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DESERT QUEEN RANCH,
ONE-STAMP GOLD MILL
(Gold Park Mine, One-Stamp Gold Mill)
Joshua Tree National Monument
Twentynine Palms Vicinity
San Bernardino County
California

HAER No. CA-111-A

PHOTOGRAPHS

REDUCED COPIES OF MEASURED DRAWINGS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

Historic American Engineering Record
National Park Service
Department of the Interior
P.O. Box 37127
Washington, D.C. 20013-7127

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HISTORIC AMERICAN ENGINEERING RECORD

INDEX TO PHOTOGRAPHS

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Brian Grogan, Photographer, 1991

CA-111-A-1 VIEW OF ONE-STAMP MILL

CA-111-A-2 VIEW OF ONE-STAMP MILL WITH RANCH HOUSE AT REAR
(See HABS No. CA-2347, DESERT QUEEN RANCH, for further documentation)

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HISTORIC AMERICAN ENGINEERING RECORD

DESERT QUEEN RANCH, ONE-STAMP GOLD MILL
(Gold Park Mine, One-Stamp Gold Mill)
Joshua Tree National Monument

HAER No. CA-111-A

Location:	Desert Queen Ranch, south by southwest of Twentynine Palms, San Bernardino County, California UTM: Zone 11, E 576740, N 3767300 Quad: Indian Cove, 7.5 minute series Twentynine Palms, 15 minute series
Date of Construction:	Circa 1918
Present Owner:	Joshua Tree National Monument National Park Service
Present Use:	Presently in disuse. Included in interpretive tours of the ranch.
Significance:	The machinery represents the obsolete technology of a California Stamp Mill. The one-stamp is a good example of the little mills which were used by prospectors and at small mines.
Project Information:	This recording project is part of the Historic American Engineering Record (HAER), a long-range program to document historically significant engineering and industrial works in the U.S. The One-Stamp Gold Mill recording project was cosponsored during the summer of 1991 by HABS/HAER, Joshua Tree National Monument, and Park Historic Preservation, Western Regional Office, National Park Service. Elizabeth (Lysa) Wegman-French, HAER Historian
Note:	See HABS No. CA-2347 for specific documentation on the Desert Queen Ranch.

INTRODUCTION

William Keys' One-Stamp Gold Mill represents the obsolete technology of a California stamp mill. Stamp/amalgamation mills were the standard in the California gold mining industry for over fifty years and were well suited to treat the state's free-milling ores. These mills extracted gold by crushing ore with metal stamps and exposing the pulp to mercury. The liquid combined with the gold to form an alloy, called amalgam. The amalgam was separated from the rock and the mercury removed, leaving a remainder of pure gold.

This one-stamp mill is considerably smaller than most mills, which may have utilized up to 100 stamps. Keys' mill is more typical of the little mills in the region used by prospectors and at small mines.

The mill currently sits in the yard of the Desert Queen Ranch, in Joshua Tree National Monument. It is about nine miles southwest of Twentynine Palms, and 140 miles east of Los Angeles. Public access to the ranch is limited to guided tours. The site is in the Mojave Desert, where the high summer temperatures average over 100 degrees. Joshua trees, Mojave yuccas, cactus, creosote bushes and other small desert shrubs are scattered across the locale. The ranch house and yard are nestled at the base of giant boulders which form the southwestern edge of an area known as the Wonderland of Rocks.

HISTORIC CONTEXT

The major gold mining area in southern California was in the Mojave and Colorado Desert regions east of the coastal mountains, part of which now forms Joshua Tree National Monument. The geological formations found here are completely different from those in the central and northern parts of the state; there were no continuous mineral belts of any substantial distance. Instead, the minerals tended to occur in broken segments and pockets. The environmental conditions facing the early prospectors were challenging. It was a forbidding area of dry sandy basins separated by many low ranges of mountains. The heat was intense, water was difficult to find, there was little wood, and transportation was arduous and expensive. Even so, the lure of gold brought prospectors willing to gamble on winning. Mines were scattered all over the region, and there were numerous mining districts.[1]

