Chapter 5

AERIAL MINE TRAMWAYS IN ARIZONA

On February 16, 1997, the aerial tramway connecting the Phelps Dodge smelter at Morenci with a lime quarry three and a half miles away, was blasted down.[1] Although not particularly historic (it was built in 1970), the demolition of this structure marked the end of an era. The Morenci system was the last remnant of more than two dozen mine trams built in Arizona over the past century. To be sure, one can still find a few standing towers and perhaps a piece of machinery, but for all practical purposes, aerial mine tramways have vanished from the landscape. While Arizona saw relatively few of these spectacular devices, some of them were unique, even controversial. This is their story.

Tramway technology was not new when Arizona's first system was erected in the early 1880s. The 1830s development of wire rope in Europe made it possible to begin constructing tramways capable of carrying loads over a distance of several miles. This technology entered the United States prior to the Civil War, but remained primitive and experimental until the 1870s.[2] It required the post-war mining boom in the Far West to spur the development of more sophisticated and effective tramways. The need was obvious. Many western mines were located in rugged terrain, at locations where it was difficult if not impossible to construct processing facilities. As a consequence, transporting ore and supplies proved exceedingly expensive for many mining companies. A device that could overcome these obstacles by riding in a straight line high over the natural terrain promised to provide considerable saving and make mining more practical.

British born inventor and entrepreneur Andrew S. Hallidie gets much of the credit for developing the first practical aerial tramways in the West.[3] Headquartered in San Francisco, by 1870 Hallidie had developed an "Endless Wire Ropeway." Based to some degree on the ideas of an English contemporary, Charles Hodgson, his tramway operated on a single rope. Basically described, the system had a large pulley at each end, through which a wire rope ran in a continual circle. To support the line across the intervening terrain, towers were erected at appropriate locations. On top of each tower were grooved pulleys through which the cable ran. Attached to the moving cable at distances of 50 feet or so were carriers, either ore buckets or hooks to which supplies could be attached. Since most loads moved downhill, gravity often provided enough momentum to keep the system running. In this manner, a tramway, traveling at 200 feet per minute and carrying 150 pounds per bucket, could deliver 36,000 pounds of ore per hour to a mill at a cost of twenty to forty cents per ton mile.[4]

Hallidie constructed his first aerial tramway in Nevada during the summer of 1871, and over the next two decades A. S. Hallidie & Co. built dozens of these devices across the West.[5] The mining world rapidly took to the aerial concept. As the editor of the Engineering and Mining Journal wrote in 1872, "the wire tramway forms its own road and cares nothing for spans in mountainous regions of 1200 feet to 1500 feet and inclines of 1 in 3 or 4. It therefore has its special applicability, and must be made use of in a hundred instances where other means of transport are wholly inapplicable."[6] Over the succeeding years Hallidie and his competitors improved the single rope system. Nevertheless, the basic design retained some serious limitations. Hauling capacity was restricted to about 150 pounds per bucket, it did not function well at distances over two miles, and the permanently attached carriers were difficult to handle.[7]

About 1880 a substantially different type of system was introduced to the American mining community. Developed by German engineers Theodore Otto and Adolph Bleichert, the new system operated on a double-rope design. Ore carriers ran on heavy stationary cables stretched between terminals to form a track. Motive power was provided by a second rope—the traction cable—which ran in an endless loop. The traction cable was attached to the carrier by means of a grip. As described in The Mining Engineers Handbook: "In operation, each load is placed in a carrier while standing on a track in the

loading terminal: the carrier is then fastened to the traction rope, and is hauled along the track cable to [the] discharge terminal; there it is released from the traction rope and [the] contents are discharged." Among the advantages of the "Bleichert" system was a greater carrying capacity, the ability to operate over greater distances, and less cable wear.[8]

Within a relatively short period of time the double-rope tramway began to supplant the single-rope variety in popularity, although both were widely used in the mining industry until after the turn of the century, when cost comparisons produced a rather clear preference for the Bleichert design.[9] By then at least a half dozen companies were manufacturing and installing tramway equipment. With the obvious advantages in regions of rugged terrain, the first aerial tramways in Arizona appeared during the 1880-1900 mining boom.

