BISHOP CREEK HYDROELECTRIC SYSTEM, PLANT 2, TRANSFORMER HOUSE
Bishop Creek
Bishop vicinity
Inyo County
California

HAER CA-145-2-C
HAER CA-145-X

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

HISTORIC AMERICAN ENGINEERING RECORD

Bishop Creek Hydroelectric System, Plant 2, Transformer House
Bishop Creek, Bishop vicinity, Inyo County, California
HAER No. CA-145-2-C

Location: The Transformer House at Bishop Creek Hydroelectric Power Plant 2 is located on the east side of California State Route 168 in Inyo County, California. From the intersection of California State Route 168 (West Line Road) and U.S. Route 395 (Three Flags Highway) in the Town of Bishop, California, the Transformer House is located approximately 13.29 miles southwest on California State Route 168 and 0.38 miles south on Big Trees Road and Forest Service Road 8S03.

The approximate center of the Transformer House is located at UTM Zone 11S, easting 360493.93m, northing 4126394.11m. Distances and coordinates were obtained on January 17, 2012, by plotting location using Google Earth. The coordinate datum is World Geodetic System 1984.

Present Owner: Southern California Edison Company
P.O. Box 800
Rosemead, California 91770

Present Use: The Transformer House is a power transmission facility associated with Powerhouse No. 2, a hydroelectric power generating facility. The Transformer House contains equipment that “steps up” the voltage of hydro-generated electricity for transmission to distant customers, as it was originally designed and constructed to do.

Significance: The Transformer House, a reinforced concrete industrial building constructed in 1908 by the Nevada-California Power Company, is a significant resource by virtue of its position in the historic Bishop Creek Hydroelectric System and its expression of the Mission Revival architectural style.

The Bishop Creek Hydroelectric System Historic District is significant for its position in the expansion of hydroelectric power generation technology, its role in the development of eastern California, and its contribution to the development of long-distance power transmission and distribution. The System is significant under National Register of Historic Places criterion A (broad patterns of history) and C (distinctive characteristics of period and type of engineering and construction). The Period of Significance for the

Bishop Creek Hydroelectric System is identified as 1905-1938.

Historian: Matthew Weintraub, Senior Architectural Historian
Galvin Preservation Associates
231 California Street
El Segundo, CA 90245

Project Information: The Historic American Engineering Record (HAER) is a long-range program that documents and interprets historically significant engineering sites and structures throughout the United States. HAER is part of Heritage Documentation Programs (Richard O'Connor, Manager), a division of the National Park Service (NPS), United States Department of the Interior. The Transformer House recording project was undertaken by Galvin Preservation Associates (GPA) for the Southern California Edison Company (SCE) in cooperation with Justine Christianson, HAER Historian (NPS). SCE initiated the project with the intention of making a donation to NPS. As recommended by Justine Christianson (NPS), a vital component of the report documents changes in operating machinery that have occurred over time. Archaeologist Crystal West (SCE) oversaw the project and provided access to the site. Historian Andrea Galvin (GPA) served as project leader. Architectural Historian Matthew Weintraub (GPA) served as the project historian. James Sanderson produced the large format photographs. The field team consisted of Andrea Galvin (GPA), Matthew Weintraub (GPA), Crystal West (SCE), Neil Sliger (SCE), James Sanderson (photographer) and Matthew Pegler (photographer assistant).

Researchers can be directed to also see:
HAER No. CA-145-2, Bishop Creek Hydroelectric System, Plant 2;
HAER No. CA-145-2-A, Bishop Creek Hydroelectric System, Plant 2, Lake Sabrina Dam; and
HAER No. Ca-145-2-B, Bishop Creek Hydroelectric System, Plant 2, Powerhouse No. 2.

PART I. HISTORICAL INFORMATION

A. Physical History of Building:

The physical history of the Transformer House was determined by reviewing original construction drawings including architectural elevations,[1] a foundation plan,[2] and a roof plan.[3] Also, drawings for alterations to the Transformer House which occurred after its original construction were reviewed.[4] These plans were retained by the power companies that successively owned and operated the plant (currently SCE). In addition, articles describing construction and operation of the power plant which originally appeared in the trade journals *Journal of Electricity Power and Gas*[5] and *Electrical World*[6] and reprinted by SCE were reviewed. They included a series of articles written by Charles O. Poole, who served as chief engineer of the Nevada-California Power Company. The building itself provided physical evidence of its history and development via field inspection,[7] as did historical photographs and contemporary drawings in the possession of SCE. Further information was found in previously completed HAER documentation[8] and evaluations of eligibility for listing in the National Register of Historic Places.[9] These sources provided thorough and detailed information regarding the historic design, construction, improvement and operation of the building.

