ORPHAN LODE MINE, HEADFRAME
(Orphan Mine, Headframe)
Grand Canyon National Park
North of West Rim Road between Powell Point and Maricopa Point,
South Rim
Grand Canyon Village vicinity
Coconino
Arizona

HAER AZ-67-A
AZ-67-A

PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

FIELD RECORDS

HISTORIC AMERICAN ENGINEERING RECORD
National Park Service
U.S. Department of the Interior
1849 C Street NW
Washington, DC 20240-0001

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HAER NO. AZ-67-A

(page 1)

Location: Grand Canyon National Park, North of West Rim Road between Powell Point and Maricopa Point, Grand Canyon Village vicinity, Coconino County, Arizona, in the SW quarter of section 14, Township 31 North, Range 2 East, Gila and Salt River Meridian, UTM: 12; 396442 mE, 3992235 mN (at headframe)

Date of Construction: 1959

Designer: Unknown

Builder: Original builder unknown. Centennial Contractors was involved in rebuilding the headframe after the 1961 collapse.

Present Owner: The National Park Service

Present Use: None

Significance: The Orphan Mine headframe is a good example of a post-World War II four-post steel headframe. During its operation, the headframe was responsible for significantly increasing ore production by allowing easier and faster access to the lower workings of the mine and providing more lifting capacity.

The Orphan Lode Mine site has been determined an eligible site for listing in the National Register of Historic Places (NRHP). The Orphan Mine is significant because it is associated with "events that have made a significant contribution to the broad patterns of our history" (1). With the discovery of uranium deposits, the mine was further explored and developed between 1953 and 1969, and was "one of the leading producers of high-grade uranium ore on the Colorado Plateau and of some of the richest uranium ore in the United States. Thus, the mine played an exceptionally important role in the development of the nation's nuclear capabilities during the Cold War" (2).

The Orphan Mine has a long history, reaching back to the late 1890s. The Orphan Lode Mine began as a copper mine. In 1891, Daniel Hogan and Henry Ward were prospecting in the Grand Canyon, where they found an outcrop of copper minerals 1,100 feet below the Grand Canyon rim at the base of the Coconino sandstone. On February 8, 1893, Hogan and Ward filed a mining claim on 20.26 acres on what would eventually become the Orphan Lode Mine. The site has since included copper mining, uranium mining, and a resort that changed hands numerous times over the years. For a number of years the resort and mine existed side by side, but eventually the vacation lodging was demolished and removed, and uranium mining—the activity that the site has become best known for—was the only activity on the property.

The dominant feature of the Orphan Mine Upper Yard is the steel headframe, which is mounted over the vertical shaft at the edge of the canyon rim. Not only is it the dominant feature, but also it is one of the few remaining features of the Upper Yard that retains its appearance and is relatively intact. While the structural framing of the headframe and the attached ore chute have retained their engineering integrity, most of the operating components such as the two sheaves located at the top of the headframe, the pulleys for the cables, and the cables themselves have been removed (3).

Prior to sinking the vertical shaft and construction of the headframe, an aerial tramway served as the only means to transport ore and mine personnel between the lower workings and the Upper Yard (4). This means of retrieving ore from the workings was a limiting factor in ore production. Between 1958 and 1961, significant development of the Orphan Mine took place to increase production (5). As part of the mine development, a vertical shaft was sunk and a steel headframe erected in 1959.

Physical Description

The headframe, which stands 80-feet tall, is mounted over a 2-1/2 compartment shaft that contains two 5 by 5 foot hoisting compartments and a 3 by 5 foot manway (6). The headframe was designed to accommodate the hoisting and dumping of two 2-ton mine ore skips (skips are the carts that haul ore to the surface). Attached to the underside of each skip a man cage was used to transport mine personnel to and from the lower workings of the mine (7). According to Maurice Castagne, the arrangement of the man cage below the skip at the Orphan Mine was unusual since the normal arrangement was for the man cage to be located above the skip (8). This arrangement allowed for a shorter headframe.