The First Trams

It is not entirely clear when or where the first aerial tramway was constructed by Arizona miners. From the remaining evidence, however, it appears likely that the first system may have been set up at the copper mines near Morenci in eastern Arizona. By 1884 miners were extracting rich ores in the Copper Mountain Mining District. One of the firms involved, the Arizona Copper Company, put up a wire bucket tramway to bring ores from the Montezuma claim to a planned smelter site. Unfortunately, there is a lack of specific information on this effort and it is unknown if the tramway ever entered service. Given the early date, however, it seems likely that the tramway would have been of the single-rope variety.[10] Even less is known about the second tramway. This one was known to be operating at Virginia Camp near Teviston (Bowie) in 1890. It was manufactured by the Badgley Company of Denver, using the Huson patent (a single-rope variant of the Hallidie tramway). Mine superintendent J. N. Tevis expressed considerable pleasure with his device, reporting that two men could handle it with ease and that the "automatic loading and dumping gear is simply perfection."[11] Considering that Captain Tevis' mining speculations failed to pay off, it may well be that the tram did not last for any length of time.

The early 1890s witnessed an increase in tramway construction. Although not all of them were successful, they were sufficiently unique to attract the attention of local wags, including newspaper editors. Thus as longer and more sophisticated systems were constructed they began to show up more in the written record.

Clifton was one of the hottest copper mining areas in the 1890s. By 1891, times were ripe for competing companies to sieze every opportunity to enhance more profits. One such organization, the Copper King Mining Company, had just opened a smelter along the San Francisco River north of town. To connect their mine with the smelter some two miles distant, company engineers opted for an aerial tramway. The necessary machinery, ordered from an eastern manufacturer, arrived by rail at Clifton during the first half of 1891. By June everything was on hand. Wooden terminals and towers went up first. Then came the difficult task of stringing the cables. As was customary during this era, the wire-rope arrived in great coils. Mule teams were used to reach the construction site. Each mule carried several loops, with the cable running to the next animal and so on. In this manner strings of twenty or more mules could haul up to a half mile of unbroken cable to the tram site. The cables were then attached to the towers and placed under tension. Unfortunately, all this effort went to waste. The Copper King tramway operated for only a few weeks before collapsing. It apparently was not rebuilt and the following year the company ceased operations.[12]

Meanwhile, the Old Dominion Copper company decided to construct a short Bleichert double-rope system to connect its new smelter near Globe with the mine entrance almost a quarter mile away. After reviewing the use of systems in operation elsewhere, company officials entered into an agreement with Cooper, Hewitt and Company of Trenton, New Jersey, to provide the equipment. The advantages seemed obvious. Under present conditions ore had to be hauled down a steep road by mule-team. This made it difficult to keep the heavy ore wagons from running over the mules on the down grade and nearly impossible to move empty wagons uphill to the mine. As a consequence, transportation of ore cost about twenty cents per ton. An aerial tramway promised to end all this and move the ore for less than half the current rate. The Arizona Silver Belt kept Globe residents informed as construction proceeded. The system featured one span of 300 feet and used locked steel wire cables an inch and a half in diameter on the loaded track. The system entered service in January 1892, much to the delight of local residents. As completed, the line utilized eleven buckets of 800 pounds capacity each, enabling the company to deliver by gravity as much as 170 tons of ore per ten hour shift to the smelter.

The Silver Belt's editor reported that "the advantages of the tramway over hauling the ore in wagons are important. The tramway can be run in all kinds of weather, and the cost of delivering ore in the bins is 9 cents per ton, against 20 cents by wagon." This tramway proved to be quite successful and it operated at least until 1906, when a new smelter was built.[13]

Also in the early 1890s a much less successful tramway was constructed to carry supplies into the copper mines at Jerome. Not technically a mine tramway, this system may have been intended as a temporary expedient until the Prescott and Arizona Central (P&AC) Railroad could build a branch line to Jerome. First proposed in 1890 by P&AC engineers to carry freight from the east end of Chino Valley up Yeager Canyon and over the Black Hills to the United Verde Mine, the proposed system would be 4.85 miles in length, with buckets capable of carrying 300 pounds each. Construction began in the spring of 1892, but the line quickly ran into trouble, perhaps because of its great length. In April, A. J. B. Berger, who had designed the system, was reportedly overhauling the line. Soon thereafter newspaper reports indicated that the route needed to be changed and rebuilt. In November 1892, a dejected Prescott editor reported "no freight yet." About this time, things fell apart for the P&AC and the United Verde Mine. Financial hard times put the P&AC out of business. And in late 1894 a rival railroad, the United Verde & Pacific, reached Jerome, making the tramway obsolete. Indeed, it is not certain that the tramway ever went into regular operation.[14]