Euro-Americans had entered the Joshua Tree National Monument region in the 1870s and 1880s to mine and graze cattle. There was a flurry of mining activity from about 1873 to 1883 but the area was

most productive in the 1890s and early 1900s. Gold production in the West slumped after World War I and stayed low for the next decade. Low gold prices and high operating costs discouraged mining activity. The district did, however, experience another surge of activity during the Depression.[2]

HISTORY OF THE ONE-STAMP MILL

The one-stamp mill is currently located at the Desert Queen Ranch, although it previously was operated at the Gold Park Mine, about eleven miles east in the Gold Park Mining District. The mill was probably new when it was built into the hillside there around 1918 or 1919.

A Mr. Roach operated the mine, using gravity to assist moving the ore. However, the mill was not used much, and Roach may have milled only about ten or fifteen tons of ore. When he neglected to do assessment work on the mine for several years, William F. (Bill) Keys claimed the mine in 1924 or 1925.[3]

Roach became upset after learning about Keys' claim on what he believed to be his mine. He brought a gun and some friends and drove up to the mine. On the way to the site, the car became mired, but that did not prevent the ensuing confrontation. Keys was also armed, however, and shot the gun out of Roach's hand. The friends promised they would keep quiet about the shooting if Keys would help them dislodge their car. Keys agreed, and Roach kept any further objections to himself.

Keys disassembled the one-stamp mill and moved it to his ranch. He placed the mill on its side north or northwest of his house.[4] The mill apparently laid in that position for over thirty years.

Bill Keys was a colorful character. He had come to this desert region in 1910, thriving in an area where few people could survive until his death in 1969. He successfully adapted to the desert conditions, due to his flexibility, resourcefulness and self-sufficiency. One of his survival techniques in this isolated area was acquiring and reusing equipment. He could never tell when he would need the hardware, either in its original condition or as replacement parts, so he seemed to gain possession of everything he could. He even purchased a junk yard. If he failed to use his acquisitions right away, he organized them in the yard of his ranch for easy access. Today one can still examine the household, mining, transportation and agricultural equipment, including stoves, beds, wagons, cars, a tractor, an adobe-mixing machine, and various nuts and bolts. Keys constantly reused these salvaged goods throughout his desert domain. He worked as many as twenty

mining claims, operated several mills, built dams, and irrigated his orchards. Equipment from one of these sites was often transferred to another. One of the ways he acquired equipment was to claim abandoned mines and the accompanying machinery. He also leased mines to others, and when they vacated the mine, Keys took possession of the equipment they left behind. Keys' claim on the Gold Park Mine, and subsequent removal of the one-stamp mill, was thus quite representative of his operating style.

In the late 1950s Keys used the mill in a one-weekend demonstration at a local festival. This was apparently the only time Keys ever milled ore with this one-stamp.[5] The Turtle Races was an annual springtime celebration in the town of Joshua Tree, fifteen miles northwest of the Desert Queen Ranch. The organizers thought that a milling demonstration would be an interesting attraction for their event. They approached Patricia Keys Garry, Bill Keys' daughter and a Joshua Tree resident, for assistance. She proposed the idea to her father, who agreed to do it if his old friend Oran Booth would help him. Booth quickly responded in the affirmative.[6]

The organizers transported the mill in a truck and helped set it up at the fsstival site. They put up a 6'-high wire fence around the mill, for safety reasons. Keys and Booth spent the weekend operating the mill while spectators pressed against the fence on all sides and asked questions. The millmen explained the process and answered the visitors' inquiries.[7] At the completion of the festival, the organizers returned the mill to the Desert Queen Ranch. They set the components in the location where they are found today; Keys never used the mill again.[8]

TECHNICAL ASPECTS OF THE ONE-STAMP MILL

Gold ore is rock which contains gold. Much of the gold ore that occurs in California is of a type that is called free-milling. The gold occurs as small particles which can be released by crushing the rock (gangue).[9] Milling is a process which extracts valuable metals from the valueless minerals which encase them. Stamp/amalgamation mills extracted gold by first crushing the ore with the stamps to release the gold particles. Next, the crushed ore was exposed to mercury. The liquid metal formed an alloy, called amalgam, with the gold. Stamp/amalgamation mills were well suited to treating free-milling ores.[10]

Stamp mills were the standard for many years in California and the West; the most highly developed gravity stamp mill was called the California Stamp Mill. Their popularity spread quickly after the first one in the state was erected in 1850.[11] Stamp/amalgamation mills were favored because they had a simple mechanical design,

were relatively easy to set up, inexpensive to operate, sturdily constructed and easily repaired.