---

[1] Nevada-California Power Company (NCPC), "Plans for Transformer House To Accompany Power House No. 2. Elevation of Northeasterly End," Sheet 1 of 5, March 1908; NCPC, "Elevation of Southeasterly Side," Sheet 2 of 5, March 1908.
[2] NCPC, "Transformer Plan," Sheet 3 of 5, March 1908, revised March 2, 1932 and May 22, 1956.
[3] NCPC, "Roof System Transformer House No. 2," Sheet 5 of 5, March 1908.
[4] California Electric Power Company, "Transformer House General Arrangement," Sheet 2 of 4, April 4, 1956, first revised September 25, 1956, most recent revision December 9, 2004; SCE, "Transformer House Electrical Equipment Plan," February 14, 1956, first revised July 29, 1964, most recent revision May 4, 2005; SCE, "Transformer House Electrical Equipment Section Evaluation," February 16, 1956, first revised July 21, 1966, most recent revision December 9, 2004.
[5] Rudolph W. Van Norden, "System of Nevada-California Power Company and the Southern Sierras Power Company. Part 1 – Power Plants," *Properties and Power Developments of the Nevada-California Power Company and the Southern Sierras Power Company*. Reprinted from the *Journal of Electricity Power and Gas*, Volume XXXI, Numbers 1-2, July 5-12, 1913, p. 1-20.
[6] C. O. Poole, "Hydraulic and electric features of stations No. 2 and No. 3 of the Nevada-California Power Company – Tailrace water of former discharges directly into intake of latter," *Power Development and Transmission Systems of The Nevada-California Power Company and the Southern Sierras Power Company*, 1915, p. 19-26. Reprinted from *Electrical World*, New York, 1914.
[7] Field inspections were conducted on October 20 and December 7, 2011.
[8] Thomas T. Taylor, "Bishop Creek Hydroelectric System," HAER No. CA-145, Historic American Engineering Record, National Park Service, U.S. Department of the Interior, 1994, p. 12-13.
[9] Robert Clerico and Ana Beth Koval, "An Architectural and Historical Evaluation of Structures Associated with the Bishop Creek Hydroelectric Power System, Inyo County, California," Southern California Edison Company, December 1986, p. 24-29; Valerie Diamond, Stephan G. Helmich, and Robert A. Hicks, "Evaluation of the Historic Resources of the Bishop Creek Hydroelectric System," Southern California Edison Company, July 1988, p. A-166-168.

Overview

The Transformer House at Power Plant 2 was constructed in 1908 by the Nevada-California Power Company. Plant 2 was the third of five plants to be established in the Bishop Creek system (preceded by No. 4 and No. 5), and it is the highest plant at an elevation of 7,999 feet. The Transformer House is a single-story, reinforced concrete industrial building designed in the Mission Revival architectural style. The Transformer House is the only example in the Bishop Creek system of a separate, enclosed building originally designed to house transformers. In 1914, the transformers within the building were able to raise the voltage of electricity produced at the plant from 2,200 to 55,000, which facilitated long-distance transmission. Currently, the Transformer House continues to function as the transmission facility for Plant 2. The power plant is situated on the northwest bank of Bishop Creek in the upper reaches of Bishop Creek Canyon. The plant originally consisted of the powerhouse (extant), a matching transformer house (extant), four residence cottages (not extant), and two outbuildings (extant).

In 1913, the *Journal of Electricity Power and Gas* provided this general description of the Transformer House, which was constructed five years previously:

> The transformers are housed in a separate building of similar construction to that of the power house. It is 63 x 25 ft. and is placed at right angles in relation to the main building. Within the building, mounted on concrete rails about 18 in. above the floor and placed in a line are 7 1,000 kw. Westinghouse oil insulated and water cooled raising transformers, one being a spare. These are wound to 2200 volts primary to 30,000 volts secondary and are star connected on the high tension side for 55,000 volts. Paralleling the line of transformers is a track on which runs a transfer car onto which any transformer may be moved and transferred. This method of handling transformers is consistently maintained at all points of the system. Two sets of Pacific Electric Company's 60,000 volt oil switches are mounted on reinforced concrete platforms placed over the transfer track and from the lines pass through window openings to the pole line of the Nevada-California system.[10]

1. **Date of Construction:**
   Construction of the Transformer House occurred in 1908, based on the top sheet of architectural drawings dated March 1908. As stated in 1914 by Charles O. Poole, chief engineer of the Nevada-California Power Company, "The plant was constructed in 1908 and has been in continuous use ever since, excepting the twenty days when the steel Y failed."[11]

[10] Van Norden, "System of Nevada-California Power Company, p. 8-9.
[11] Poole, "Hydraulic and electric features of stations No. 2 and No. 3," p. 21.