During the late 1880s two more aerial tramways were constructed at Arizona mine sites. One was built for the United Globe Mine, located next to the Old Dominion operation. Perhaps impressed by what they had seen of the Old Dominion tramway, United Globe managers built a line that nearly duplicated the Old Dominion application. To eliminate hauling ore from the mine entrance to its Buffalo smelter, in 1896 the UG purchased a 3,000 foot Bleichert system from the Trenton Iron Company. At the time, Trenton was a leading national supplier of double-rope systems, having been in the tramway business since the 1880s, and holding patents on several technological improvements, particularly gripping devices.[15] The United Globe tramway was placed in operation in February 1897. Once the Gila Valley, Globe and Northern Railroad reached the Buffalo smelter in 1899, the company began to produce copper at a profit, aided by the operating aerial tramway, which ran until well after the turn of the century.[16]

The last of the 19th century tramways proved to be unique in several respects. Created to serve a gold mining operation along a desolate stretch of the San Pedro River, near present San Manuel, the line served various functions.. Mining claims in this desert region dated backed to 1882 and by 1887 the town of Mammoth was large enough to support a Post Office. About this time a 30-stamp mill opened adjacent to the San Pedro River, there being no water at the mine site, some three miles away. Sporadic mining took place until 1897 when a financial reorganization created Mammoth-Collins Gold Mines, Ltd., a firm with British interests. With an infusion of new money, the company decided to modernize operations by constructing a 2.75 mile Bleichert tramway to carry ore from the mine to the mill at Mammoth. The tramway was expanded a year later and provided a back traffic service by using empty tram buckets to carry river water back to the mine. Nevertheless, the tramway was largely unsuccessful. At one point some 20 of its towers collapsed. Then, in April 1901 a cave-in put the Mammoth-Collins mine and tramway out of business. It is unlikely that the tramway ever operated again. When the mines were reopened in 1906, the Mohawk Gold Mining Company built a mill near the mine, using water pumped from the old Mammoth shaft, which had ironically flooded at the 800 foot level.[17]

The Boom Era

During the first two decades of the 20th century, Arizona mine operators erected over a dozen aerial tramways. Although achieving varying degrees of success, this construction boom coincided with the most intense period of aerial construction in the mining West. With a couple of exceptions, all the Arizona tramways were variants of the Bleichert double-rope system. A brief survey shows the following operators, dates of construction, and length (where available): (1) The Arizona Copper Company west of Metcalf, 3,500 feet, 1900; (2) Standard Copper Mines near Metcalf, 3,200 feet, 1904; (3) De Soto Mine near Cleator, .75 mile, 1904; (4) Blue Bell Mine near Mayer, 3.3 miles, 1905; (5) Old Shattuck Mine, Bisbee, 3,300 feet, 1905; (6) Black Eagle Mine near Oatman, 1908; (7) Copper King Mine near Clifton, 1909; (8) Big Jim Mine near Oatman, ca. 1913; (9) Magma Mine, Superior, 2,600 feet, 1914; (10) Mascot Mine, near Willcox, 10,000 feet, 1915; (11) Christmas Mine,

Christmas, 7,300 feet, 1916; (12) Boulder and Abbie B. mines, near Metcalf, 1917. Fragmentary evidence points to several other tramways.

With such a wide variety of tramway operations, it is not necessary to describe each one in detail. Instead, a few of the more notable or unusual operations of this period will be discussed.

Two of the most interesting tramways were located in the Bradshaw Mountains, north of Phoenix. Both the De Soto and Blue Bell tramways were similar in construction, were connected to the Bradshaw Mountain Railway, and were owned by the Consolidated Arizona Smelting Company. They appeared at the height of the Arizona copper boom and managed to survive into the 1920s.