The Orphan Mine headframe is a four-post design with two back bracing struts. The back bracing struts attach to the tops of the rear tower legs at the upper platform level and extend to grade. The footprint of the headframe tower measures approximately 14 feet by 9-1/2 feet. The tower portion of the headframe is braced in each plane of the tower. The back bracing struts are braced in each direction, between each of the struts and between each strut and the rear leg of the tower. The primary framing members, which include the tower legs, back bracing struts, and the horizontal struts of the tower, are 6-

inch wide flange shapes. The bracing members are single angles, with the exception at the lower portion of the tower where there are bracing members that are 6-inch wide flange shapes and double angles. At the upper level of the headframe, four heavier steel wide flange shapes support the sheave wheels. All members of the headframe are connected with bolts.

The headframe is supported on concrete foundations that rest on mine waste rock that was placed on the canyon rim edge, probably to provide a level surface (9). Because of the steep grade incline, the front legs of the headframe extend to a lower level. Each of the vertical legs and rear bracing struts of the headframe are secured to the foundations with steel anchor bolts.

The original headframe, as built in 1959, contained an ore bin that was situated between the rear legs of the tower portion of the headframe and the rear bracing struts. Due to a design flaw in the ore bin, the bin collapsed on December 22, 1961 (10). None of the workers were injured but hundreds of tons of ore fell back into the shaft. Damage to the headframe was considerable, and mining stopped for several months while the damage to the headframe was repaired. Repairs were completed in 1962 (11) with modifications to the headfame, which included eliminating the ore bin and replacing it with an ore chute.

The ore chute, which received ore and waste rock from the skips, deposited these materials directly on the ground. There it was loaded into trucks for shipment to the mill. A steel-framed retaining wall located below the rear back braces of the headframe controlled the spillage from the chute. The upper end of the ore chute is supported by a steel frame that is positioned adjacent to the rear legs of the headframe tower. Each leg of this support frame is braced laterally by a diagonal brace. The chute at its lower end is supported on the framing of the steel retaining wall.

Headframe Design Criteria

Headframes can be categorized into four basic designs proven to meet the rigors of a production class ore mine. These include the four-post frame, the six-post frame, an A-frame known as the California frame, and a heavily braced two-post structure referred to as the Montana frame. The four and six-post frames feature back bracing struts that extended diagonally from the upper portion of the rear posts to a point at grade between the rear posts and the hoist engine (12). As a design guideline, the position of the back bracing struts should fall within the pull of the hoisting rope in the shaft and the pull of rope from the hoist (13).

The earliest headframes were built with heavy timbers. By the early 1900s, steel replaced timber as the construction material for production class headframes. Steel headframes of the post-World War II era were constructed with rolled steel shapes while the earlier steel headframes used built-up steel sections. Post-World War II steel headframes were also characterized by either bolted or welded connections, whereas connections of the earliest steel headframes were riveted.

Although more costly, steel as a construction material has some distinct advantages, primarily it being a much stronger material, decay resistant, and non-flammable. With adequate bracing, steel headframe structures are capable of supporting heavier production loads and reaching taller heights.

The selection and design of a headframe is dependent on many factors. Staley, in his *Mine Plant Design*, lists the following factors that influence the selection and design of a particular headframe.

1. Amount of material to be hoisted.
2. Hoisting speed.
3. Method of hoisting.
4. Shaft depth.
5. Inclination of the shaft.
6. Arrangement of compartments in the shaft.
7. Height at which the ore is discharged on the headframe.
8. Method of dumping skips.
9. Equipment such as ore bins or chutes attached to the headframe.
10. Location of the hoist in reference to the headframe.
11. Topography of the site where the headframe is mounted.
12. Effects of wind.
13. Height of the headframe.
14. Material of headframe construction.

The engineering of the headframe structure involved considering many different forces, both vertical and horizontal. Vertical forces included dead loads, live loads, and braking loads. The live loads included the weight of the ore that was transported in the skips, weight of equipment and/or mine personnel that were transported in and out of the mine, and the weight of any ore that was deposited and stored in the ore bin. Horizontal forces included the reaction of the horizontal thrust of the hoist and wind loads. Adequate bracing of the structure was necessary to prevent racking and swaying of the structure under various loads, vibrations, and shocks (14).