2. **Architect/Engineer:**

The engineers of the construction of the Transformer House were (R. G.) Manifold & (Charles O.) Poole of Los Angeles, who are listed as such on the top sheet of construction drawings dated 1908. Poole served as chief engineer of the Nevada Power, Mining and Milling Company, later the Nevada-California Power Company. The top sheet of construction drawings included the notation "by Paul H. Ehlers," who was probably the draftsman and possibly an architect. Other architects and/or engineers are not known.

3. **Builder/Contractor/Supplier:**

The builder of the Transformer House was the Engineering-Contracting Co., which is listed on construction drawings dated 1908. Other builders, contractors and material suppliers are not known.

4. **Original Plans:**

The Transformer House was designed as rectangular in plan with exterior wall-to-wall dimensions of 26'8" x 64'8". It was built of concrete reinforced with "new style" corrugated metal bars and finished in stucco. The building was constructed two bays wide and four bays long as defined by regularly spaced columns that extended to the interior. The concrete columns, or "pilasters", were spaced 13'0" center-to-center at the building ends (north and south walls) and 16'0" center-to-center at the long sides (east and west walls). Between the columns were suspended curtain walls 4" thick. End walls terminated in three-level stepped parapets with square-profile coping that reached a maximum height of 31'9". The parapets were composed of first tiers 3'0" in height, second and third tiers 2'0" in height, and coping 5" tall across the tops and 12" wide at the sides.

The building was originally designed with a moderately pitched gable roof composed of reinforced concrete roof slabs 5'4" wide and supported by reinforced concrete roof beams 10" wide at the top surfaces and 8" wide at the undersides. The reinforced concrete roof was designed with a height of 23'6" to the tops of the eaves, which projected 8" beyond the side walls, and ridge height of 29'6" (more than a foot shorter than the parapet coping). However, the actual roof construction and dimensions differed from the original plans. As constructed, the roof was supported on three Fink steel trusses and sheathed in interlocking, barrel-shaped pressed metal "tiles" that matched that of Powerhouse No. 2. The roof was built with a slightly steeper slope than originally planned for the reinforced concrete roof so that the ridge of the metal roof terminated just below the parapet coping.

The long side walls were identically fenestrated in a regular pattern with pairs of 16-light-over-4-light wood windows in each bay. The side walls were also pierced by four diamond-shaped, 12-light windows centrally located in the upper portions of each bay. At the symmetrical building ends, the bilateral arrangement of bays included a single 16-light-over-4-light wood window below a square 16-light window at one side and large double-leaf doors with three metal side hinges and central latches at the other side. The building was originally designed with the doors located on the west side of the end walls. However, it was constructed in reverse with the doors located on the east side of the end walls and the windows on the west side. At the south end wall, another square 16-light window was found above the doors. At the north end, the upper wall above the doors contained a 3-light transom filled with double-strength glass panes and 6" circular holes cut in the centers. A small platform on knee-braces projected from the wall at the base of the transom and supported insulated bushings that connected to the transmission wires that passed through the transom panes. At both end walls, the gable ends contained centrally located circular louvered vents.

At the interior, the single room that occupied the structure measured 26'0" x 64'0". The room was open in plan without partitions. The long walls contained recessed bays formed by the pilasters that extended to the interior and the windowed curtain-wall panels. The building was open vertically through the trusses. The floor plan was divided bilaterally along the long axis, with transformer equipment and mountings occupying one side and extending over the centerline of the building, and a transfer car track at the other side running between the service doors in the building ends. The building was originally designed with the transfer car track located on the west side, which corresponded to the originally designed locations of the service doors. However, it was constructed in reverse with the transfer car track located on the east side, aligned with the doors, and the transformer equipment and housings on the west side. The 35-lb. steel rails of the transfer car track were embedded in the concrete floor with their centerline located 7'0" from the east wall. Above the track, at the third interior bay of the east wall (counting from south to north), concrete platforms on a post-and-beam system and 14'0" above the floor supported two sets of oil switches. At the interior north wall, between the transom and the doors, a knee-braced platform with insulated bushings for three transmission wires corresponded and connected to its identical counterpart at the exterior.