The De Soto's tramway came first. Located on a high plateau, the mine site had been known to contain copper deposits since the 1870s. A lack of access, however, had made it impossible to successfully develop the property, owing to the fact that ore had to be packed all the way to Prescott. The completion of the Bradshaw Mountain Railway to Middleton in 1903 put the mine less than a mile from the railroad, offering an opportunity to develop the De Soto.

This was especially fortunate, since the railroad, as it wound its way from Prescott, passed through Humboldt, where Consolidated Arizona operated its smelter. This led Consolidated to purchase the De Soto in 1904, refurbish the mine, and construct a 3/4 mile aerial tramway to connect the mine with a siding at Middleton. Completed in April 1904 using machinery supplied by the Trenton Iron Company, the double-rope tram could deliver about 300 tons of ore per day to the terminal loading bins for shipment to Humboldt.[18]

A year later, Consolidated Arizona acquired the even more productive Blue Bell property, located about five miles north of the De Soto. Quickly upgrading the property, the company installed a 3.3 mile Trenton tramway, running in a northerly direction to connect with the Bradshaw Mountain Railway at Blue Bell Siding, a few miles from Mayer. Thus, although the two mines were only five miles apart, their tramways went in opposite directions to connect with the same railroad. At Blue Bell Siding the Consolidated Arizona constructed a large wooden tramway terminal. The Blue Bell tramway proved to be a good investment. At a capacity of 500 tons per day, it delivered ore to the railroad at a cost of 5.6 cents per ton mile. This included wages for two operators per shift, at a daily rate of $4.65.[19]

In their day these two tramways provided considerable excitement. Although well-built, they had their share of troubles, especially when periods of financial constraint deferred proper maintenance. From time to time, buckets broke loose and dropped to the ground. In one incident on the Blue Bell line, the traction rope came off a bucket, causing it to slide backwards down the line until it collided with the following bucket, which happened to contain a load of dynamite. Upon impact, both buckets fell to the ground, but fortunately no explosion occurred. Explosives and supplies, of course, were not the only items sent to the mine by tramway. Both trams delivered drinking water to the miners and even the casket of a miner killed in an accident came down the De Soto tramway. Passengers also used the bucket line to take advantage of a free ride. Most people sat in empty buckets going up, but were forced to ride on top of the ore going down. Despite the discomfort, a tram ride could be spectacular. Perhaps some of the passengers expressed sentiments similar to those of Martha Kelsey, who described an aerial tramway ride over Chilkoot Pass in 1898: "straight up the mountain side and in to a dark canyon I went as if I were a bird. Higher and higher up from the ground the cables carried me, and I was afraid to look down."[20]

The De Soto and Blue Bell tramways operated on or off for several years, their use dependent on the vagaries of the copper market and the quality of ore reserves. The De Soto line operated from April 1904 to August 1907, and again from 1915 until the Humboldt smelter shut down in 1920. In 1922 Consolidated Arizona successor Southwest Metals sub-leased the mine to a succession of small operators who may have used the tramway for short periods before a fire in 1930 destroyed the terminal and several towers at Middleton. Although activity at the De Soto property ceased permanently in 1931, a number of the upper towers have survived the ravages of time, and can still be seen from the road to Crown King. The history of the Blue Bell line followed a similar chronology. After closing about 1907, it reopened in 1913 with a completely refurbished tramway line, which ran until 1921. It apparently operated again between 1924 and 1926, by which time the mine was played out. Although Southwest Metals subleased the property, the tramway had deteriorated to such a degree that it was inoperable. The system was dismantled in 1932. Nothing remains today to mark its existence.[21]

Although most of the early century tramways were of the Bleichert design, several exceptions are known to have existed. It appears from the scanty evidence available that the single-rope Huson tramway first used in 1890 at Virginia Camp many have later been used at the nearby Mascot Mine near Willcox in Cochise County. In 1915, the Mascot Copper Company, run by the flamboyant Thomas N. McCauley, set up a 10,000 foot aerial tramway between its mine and the newly constructed Mascot and Western Railroad. After minimal success for several years, the Central Copper Company was organized to run the mine. About 1924 an additional mile was added to the bucket line. This second-hand system would have sported an automatic loading and unloading feature which could be operated by two men at minimal cost.[22]