However, there were disadvantages to stamp mills. Large mills were cumbersome and required a great deal of space due to their heavy frames and large foundations, the initial and transportation costs were high, and they did not adapt well to dry crushing. Nonetheless, the advantages so greatly exceeded the disadvantages that the stamp mill continued in its favored position for many years.[12] Small mills, such as Keys', evaded some of these problems. They cost less originally, had lower transportation costs, and used less space than larger mills.

By the 1930s, substitute methods of grinding and milling had been developed, eroding the stamp mill's popularity. Ball and tube mills and flotation and cyanidation were substituted at many newer, larger plants.[13] Even so, in the 1930s, "thousands of stamps [were] still dropping in numerous mills throughout the world."[14]

Prospecting mills were usually made in the one-stamp size, although batteries of up to five lightweight stamps were used for that purpose.[15] Their frameworks were often constructed so the mills were free-standing. Keys' one-stamp is currently free-standing, but Keys may have constructed the framework for the demonstration. One indication for this is the presence of lightweight uprights on the sides of the stamps; these would normally be made of heavier timbers. Although the Keys mill is small, and may appear to be portable, the manufacturer did not intend it that way. The mill was heavy and difficult to haul; it took more than two or three men to handle it. It was also quite a chore to set up the mill to operate it. Roach had built it into the hillside at the Gold Park mine.[16]

INDIVIDUAL PARTS AND PROCESSES

Engine

When the mill was at the Gold Park Mine, a Smith, Booth and Usher engine powered it. However, Keys used a six-horsepower, 400 r.p.m. Fairbanks-Morse Type Z gasoline engine, a type which was first introduced in 1915.[17] This engine is currently setting inside the mill.[18]

The engine had a make-and-break ignition; there was no spark plug. The timing was set so that a spark jumped between the points while they were open. The points would become dirty, however, preventing the spark and killing the engine. Oran Booth disliked this type of ignition and, as he anticipated, he had trouble with the engine at

the Turtle Races. The engine repeatedly stopped, and Booth had to continually restart it.[19]

The power from the engine was transferred to the stamps and the crusher via belts and pulleys. The belts were left a little loose, so that they could be placed on and removed from the pulleys easily. However, the belts needed to be taut during operation, so an idler was used to push against the belt and take up the slack. An idler is currently sitting near the mill. The pulley on the stamp battery was a large bull wheel, built of laminated wood, in the traditional style of stamp mills.

Crusher

A jaw crusher, or rock breaker, used compression to break the ore. This preliminary crushing was done by a breaker; this machine was much less expensive to operate than the stamps.[20] The breaker had a cast-iron body, a stationary jaw, and a swing jaw which was hinged on the bottom. The ore was deposited into the V-shaped area between the two jaw plates. The swing jaw oscillated in short, rapid movements, breaking rock with each inward stroke. The smaller pieces dropped through the throat between the plates.

The crusher that is currently sitting beside the mill was used at the Gold Park Mine,[21] and at the Turtle Races.[22] It is a No. 3 Dodge Rock Breaker manufactured by Harron, Rickard and McCone of San Francisco under patents dated 1883 and 1890.[23] Dodge breakers, and their imitators, were standards in the industry; major competitors were Blake-type crushers.[24] Harron, Rickard and McCone was a large, well-known mining supply company which also had offices in Los Angeles.

The position of the crusher was determined by its setting. At the Gold Park Mine, the mill was built into a hillside, below the mine. The crusher was near the level of the mine, supported above the ore bin by a timber framework. A tram brought ore from the mine shaft to the crusher; after the ore passed through the crusher it dropped into the bin.[25] Keys did not build such a structure for the two-day demonstration, choosing to set the crusher on two timbers which were on the ground instead. This allowed some clearance under the machine. A bucket conveyor belt was positioned to move the crushed ore from under the crusher up to the top of the ore bin.[26] The crusher is presently attached to those timbers and is positioned, backwards, near the stamps. The conveyor belt currently lies alongside the one-stamp mill.