An important part of the engineering task was to establish the required height of the headframe. The height of the headframe is mainly controlled by the length of the skip and cage and its connection to the hoisting rope, the height of point of dumping for the skips, and an allowance for overwinding of the hoist rope (15). The height of a headframe not only impacted the cost of the headframe but also affected the design, particularly the lateral stability of the frame. A taller frame meant larger member sizes and possibly a larger footprint of the frame so as to resist the resulting larger overturning moment.

The design of a headframe would vary to suit the local mine conditions. For example, at mines located in colder climates or at high altitudes, parts or all of the headframe might be enclosed. The design would also reflect the ideas of its designer. Each mine would have peculiarities that apply to it specifically, effectively preventing standardization of the headframe. Thus, each headframe is a custom design to meet that mine's particular requirements.

Summary

The design of a production class headframe, such as the Orphan Mine headframe, presented a challenging task to its designers. Not only did the designer have to consider the many functional requirements of the headframe and account for a variety of forces that acted upon the structure, but he also had to contend with a very difficult site. Erecting a headframe on the rim of the Grand Canyon posed a serious challenge.

In the case of the Orphan headframe, the ore bin had a direct influence on establishing the height of the headframe. The height of the bin was set so a truck would clear the underside of the bin. This height in turn set the point of dumping for the skips, which with an allowance for overwinding set the height of the headframe. If the frame had originally been designed with a chute instead of an ore bin, the frame could have been shorter (16).