The other unusual tramway served the Rainbow Mine near Chloride. Built about 1920, this 8,000 foot system connected the mine with a loading terminal near the Tennessee Mine. Although little documentation exists, a description of the ruins indicate that it was an "Automatic Aerial Tramway" built by the Interstate Equipment Company of New York. At the time, Interstate had just introduced a distinctive new design. This system featured cars, much like mine cars, mounted on four grooved wheels which rode on two parallel cables and were pulled by a traction cable attached directly to the bottom of the ore car. This three cable arrangement offered more stability, with the ore cars discharging their contents at the terminal and returning to the mine upside down on a second line which usually ran below the first one. It is not known how long this line operated before being abandoned.[23]

A much more typical example of early century Arizona tramways was the one located at Christmas in Gila County. Although copper claims in the area dated back to 1879, little mining was done until after 1900 when the Saddle Mountain Mining company began operations in this remote region. While waiting for rail connections to arrive from Winkelman, the company built a 3,600 foot aerial tramway in 1907 from the mine at Christmas Camp to bins located on the Gila River. This construction unfortunately coincided with a slump in copper prices, which idled the mine and eventually led to its purchase in 1909 by the Gila Copper Sulphide Company, a subsidiary of Frank M. Murphy's Development Company of America. In 1911 the Arizona Eastern Railroad completed its line up the river to a terminus at the mouth of Copper Canyon (about a mile and a half from the mine). Once again, however, financial problems shut the mine down. It was reopened in February 1916 by the American Smelting and Refining Company (which leased the property from Gila Copper Sulphide). To work the mine effectively, in April 1916 the company replaced the old tramway with a 7,300 foot Bleichert system, which connected the Christmas Mine with the Arizona and Eastern Railroad terminal. The tramway itself dropped some 950 feet at a rated capacity of 50 tons per hour. It also turned an electrical generator, which provided power to the mine. The upper ore bin held 250 tons, the bottom one 1,000 tons. Cost of operation in 1919 was reported to be 17 cents per ton. Ore delivered to the terminal was hauled by rail to the ASARCO smelter in Hayden. Like other copper mines, the Christmas operated sporadically after 1920, although it did not close entirely until 1977. Exactly what happened to the tramway is not clear. It was most likely used during the 1920s to ship ore to the railroad, but with deferred maintenance. It probably became inoperable during the 1930s and by the time the Inspiration Copper Company converted the property to an open pit in 1966, all remaining traces had vanished.[24]

Post-War Finale

It seems doubtful that any of the early century tramways operated past the early 1930s. Economic conditions during the Depression did not justify maintaining such equipment, especially as most of the mines were pretty much played out. After the Second World War advances in road building, bigger trucks, and the trend to open pit mining ruled out the need for tramways at most locations. Nevertheless, three aerial systems were constructed in Arizona after the war, two of which were located in the Grand Canyon.

The Orphan Mine, a leading high-grade uranium mine on the South Rim of the Grand Canyon was one of Arizona's most controversial operation. Claims to the Orphan Lode, located in Grand Canyon National Park a few miles west of Grand Canyon Village, date back to the 1890s. At that time, Daniel L. "Pops" Hogan discovered an outcropping of unusual minerals about 1,100 feet below the rim. In 1906, just before the federal government began protecting the Canyon, Hogan received a patent for his claim, which, because of its green colored ores, he believed to be rich in copper. Despite a failure to make anything of the mine, Hogan held onto the property until 1947. By this time, the Orphan Mine represented the only privately held land within Park boundaries, and was

greatly coveted by the National Park Service, which viewed it as an "ugly intrusion" on the Park. Nevertheless, Hogan sold the claim to the Prescott woman, who used the land on the rim to construct a tourist lodge. Meanwhile, assays showed that the mine's bright green ore was actually uranium.[25]

The property was sold to the Golden Crown Mining Company in 1953. Hoping to cash in on the booming demand for uranium, Golden Crown (a subsidiary of Western Gold and Uranium) sent out geologists to determine the most practical way to bring ore 1,100 feet to the canyon's rim. At the end of 1955 they decided to build an aerial tramway rather than service the mine by Hogan's steep trail and series of ladders. After an early tramway proved unworkable, materials for a second line were acquired from the Riblet Tramway Company in Spokane and installed by Western Gold and Uranium for a total cost of $61,800. Actual construction presented some unique challenges. Because of the steep canyon walls, the towers were set in place by workers strapped to Bosun's chairs suspended by ropes. When completed the tramway stretched a total distance of 1,800 feet. Supported by several intermediate towers and two terminal towers, the line descended at a 37 degree angle for the first 1,000 feet, then at 57 degrees for the final 800 feet. Ore deposited atop the rim was trucked to a mill at Tuba City, Arizona, for processing. This tramway became operational in April 1956.