Ore Bin

The ore bin, or hopper, is positioned on the back side of the stamp battery. This same piece was also used at the Gold Park Mine.[27] The bin held the ore from the crusher before it was fed into the stamp battery. The ore feeder, positioned between the bin and the mortar, controlled the flow of ore to the stamp. The braces on the support structure are curved, and may have been fashioned from a bull wheel.

Stamp Battery

A stamp battery was the center of attention in a stamp mill. It ground ore into a fine sand using a pounding action, similar to a hammer and anvil. A die, similar to an anvil, was an iron or steel pad set in the bottom of a heavy metal trough called a mortar (or mortar box). The sides of the mortar were made of screen. Water, ore and mercury were placed inside the box.

A stamp acted like a hammer, and was composed of a stem, a shoe, a boss, and a tappet. The stem was the centerpiece. It was a long rod, about 3" in diameter, and made of solid metal, either iron or steel. A shoe, which attached to the bottom of the stem, was shaped like a cylinder topped by a truncated cone. The shoe weighed 85-200 pounds when new, but was reduced to 20-50 pounds when worn out. The life of a shoe varied, but it could usually process 85-900 tons of ore.[28] The stamp head or boss was a cylindrical metal piece that connected the shoe to the stem, and added weight.

A tappet was connected to the stem, towards the top end. Next to the tappet, a cam rotated on a horizontal shaft. The lobe of the cam moved under the tappet, lifting it along with the stem and shoe. When the lobe rotated past the tappet, the tappet dropped, and the shoe plunged onto the ore in the mortar. The cam was designed to make the stamp rotate slightly with each drop, to average the wear on the shoe and die.[29] Since the stamp dropped by its own weight, this unit is classified as a gravity mill.

The violent action of the plummeting shoe crushed the ore and forced the finer particles, along with some water, through the mortar screen. The repeated drop established a wave motion, and the pulp (the water/ore mixture) rushed out in regularly timed spurts. Pieces that were still too large stayed in the box until they were ground smaller. Some of the gold adhered to the mercury in the mortar, and dropped to the bottom of that box. As the pulp left the mortar, the level of the stamp dropped lower. At a

certain level the tappet bumped a knob which jiggled the ore feeder, depositing more ore into the mortar. After the pulp was flushed out of the mortar, it swept onto the amalgamation table.

This mill is unusual because it has only one stamp in its mortar. One mortar with the accompanying stamps, cams, frames, and other accessories was called a stamp battery. A mortar in a gravity stamp mill usually contained two, three or five stamps, although five was the most commonly used number in this country.[30]

Because of the variation in the battery size, the capacity of a mill was measured by the total number of stamps. Mills were usually set up with multiples of five stamps. Ten stamps was a common mill size but there could be as many as eighty or even 100.[31] This one-stamp mill was thus considerably smaller than the typical mill. Its capacity was probably a little over one ton in twenty-four hours[32].

Amalgamation Table

Amalgamation was a process in which gold from crushed ore came in contact with mercury and formed an alloy called amalgam. The gold and mercury were removed from the pulp and could then easily be separated. It was the principal means of recovering gold from ores until the successful introduction of the cyanide and flotation processes. Even after these newer techniques became common in the newer and larger plants in the 1930s, amalgamation was still very important, especially in small mills. It was particularly adapted to small-scale operations due to the relatively low initial investment and low operating costs (in small units), simplicity, flexibility, and good recovery from variable grades of ore.[33]

Amalgamation tables had a basic design which changed little over the years. The top was covered with a copper plate, usually silver-plated and coated with mercury. The surface of the table slanted away from the mortar. Before the stamps started dropping, the millman dressed the plates using a good-sized scrub brush, water, and mercury.[34] Keys kept mercury in small food jars (possibly pint fruit jars), with a thin piece of canvas tied across the top. The millman shook the jar, like a salt shaker, over the plate, sprinkling the mercury. He used the brush to work the mercury and water, pushing it back and forth to get a good wet plate.[35]