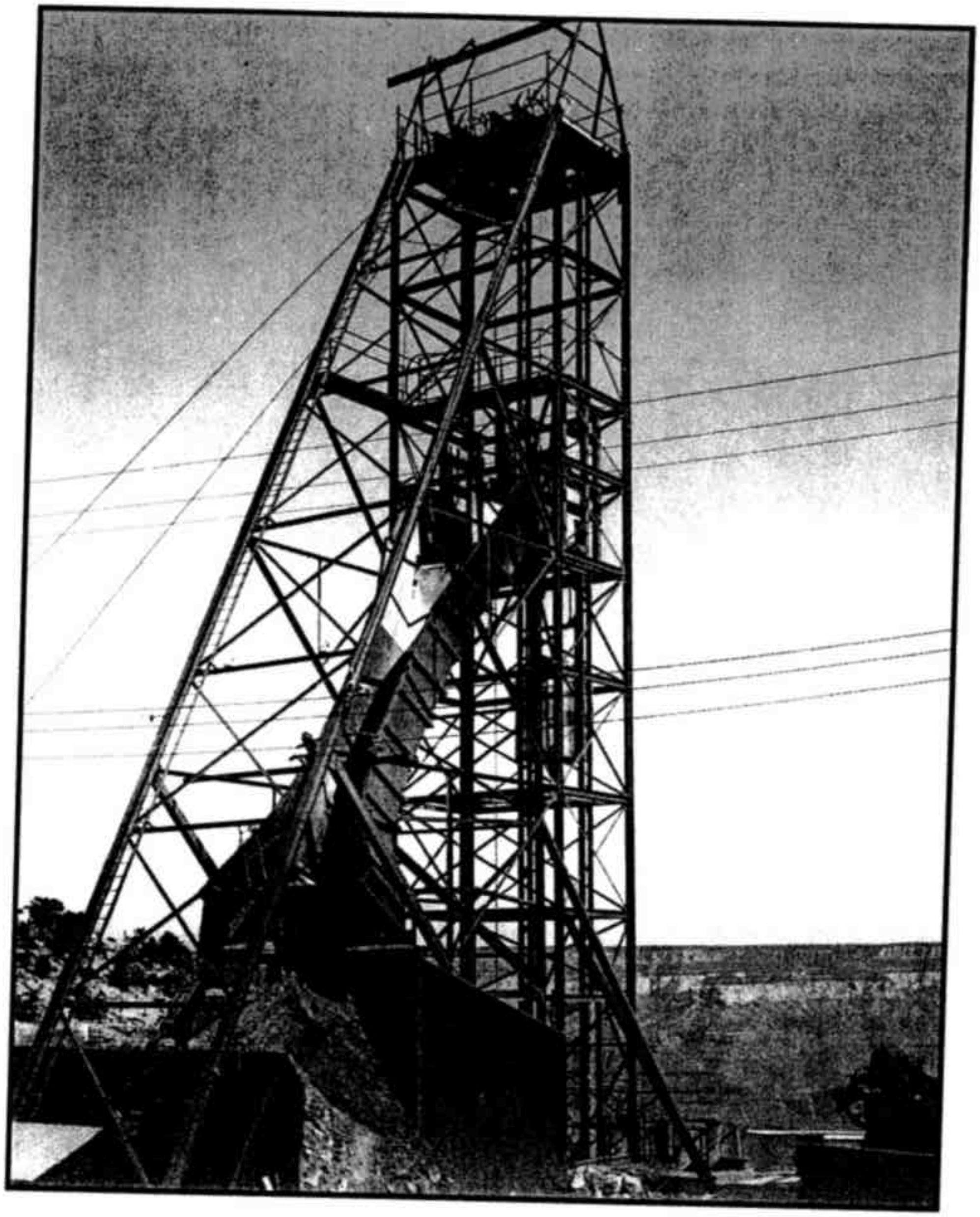

Photo 1. View of Orphan Mine headframe with ore chute (Source: NPS, 1963).