Because of the rugged terrain, the Orphan tramway also carried miners and supplies to the mine. Although the mine was one of the richest in the United States, the Park Service wanted what amounted to an eyesore removed from the middle of a pristine area visited by millions of people each year. Local politicians, however, saw the mine as a key factor in the survival of northern Arizona's uranium industry and wanted to secure access to adjacent ore deposits under NPS land. Meanwhile, the tramway proved inefficient and expensive to operate. The two bucket, jig-back system limited the amount of ore that could be carried to the rim, pushing costs to about $25.00 per ton. To counter this problem, in 1959 the owners sunk a shaft from the rim directly to the lode. With this, the tramway became obsolete for hauling ore, although it continued to be used for several more years to transport personnel and supplies. In 1969 the mine ceased operations, largely because of NPS opposition, a decline in uranium prices, and the fact that ore now had to be carried to Colorado for processing. The Orphan claim was finally turned over to the Park Service in 1987. Portions of the old tramway can still be observed near the rim.

The other Grand Canyon tramway, also built in the late 1950s, became famous as a major "boondoggle." This system was created to service the "Bat Cave," a natural cavern located deep in the western part of the Canyon, about 800 feet above the Colorado River. The cave got its name from deposits of bat guano, which in the 1950s was being touted as a natural plant fertilizer. In 1958 the U.S. Guano Company leased the cave in order to extract an estimated 200,000 tons of guano deposited over the centuries. After unsuccessfully experimenting with the use of boats and aircraft to remove the guano, the company contracted with the Western Steel Division of U.S. Steel to construct a 10,000 foot modern double-rope jig-back system using two cable cars. Again construction presented challenges, including how to get the initial cable across the Canyon, a feat finally accomplished by helicopter. When completed, the longest span, from the south rim to a tower near the river, covered a mile and a half, giving the tramway by far the longest span across a canyon in the United States. Unfortunately, the "Bat Cable" was troubled from the start. During the first year cables snapped twice, crashing to the Canyon floor. Once operations began, it was discovered that the cave contained only 1,000 tons of guano, and within a year the mine had played out. As one critic noted: "The Company had spent $3.5 million to salvage 1,000 tons of guano which sold for 69 cents a pound." Shortly after the mine closed an Air Force jet clipped one of the lines, which dropped into the Canyon. The remaining cable was used one final time to make the 1959 film Edge of Eternity, featuring Cornell Wilde and the tramway. Although a costly failure, U.S. Steel considered the project worthwhile because "we got a million dollars worth of free advertising doing the job."[26]

The final aerial mine tramway built in Arizona went up at Morenci in 1970. Built to connect a limestone quarry east of the San Francisco River with the Phelps Dodge smelter at Morenci, the four mile tramway was built by the Interstate Equipment Company, which used a modernized version of the same system it set up at the Rainbow Mine in the 1920s. Employing several high steel towers, cars holding 2,000 pounds of limestone operated on two parallel cables during the slow trip from one end to the other. At the unloading terminal "each car was flipped over on its back, the rock would fall out, and the car would ride back to the quarry upside down

for another load." This tramway operated for less than a decade before a better source of limestone was located. It then remained idle until February 1997, when Phelps Dodge took it down.[27]

With the demise of the Morenci tramway, the era of aerial mine transportation in Arizona came to a close. For over a century these devices helped to make mining a more profitable venture in areas where surface transportation would be expensive. The tramways themselves had a rather checkered record; some worked well and served their intended purpose, others failed. Always a spectacular sight, with buckets of ore moving across miles of rugged countryside suspended from thin cables, the trams never attracted as much attention as railroads. Nevertheless, they formed a rather remarkable piece of Arizona's mining history. It is perhaps unfortunate that none have survived intact. Still here and there a sharp eyed observer can still spot a remnant or two.