When the pulp gushed out of the mortar, it flowed down the copper plate. Gold adhered to the mercury on the plate. The table was positioned a few inches lower than the mortar. The drop increased the agitation of the pulp, exposing more gold to the mercury. When

a mill was in operation, a ridge of amalgam could be found at the splash line below the mortar. In addition, the pulp flowed in constantly recurring waves, corresponding to the wave action in the mortar. This movement provided a better opportunity for gold particles to contact the mercury. Usually, there would be a mercury trap at the foot of the table. Keys' table, however, does not have a trap, perhaps because it was not set up to operate in this location.

Running an amalgamation mill was more an art than a science. The millman determined the quantity of quicksilver needed by sliding his finger on the plate. If the mercury was solid, with little hard-looking riffles, he added more to the mortar; too much mercury would feel slick and run too fast. The surface of the plate and mercury was supposed to have the consistency of mushy putty. Depending on the character of the ore, he added a drop or two of mercury to the mortar every hour or so.[36]

The copper plates on this one-stamp came from Gold Park with the mill.[37] Apparently, they had never been silver-plated, and had turned green (they would have been spotted if the silver had worn off). Silver reportedly improved the amalgamation process, and prevented the copper from absorbing the mercury. This lack of silver made the plates very difficult to work with. At the Turtle Races demonstration Keys worked incessantly on the plates, but they continued to perform poorly. Booth declared that he had never seen plates as bad as the ones on this mill.[38]

Cleanup

After all the ore had gone through the stamp, the millman collected the amalgam and prepared to extract the gold; this process was called the cleanup. The millman kept the stamp running for a while, after the ore was crushed, to flush the sand out of the mortar. Next, he stopped the stamp, cleaned up, and panned the amalgam.

To stop the stamp, he hung up the tappet on a finger bar. To do this, he first used the cam stick, or skid. This was a wooden wedge which was covered with a piece of belting or leather on the upper side (to keep the wood from getting cut up and prevent it from slipping) and grease on the lower side (to make the wedge easier to remove). The millman placed the cam stick on the top of the revolving cam, so as it rotated to the top, it rode between the cam and the tappet and lifted the tappet higher than usual. At the moment it reached the peak, he pushed a pivoted wooden bar (called a latch bar, finger bar, latch finger or lifter) under the tappet. The finger bar was a board hinged to the frame near the cam. This

bar held the tappet higher than the cam, so the stamps stopped dropping. This maneuver had to be done carefully, since the millman could pinch or even lose his fingers in the process. The stamp on Keys' mill is currently in this lifted position, supported by the finger bar.

Next, the millman turned off the water and the engine. This completed, he opened the mortar and pulled out the shoe and die, cleaning them along with the inside of the mortar, using small paint brushes. The millman put all the material into gold pans. Next, he scraped all the amalgam off the plate on the table, using a hard rubber or wood squeegee, and put that into the gold pans also. When everything was cleaned off, he added water to the pans and panned them by hand to get the sand out.[39]

The amalgam was silver-colored and spongy, like a heavy mud in consistency; the gold was not visible in it. The millman put the amalgam into a chamois skin, holding it over a gold pan, and squeezed the chamois, forcing out the mercury. The gold remained inside, and was then ready for retorting.[40]

Retorting

After the amalgam was squeezed in the chamois, there was still some residue of mercury on the gold, which had to be removed. The gold was wrapped in a cloth and tied closed with string, then placed in a cast-iron retort. This was a covered metal pot; it had a tube coming out of it, which was lowered into a pan of water. A retort currently sits near the one-stamp mill. The retort was then heated slowly over a wood fire. The mercury vaporized at a relatively low temperature, then moved from the retort through the pipe and into the water. There it cooled, liquified and was recovered. The gold remained in the retort; the temperature was not high enough to melt the precious metal. When the retort had cooled, it was opened. The spongy-looking gold-colored matte inside resembled the texture of a corn meal muffin. The gold was usually sent to the U.S. Mint in San Francisco in this form.