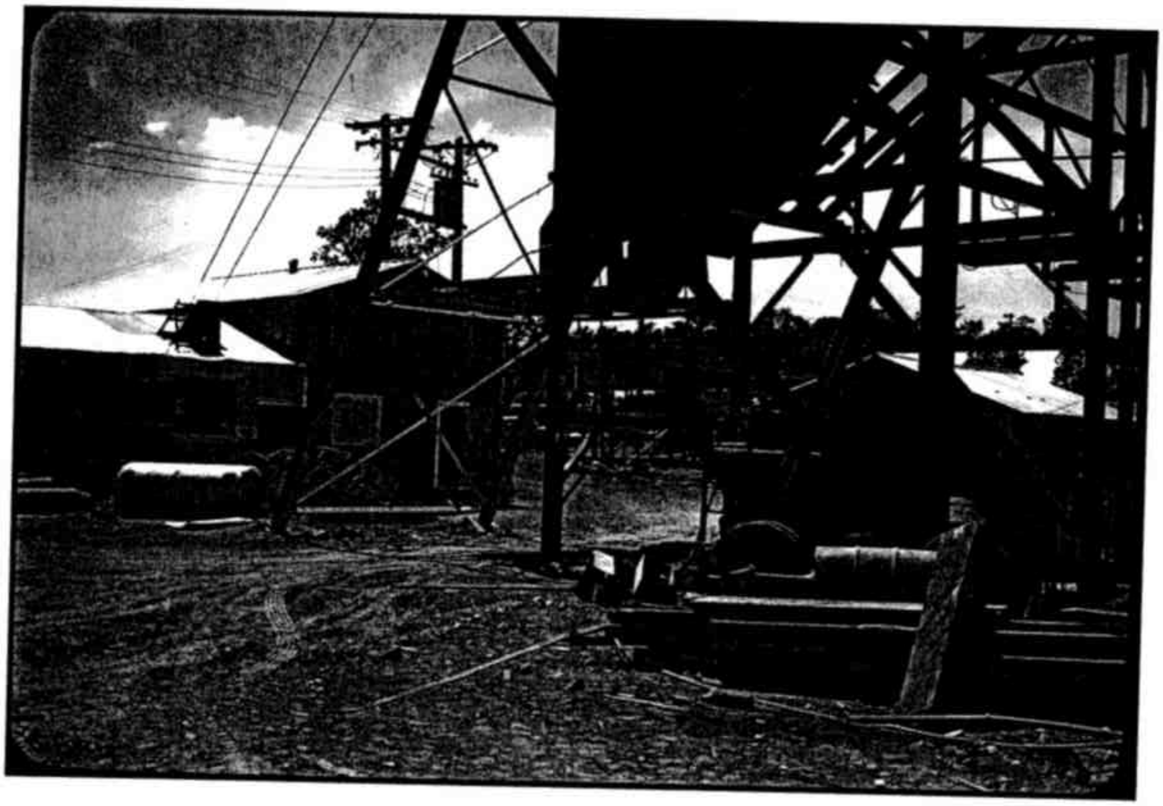

Photo 2. Ore bin attached to headframe of Orphan Mine. Note back bracing strut bisects angle formed by hoisting rope and rear legs of headframe (Source: NPS, 1959).

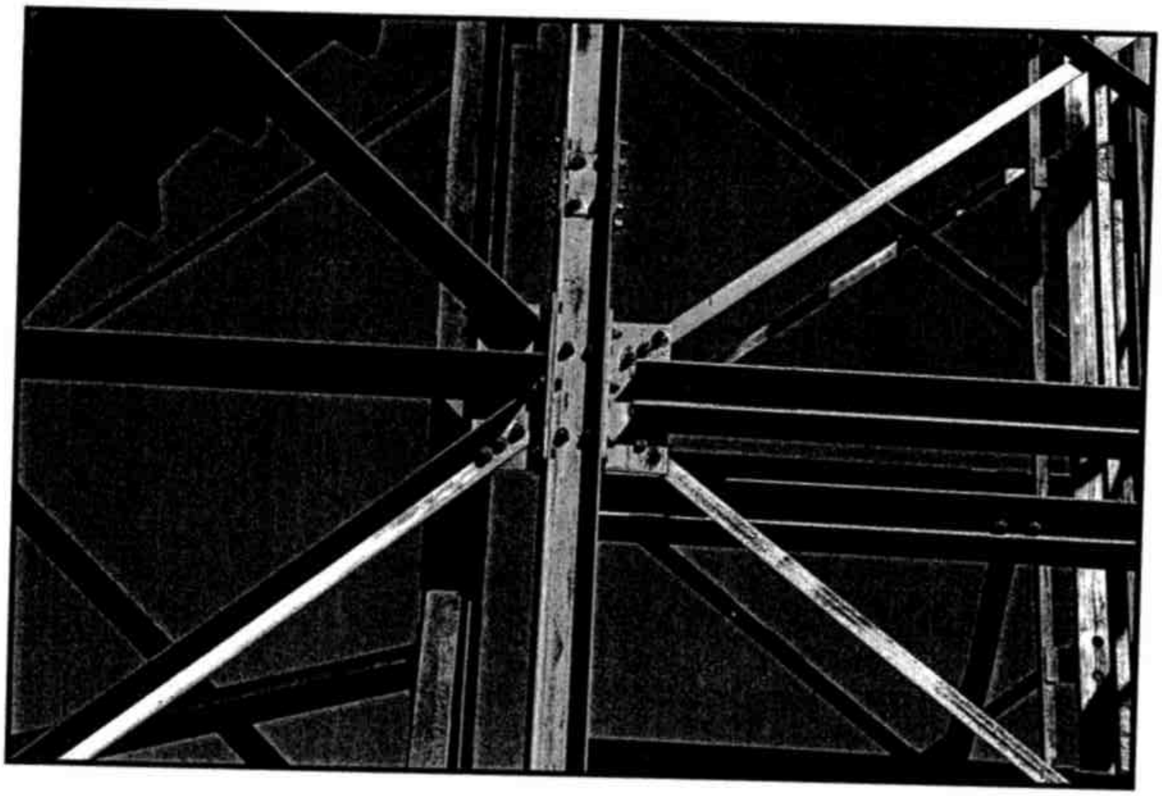

Photo 3. View of typical bolted connection of struts and bracing members to headframe leg (Source: George Weaver, 2005. No copyright restrictions).