NOTES

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3. Edgar M. Kahn, *Andrew Smith Hallidie: A Tribute to a Pioneer California Industrialist* (San Francisco: privately published, 1953), 1-13; Lynn R. Bailey, Supplying the Mining World: The Mining Equipment Manufacturers of San Francisco, 1850-1900 (Tucson: Westernlore Press, 1996), 122-126.

4. The best description of Hallidie's cable system is provided in his own words. See Andrew S. Hallidie, *Transportation of Ore and Other Materials by Means of Endless Travelling Wire Ropes* (San Francisco: C. A. Murdock & Co., 1978), 1-25. See also "Hallidie's Endless Wire Rope Tramways," E&MJ (July 2, 1871): 2.

5. Hallidie, *Transportation of Ore*, 6-7; "The Denver Exposition," Mining and Scientific Press (hereafter M&SP) (September 15, 1883): 162.

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7. Stephen De Zouidovia, "Aerial Tramways," *The Iron Age* (September 24, 1903): 30; Edward B. Durham, "Aerial Tramways and Cableways," in Robert Peele, ed., *Mining Engineer's Handbook* (New York: John Wiley & Sons, 1927), Vol. II, 1787.

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10. David F. Myrick, *Railroads of Arizona, Vol. III: Clifton, Morenci and Metcalf Rails and Copper Mines* (Glendale, CA: Trans-Anglo Books, 1984), 78.

11. "Huson's Patent Automatic Wire Rope Tramway" (Denver: C. W. Badgley & Co., circa. 1893), 19.

12. Myrick, *Railroads of Arizona, III*, 93. A good description of how mules were used to bring cables to the construction site is contained in "Unusual Feat in Transportation," E&MJ (June 15, 1907): 1159.

13. *The Arizona Silver Belt* (Globe), July 18, August 8, 1891, and January 30, 1892; David F. Myrick, *Railroads of Arizona, Vol. II* (San Diego, CA: Howell-North Books, 1980), 835, 847; Clara Woody, "The Old Dominion Mine," Globe Chamber of Commerce, nd; Frank Badilla, "The Old Dominion Mine," *Copper Sense* (October 1987): 6.

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16. Myrick, *Railways of Arizona, II*, 847, 916, 923.

17. Ibid., 724; *The Arizona Silver Belt*, March 4, 1891: Kim M. Howell, "The History of Tiger, Arizona," unpublished typescript, 1988, Mascot Mine file, Arizona Department of Mines and Mineral Resources.

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20. Sayre, *Ghost Railroads*, 77, 91; "Report on De Soto Mine;" Times-Gazette (Redwood City, California), March 5, 1898.

21. "Report on De Soto Mine;" Annual Report, Consolidated Arizona Smelting Company, 1916;" Sayre, *Ghost Railroads*, 77-78.

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23. "Rainbow Mine Tram Line," typescript, Mohave County Historical Society, Kingman, AZ; *The Mining Catalog (Metal and Quarry Edition)*, fifth issue, 1925 (Pittsburgh: Keystone Consolidated Publishing., Inc., 1925), 502, 511.