CONCLUSION

The Desert Queen Ranch One-Stamp Gold Mill represents the small mills which were used by prospectors at small mines and considered the standard in the California gold mining industry for over fifty years. The fact that this mill has only one stamp is unusual for two reasons. Mills usually had five stamps in each mortar, instead of one. In addition, most mills had many more total stamps. This one-stamp mill was thus considerably smaller than the typical mill.

ENDNOTES

1. *California Mines and Minerals*, for the California Meeting of the American Institute of Mining Engineers (San Francisco: California Miners' Association, 1899), 396-98.

2. U.S., Department of the Interior, National Park Service, Alaska/Pacific Northwest/Western Team, *Historic Resource Study: A History of Land Use in Joshua Tree National Monument*, by Linda Greene (Denver: Denver Service Center, 1983), 91.

3. Willis Keys, interview by author, 6 August 1991, North Fork, California, tape recording, Joshua Tree National Monument Museum, Twentynine Palms, California.

When a person filed a claim on a mineral site on federal lands, he did not own the property. He only reserved permission to be the exclusive user of the minerals. Miners had to renew their claim annually by doing assessment work (that is, by expending a certain amount of money and labor); and by filing a proof of labor at the county courthouse. A person did not *lose* his title to the claim by failing to do the assessment work, he merely threw the claim open to location (jumping) by another. If no one else claimed the site, the title remained with the original locator. "Government Can Not Challenge Right to Mining Claims," *California Journal of Mines and Geology* 30, no. 4 (October 1934): 440.

4. Keys, 6 August 1991.

This site was near the chicken house, which Keys had made from two cyanide tanks. The tanks were later moved and used for harness storage.

5. Ibid.

6. Oran Booth, interview by Bill Truesdell and Lysa Wegman-French, 26 June 1991, Twentynine Palms, California, tape recording, Joshua Tree National Monument, Twentynine Palms, California.

Oran Booth had first met Keys in 1928. When Booth abandoned the Wall Street Mill site, he gave the rights to Keys. Booth later operated Keys's two-stamp mill on that site. Since Booth was a mechanic, Keys frequently enlisted his aid in projects. They remained friends until Keys's death in 1969.

7. Ibid.

8. Keys, 6 August 1991; Bob Michels, interview by Bill Truesdell, Lysa Wegman-French and Guek Hoon Ong, 17 July 1991, Keys Desert Queen Ranch, California, tape recording, Joshua Tree National Monument Museum, Twentynine Palms, California; and Oran A. Booth,

interview by author, 2 August 1991, Twentynine Palms, California, tape recording, Joshua Tree National Monument Museum, Twentynine Palms, California.

9. Gold also occurs in: 1) high-grade ores suitable for smelting, 2) non-amalgamating ores, 3) placer gold, and 4) complex ores.

10. Selecting a method of treating ore was determined by several characteristics besides the character of the ore, including the amount of capital, the availability of water, and the tonnage expected.

11. T. A. Rickard, *The Stamp Milling of Gold Ores* (New York: Engineering and Mining Journal, 1903), 35.

12. Robert H. Richards, *Ore Dressing* (New York: Engineering and Mining Journal, 1903), 222.

13. C. McK. Laizure, "Elementary Placer Mining in California and Notes on the Milling of Gold Ores," *California Journal of Mines and Geology* 30, no. 2-3 (April, July 1934): 265, 270.

At that time there were six common methods of extracting gold. Ores could be treated by one or more methods: 1) hand sorting, 2) amalgamation, 3) smelting, 4) gravity concentration, 5) flotation concentration, and 6) cyanidation.

14. U.S., Department of Commerce, Bureau of Mines, *Gold Mining and Milling in the United States and Canada: Current Practices and Costs*, by Charles F. Jackson and John B. Knaebel, bulletin 363, (Washington, D.C.: Government Printing Office, 1932), 107. Hereafter cited as Jackson.

15. Algernon Del Mar, *Stamp Milling: A Treatise on Practical Stamp Milling and Stamp Mill Construction* (New York: McGraw-Hill Book Company, 1912), 126.