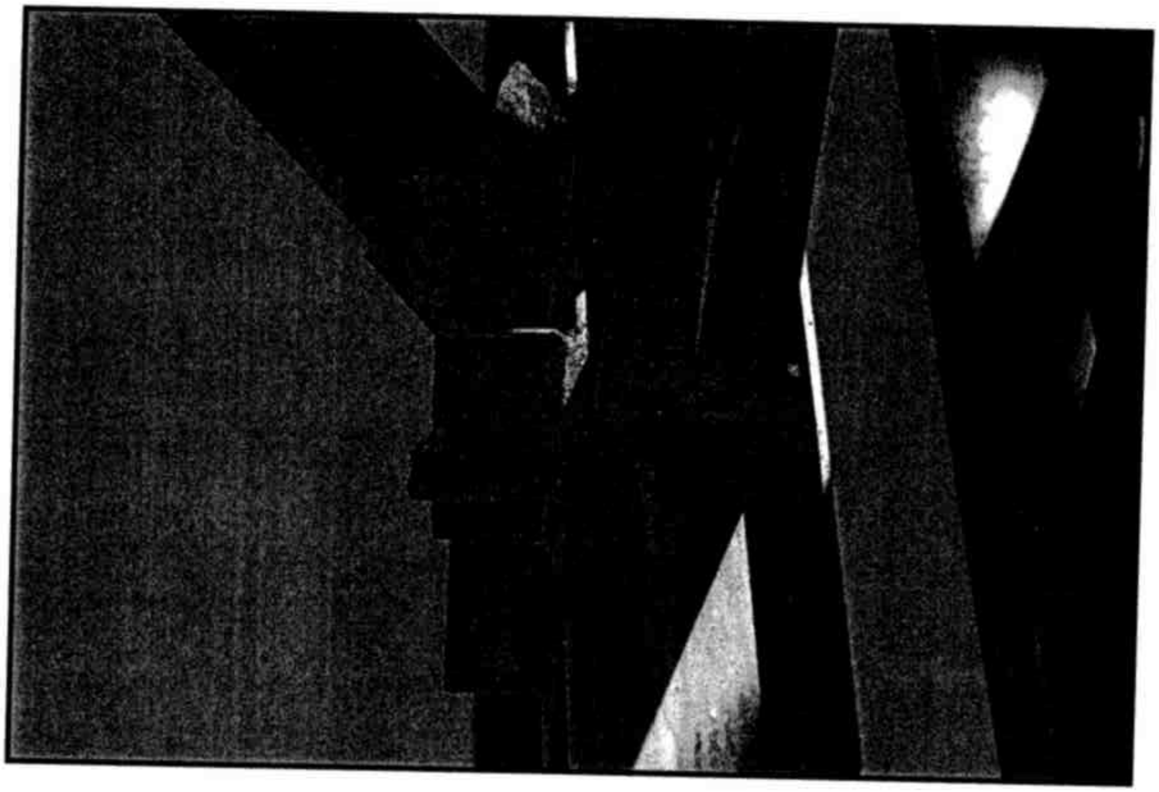

Photo 4. Welded connection at ore chute support frame (Source: George Weaver, 2005. No copyright restrictions).