The concrete foundation was constructed with mountings and channels for transformer equipment. The transformer mountings consisted of trapezoidal-in-profile concrete bars, two per unit and fourteen in total, aligned in parallel directly west of the centerline of the building. The concrete bar mountings were 12" high, 12" wide at the top and 24" wide at the base, and 7'0" long. A 35-lb. steel rail was embedded in the surface of each concrete bar mounting. The bars of each mounting set were separated by 16". A pipe duct ran directly beneath the centerline of the parallel mountings along the length of the room. The concrete pipe duct was square in profile, 14" wide and 12" deep. Another square-in-profile concrete channel, the wire duct, ran along the length of the room directly to the west of the mountings, 12" from the rail ends. The wire duct was 61'0" long, 24" wide and 18" deep. It was covered with 15 steel plates, 24" x 48" and 3/16" thick, bolted into the concrete foundation. Each set of transformer mounts was located in a floor bay defined at the sides by short concrete pits 12" wide and 3'0" long that sloped down from grade to the depth of the wire duct.

5. Alterations and Additions:

The Transformer House has undergone noticeable changes to its exterior and interior fabric. The barrel-shaped pressed metal "tiles" that sheathed the roof were replaced with sheet metal panels sometime before approximately 1927-1928. Sometime after approximately 1927-1928 and before 1988, various wall openings were altered and/or eliminated. At the long side walls, all of the diamond-shaped windows and one in each pair of rectangular windows, including the two outermost and two innermost on each wall, were removed and filled with stucco-clad wall surface. At the building ends, all of the windows and vents were similarly removed and filled, with the exception of the 3-light transom with circular wire passages located above the north end doors. Steel sash replaced original wood sash in remaining window openings. At the south end, a corrugated metal roll-up door replaced the double-leaf doors in the original opening and a solid metal man-door was installed at the west side in the former window bay. At the interior, the elevated concrete platforms were removed from the east side of the room. At the west side and center of the room, the complex arrangement of concrete transformer mountings and wire and pipe ducts was replaced by a simple rectangular concrete platform, 5-½" high, 10'0" wide and extending most of the length of the room, upon which transformer equipment was installed. Behind the concrete pad, steel frameworks for equipment support were constructed along the west wall.

B. Historical Context:

The following historical context was included in previously completed documentation which established the eligibility of the Bishop Creek Hydroelectric System for listing in the National Register of Historic Places.[12]

The turn of the twentieth century saw a dramatic change in technological history. The production of cheap, dependable hydroelectric power, and the ability to transport the power over great distances, was perfected at this time. In short order, drainages with sufficient flow for hydroelectric power generation began to be developed. By 1923, the only suitable streams draining the east slope of the Sierra Nevada which were not being used for electricity production were the Carson and Walker river systems. The first hydroelectric power generation along Bishop Creek was a small plant operated by the Bishop Light and Power Company. The facility was reported to be a half mile west of the Standard Flouring Mills (present site of Plant 6) and two and a half miles from the town

---

[12] Clerico and Koval, "An Architectural and Historical Evaluation," p. 5-12.

of Bishop. The plant consisted of a Stanley polyphase generator (capable of 150 horsepower) driven by a 48-inch Pelton wheel. The power was generated for local use.

Through the efforts of Loren B. Curtis, an engineer, and Charles M. Hobbs, a banker and financier, the Nevada Power, Mining and Milling Company was incorporated on December 24, 1904. The first facility built by the Nevada Power, Mining and Milling Company was put into operation in September, 1905, supplying hydroelectric power to the mining communities of Tonopah and Goldfield, Nevada. Executives of the power company had purchased controlling interest in the locally operated facilities in Tonopah and Goldfield, so that, when production began, there was a market ready for their product. The original transmission line extended east across Owens valley, the White Mountains, Fishlake Valley, and the Silver Peak Range to the town of Silver Peak in Clayton Valley. Here the line split, diverging northeast to Tonopah and due east to Goldfield. The line distance from Bishop Creek to Goldfield was 95 miles, and that to Tonopah was 118 miles. This was a new record for long distance transmission. On January 5, 1907, the Nevada-California Power Company, successor to the Nevada power, Mining and Milling Company, was incorporated; most of the original corporate officers remained with the new company.

Between 1905 and 1913, four more generating plants were placed on line, in tandem along Bishop Creek, and additional generators were placed in existing plants. As a result of this additional power generation, the “Tower Line” from Bishop to San Bernardino was completed in 1912 and put into operation, again creating a new record for long distance transmission (239 miles). The directors of the Nevada Power, Mining and Milling Company were well aware of the vicissitudes of the boom-bust mining industry and took steps to secure a more constant market for their product. In 1911, the Southern Sierra Power Company was incorporated with the main purpose of creating and servicing the power needs of southeast California. From then until 1918, several smaller power companies were purchased by the new company. The development of southern California's Imperial Valley corresponds directly with Bishop Creek's production of cheap, reliable electricity.