16. Keys, 6 August 1991; Booth, 26 June 1991; and Willis Keys, interview by Reino Clark and Don Black, March 1975, transcript, Joshua Tree National Monument Library, Twentynine Palms, California.

17. C.H. Wendel, *American Gasoline Engines Since 1872*, (Sarasota, Florida: Crestline Publishing, 1983), 159.

Fairbanks, Morse & Company began making gasoline engines in 1893, and became one of the world's largest manufacturers of engines. The Type Z series was the company's most popular model. Its sales were so widespread that it forced smaller competitors out of business, and even the large International Harvester took notice. Ibid., 158-59.

18. Keys, 6 August 1991; Keys, March 1975; and Booth, 2 August 1991.

19. Booth, 26 June 1991; and Booth, 2 August 1991.

20. Richards, 207.

21. Keys, 6 August 1991.

22. Keys, March 1975; and Booth, 2 August 1991.

23. See U.S. Patent Office, *Official Gazette* 50, no. 2 (14 January 1890), 193; and 23, no. 10 (6 March 1883), 886.

24. Dodge-type crushers were hinged on the bottom, while Blake-type jaw crushers were hinged on the top. Richards, 33-34.

25. Keys, 6 August 1991.

26. Ibid.; and Booth, 2 August 1991.

27. Keys, 6 August 1991.

28. Richards, 181, 182.

29. Richards, 194.

30. Ibid., 145.

31. Otis E. Young, *Western Mining*, (Norman: University of Oklahoma Press, 1970), 198.

32. Michels, 17 July 1991.

33. Jackson, 105, 133.

34. Keys purchased mercury in seventy-six pound steel cans, called flasks, although a mill of this size would have used only about a pint. One of these flasks currently sits by the stamps.

35. Booth, 26 June 1991.

36. Booth, 2 August 1991; and Keys, 6 August 1991.

37. Keys, 6 August 1991.

38. Booth, 26 June 1991.

39. Ibid.; Booth, 2 August 1991; Keys, 6 August 1991; and Richards, 202-03.

40. Keys, 6 August 1991; Booth, 26 June 1991; and Booth, 2 August 1991.

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"Government Can Not Challenge Right to Mining Claims for Failure to Perform Annual Assessment." *California Journal of Mines and Geology (Report of the State Mineralogist)* 30, no. 4 (October 1934): 440-443.
A clarification of laws concerning annual assessment work.

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This mining engineer provided a comprehensive guide to ore mills which could be used as a textbook.

Keys, Willis. Interview by author, 6 August 1991, North Fork, CA. Tape recording. Joshua Tree National Monument, Twentynine Palms, CA.

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Michels, Bob. Interview by Bill Truesdell, Lysa Wegman-French and Guek Hoon Ong, 17 July 1991, Keys' Desert Queen Ranch, CA. Tape recording. Joshua Tree National Monument Museum, Twentynine Palms, California.

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An excellent source for details on the operation of stamp mills, including actual data from functioning mills.

Rickard, T. A. *The Stamp Milling of Gold Ores*. New York: Engineering and Mining Journal, 1903.
A classic in the field, this well-known mining engineer and metallurgist discussed the characteristics of California milling in comparison with those of other regions. He includes many details, with examples from specific mills.

U.S. Department of Commerce. Bureau of Mines. *Gold Mining and Milling in the United States and Canada: Current Practices and Costs*, by Charles F. Jackson and John B. Knaebel. Bulletin 363. Washington, D.C.: Government Printing Office, 1932.
Discusses geology, exploration, development and mining, as well as milling methods and costs for a general public audience.

U.S. Patent Office. *Official Gazette* 23, no. 10 (6 March 1883), 886; and 50, no. 2 (14 January 1890), 193.
Illustrations and brief descriptions of Miles B. Dodge's patents for his rock breaker.

Wendel, C. H. *American Gasoline Engines Since 1872*. Sarasota, Florida: Crestline Publishing, 1983.
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This standard history describes mining and milling methods in the West in an entertaining manner. Young's broad knowledge of the topic enables him to put specific information in context.