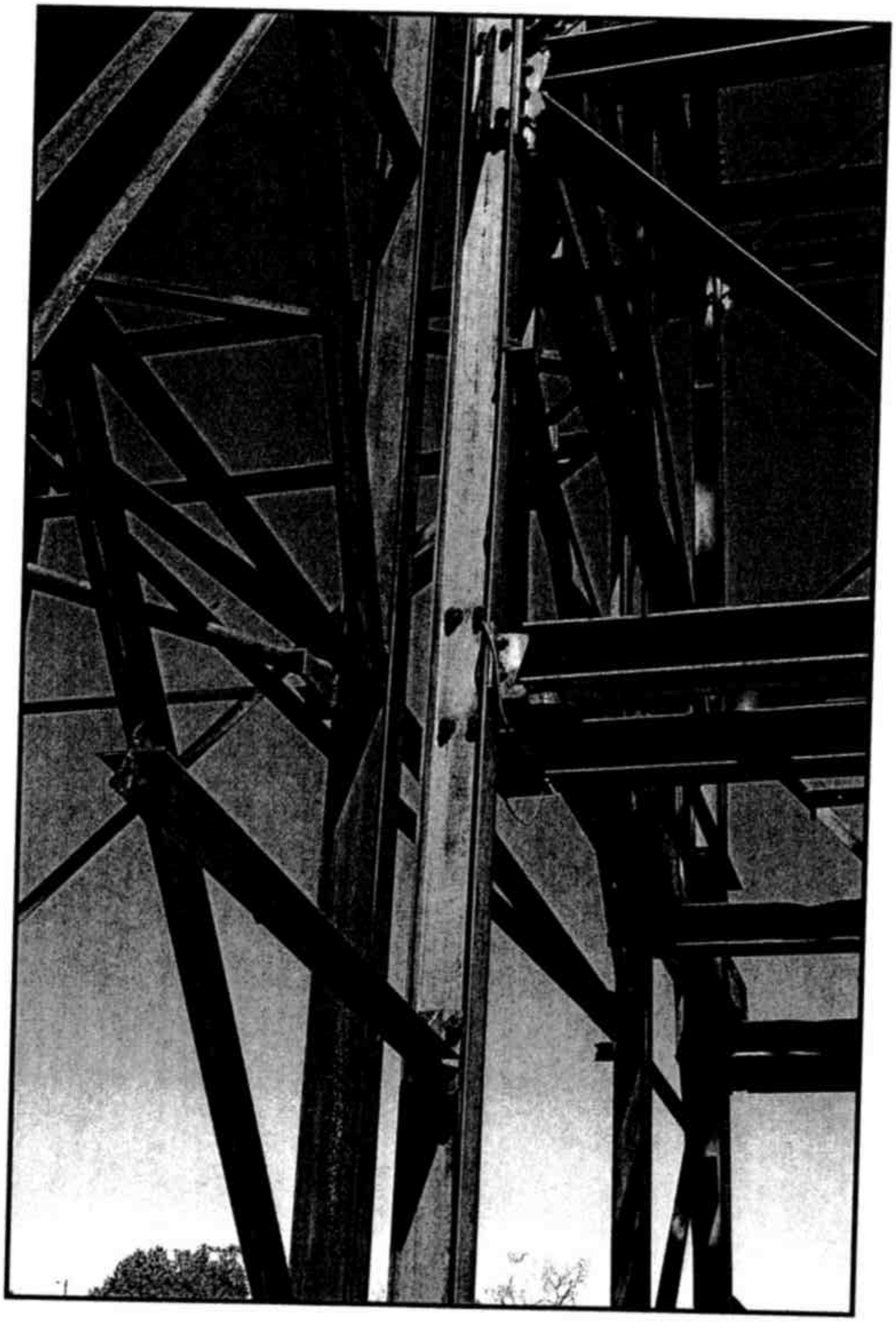

Photo 5. View of cut members remaining attached to rear leg of headframe
(Source: George Weaver, 2005. No copyright restrictions).