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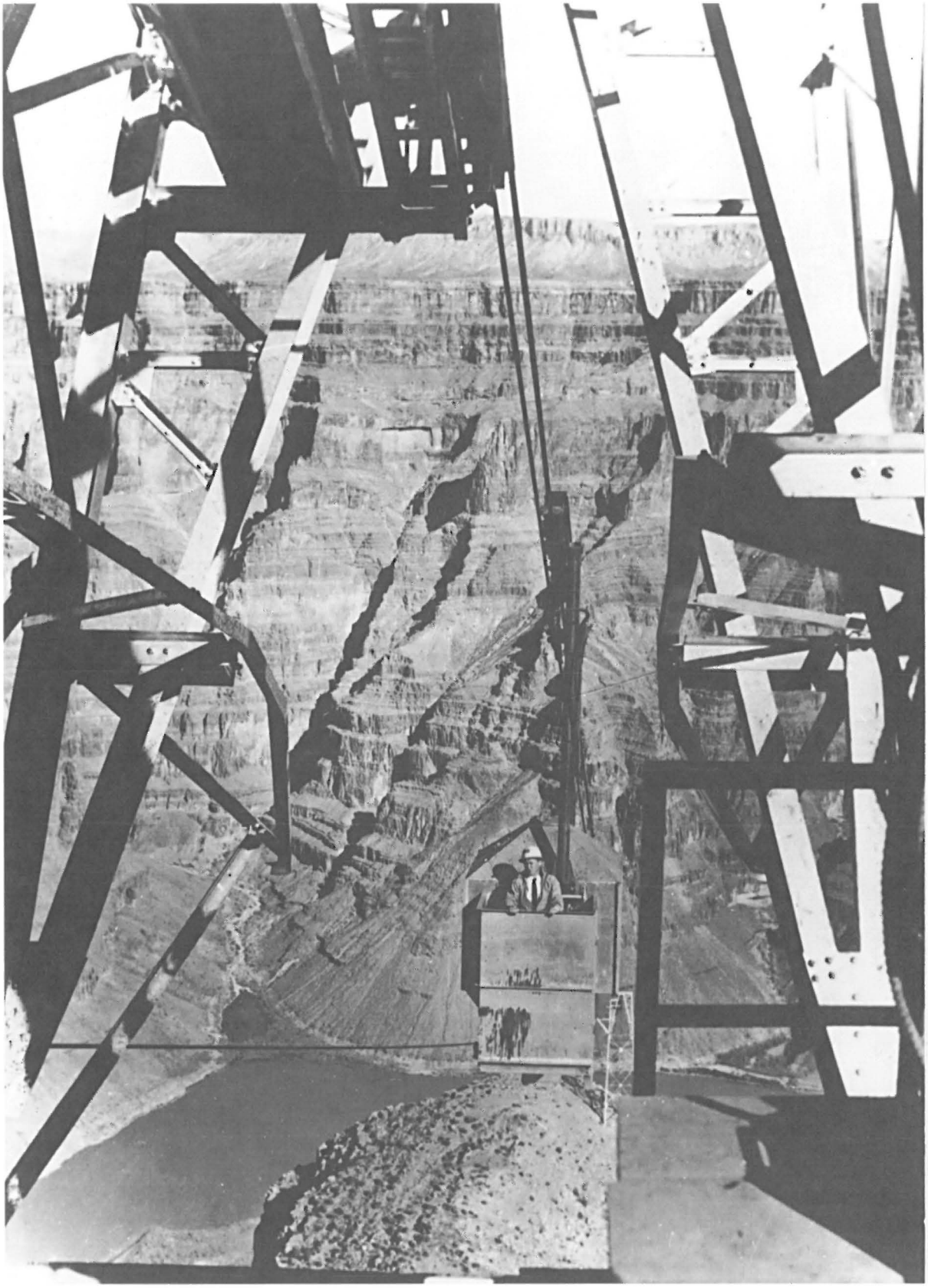
25. The most complete history of the Orphan Mine is contained in a National Register of Historic Places nomination, done in 1993 by National Park Service historian Harlan D. Unrau, copy in author's possession. Other useful sources include: "Field Engineers Report," September 4, 1959, Arizona Department of Mines and Mineral Resources; "They Go To Work In A Bucket," *Arizona Days and Ways Magazine* ((June 9, 1957): 6-11; "How Western Gold Mines Uranium in Grand Canyon," *Mining World*, (January 1959): 32-35; Clyde M. Brundy, "Orphan with a Midas Touch," *The Denver Post* (November 27, 1977); "Orphan Mine Suspends Uranium Ore Production," *Pay Dirt* (April 28, 1969).

26. Field Engineer's Report, July 29, 1957, U.S. Guano Company file, Arizona Department of Mines and Mineral Resources; *Arizona Republic* (July 28, 1957); Bud DeWald, "Canyon Cable to Riches," *Arizona Days and Ways* (January 12, 1958): 7-8; Greer Cheser, "Treasure of the Granite Gorge," *Canon Journal* (Spring/Summer 1996): 12-13.

27. Myrick, *Railroads of Arizona, III*, 288; *Phoenix Gazette* (October 6, 1972); Conger, "Old Clifton Stack and Tramway Hold Many Memories."



Tramway car arriving at the upper terminal of the ill-fated "Bat Tram" in the Grand Canyon, 1958. Guano miners rode the tram cars daily to reach work. Courtesy of the Mohave Historical Society #5486.

Shattuck Tramway. Courtesy of Arizona Historical Society/Yuma.

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