica Powerhouse, originally built to support mining interests, was later converted to public power generation. This powerhouse straddled Murphys creek and used a powerful Pelton Wheel to operate two turbines. The largest hydraulic-powered private operation in Calaveras County was probably the Gwin Mine in Paloma. Using water from the Utica Ditch system, the mine operated their main hoist with power generated from a Pelton Wheel. Similarly, the ditch system that ran alongside Dogtown Road often powered small private water wheels.

Sadly, countless water wheels have disappeared to time and were scrapped for metal during the war effort. Today few wheels remain to be seen, but fortunately a few fine examples continue to exist within easy reach. Calaveras County residents drive past a large Pelton Wheel regularly on Highway 49 through Angels Camp. In front of the Angels Camp Museum is a grand 90 inch wheel next to where

“Ol’ Beth” greets visitors. This wheel was donated by PG&E when they upgraded Camp Nine to a more modern Pelton Wheel. Behind the museum is another example of a water wheel, an overshot wheel, which continues to stand in place over the flume which provided the water to power it. It was once used on the property to generate power, and is reputed to have operated an arrastra as well. Water to power the wheel came from the Angels Mine across the street via the flume system.

On display in the Historic Jail Yard behind the Calaveras County Museum is also an authentic 48 inch Pelton Wheel. This wheel was recovered from the nether-lands of western Calaveras County by past Historical Society President George Poore and installed in the jail yard for display. In 2002, society members Bill and Beverly Burton and their grandson Joseph Auld and current Vice President Duane Wight rescued the wheel from its bed of dirt and mounted it for a more attractive display. Museum visitors are encouraged to pay the wheel a visit and admire its place in history. It is hard to imagine how a little wheel with cups could revolutionize an entire industry.

The hydraulic power of the mountain stream was held in reservoirs and used extensively to support the later mining enterprises. Using the impulse wheels, this power source was further developed to mass produce hydroelectric power, which was widespread by the early 1900s. Like the carbide lantern, the small impulse wheel went the way of obscurity when electric power became widely available. The engineering that



A home made 7-1/2 inch water wheel (leaning against an oil lamp) from the Shaw Ranch, courtesy of the Stevenot Winery.

Photo by Bonnie Miller, December 2005

was developed for the end use was transferred back to the supply end of the operation. The public power that became available was predominantly hydraulic power courtesy of a water wheel. Water, California's *other* gold, had advanced from a handtool for the first placer miners of 1849, to a mechanical power source for the hardrock miners and ore processors of the 1880s, and lastly as a source for electric power for the country thereafter. Never underestimate the power of water!

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The 90 inch Pelton Wheel from the Camp Nine hydroelectric plant, donated by PG&E and on display in the Angels Camp Museum. Photo by Bonnie Miller, December 2005

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The Calaveras County Historical Society is a non-profit corporation. It meets on the fourth Thursday of each month in various communities throughout the County. Locations and scheduled programs are announced in advance. Some meetings include a dinner program, and visitors are always welcome.

The Society operates the Calaveras County Museum which is open daily from 10:00 to 4:00 in the historic County courthouse located at 30 Main Street in San Andreas.

The Society's office is located in historic San Andreas, the Calaveras County seat. Visitors are always welcome to stop by the office for assistance with research, and are encouraged to visit the museum while in the area. The office is open Monday through Friday from 8:30 to 4:00, and the telephone number is (209) 754-1058, or contact us at: CCHS@goldrush.com.

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The Historical Society welcomes the following new members:

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