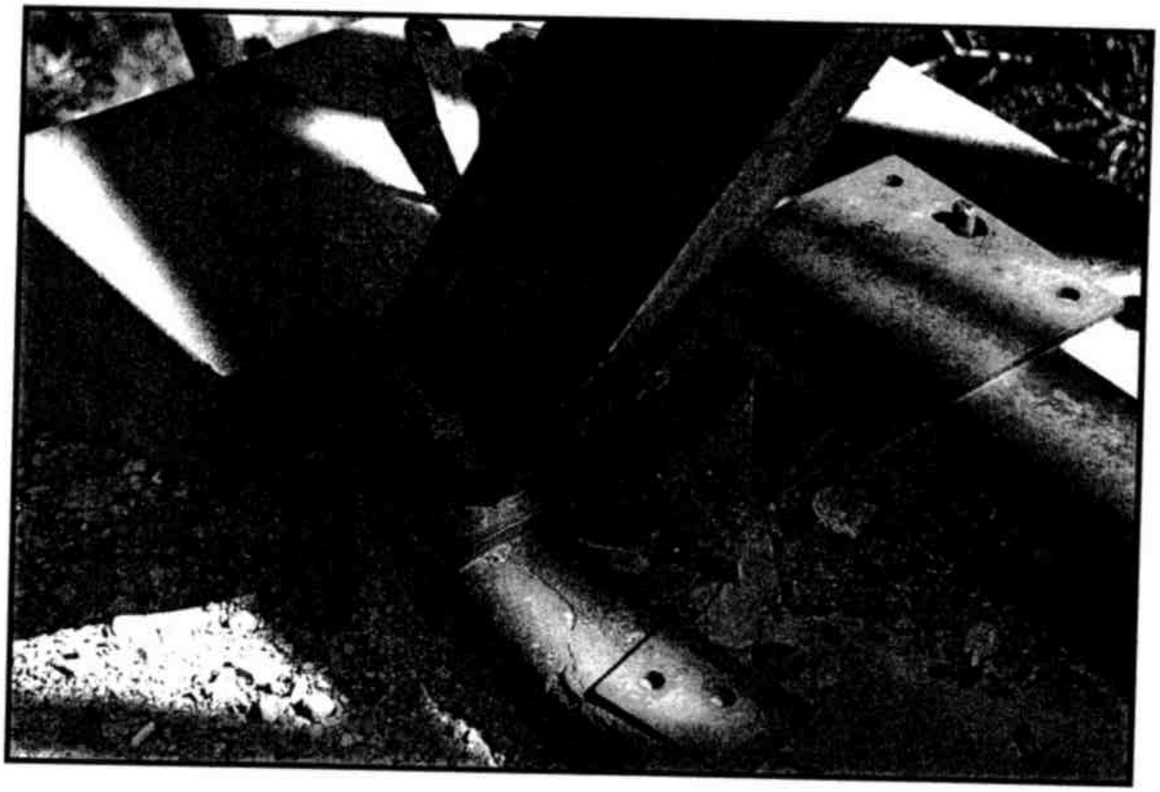

Photo 6. View of base connection of lateral bracing strut to top of concrete foundation. Note adjacent remaining support strut for original lateral bracing strut (Source: George Weaver, 2005. No copyright restrictions).

Endnotes:

1. Harlan Unrau, "Draft, National Register of Historic Places, Registration Form. Orphan Lode Mine, Grand Canyon National Park" (NPS Denver Service Center, Colorado: U.S. Department of Interior, National Park Service, 1993), Section 8, p. 1.

2. Unrau, Section 8, p. 1.

3. Ted Hoefer, III, and Elizabeth B. Roberts, "Cultural Resource Evaluation of the Orphan Lode Mine, Upper Yard, Grand Canyon National Park, Coconino County, Arizona." (Lakewood, Colorado: RMC Consultants, Inc., August 31, 2002), p. 46.

4. Unrau, Section 7, p. 4 and Section 8, p. 19.

5. Unrau, Section 8, p. 22.

6. Hoefer and Roberts, p. 46.

7. Maurice Castagne, *Grand Canyon Orphan Mine.* (Self published, 2004), p. 29 and p. 63.

8. Maurice Castagne, interview by George Weaver, Westchester, Pennsylvania, 13 June 2005

9. Hoefer and Roberts, p. 46.

10. Unrau, Section 8, p. 30.

11. Castagne, 2005.

12. Eric Roy Twitty, *Historical Context for the Creede Mining District* (Creede, Colorado: Mountain States Historical, 1999), p. 67-68.

13. Robert S. Lewis, *Elements of Mining* (New York: John Wiley & Sons, Inc., 1933), p. 192.

14. Twitty, p. 67.

15. Lewis, p. 192.

16. Castagne, 2005.

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