By the end of 1913, the Bishop Creek system was essentially complete with all five plants operating. In descending order down the drainage, the Bishop Creek facility then consisted of:

> Power Plant 2: Three Westinghouse generators, each capable of 2,000 kw of power (total output of 6,000 kw). Units 1 and 2 were driven by Pelton wheels and unit 3 by a Doble wheel.
>
> Power Plant 3: Three Crocker-Wheeler generators, each capable of 2,250 kw of power (total output of 6,750 kw). All three units were direct connected to Henry impulse wheels.

Power Plant 4: Five generating units consisting of: two National Electric Company, 750 kw, generators connected to Pelton wheels; one Bullock, 1,500 kw, generator driven by a Pelton wheel; one Allis-Chalmers, 1,500 kw, connected to a Pelton wheel; and one Allis-Chalmers, 1,500 kw, machine driven by a Doble wheel (total output of 6,000 kw).

Power Plant 5: Two generating units, one of which was a 1,500 kw, Allis-Chalmers machine driven by a Doble wheel and the other a 1,850 kw unit connected to a Pelton-Francis wheel (total output of 3,350 kw).

Power Plant 6: A single generator capable of 2,250 kw driven by a Pelton-Doble wheel.

It is interesting to note that Power Plant 1 was to have been built at the present site of Intake No. 2, but the plant was never built due to the vulnerability of the site to avalanches. The plant number designators were not adjusted accordingly, so that there is no Power Plant 1, nor has there ever been.

In 1936, the Nevada-California Electric Corporation again was reorganized to become an operating company. The corporation became California Electric Power Co. and continued to operate under this name until 1964, when the company known as Calectric was subsumed by Southern California Edison Company. Since 1964, as a result of acquisition through merger consolidation, Southern California Edison (SCE) has owned and operated the Bishop Creek plants.

PART II: SITE INFORMATION

A. General Description of Building:

The following description of the Transformer House incorporates information included in previously completed HAER documentation[13] and evaluations of eligibility for listing in the National Register of Historic Places.[14] This information was verified and new information was gathered via field inspection to inform the building description.[15]

Overview

The Transformer House is a one-story, reinforced concrete industrial building resting on a deep concrete foundation and topped by a metal gable roof. It was designed and constructed in the Mission Revival architectural style with stepped parapets at end walls. The main volume houses transformers that raise voltage for transmission of electricity over long distances.

Exterior

The Transformer House is a one-story, rectangular-in-plan, reinforced concrete building resting on a concrete foundation. A tan, rough-textured stucco covers the exterior. Structural pilasters subdivide the walls into panels. The structure is two bays wide and four bays long. Pilasters at side walls terminate at the eaves, while pilasters at end walls terminate on the façades in well-defined drainage slopes. The building is covered by a medium-pitched gabled roof sheathed with corrugated sheet metal panels. The transition from the roof to the side walls is accomplished with very simple, square-in-section, sheet metal cornices. The roof is painted to match the exterior wall covering.

The end walls, which conceal the gable ends, culminate in symmetrical, three-tiered, stepped parapets, finished with square-in-section concrete coping. End walls contain large service openings at the east sides. The south service opening contains a corrugated metal roll-up door and the north service opening is filled by metal double-leaf doors. The only other openings in the end walls are a solid metal man-door located at the southeast corner and a 3-light transom located above the north wall doors. The transom panes include circular openings at their centers that allow power transmission wires to pass through them. The wires are attached to insulated bushings mounted on a metal rack supported by knee braces just below the transom. The long walls are each pierced by four rectangular metal sash windows, 6-light-over-4-light-over-2-light. The central 4-light panels are hinged and covered with metal security grates. The windows are grouped around the second and fourth pilasters on each side with slightly recessed stuccoed surrounds and projecting lugsills. At all exterior walls, the outlines of original window and vent openings that were removed and filled are visible.

[13] Taylor, "Bishop Creek Hydroelectric System," p. 12-13.
[14] Clerico and Koval, "An Architectural and Historical Evaluation," p. 24-29; Diamond, Helmich, and Hicks, "Evaluation of the Historic Resources," p. A-166-168.
[15] Field inspections were conducted on October 20 and December 7, 2011.

Interior

The main rectangle of the building is open in plan. The floor is poured concrete with a scored grid pattern. Two parallel metal rails embedded in the concrete floor run the length of the interior room between the large service openings at the east side. A raised rectangular concrete pad at the center and west side of the room is located so that it edges over one of the rails, indicating that it was poured after original construction. A transformer bank is located on top of the concrete pad. Another transformer bank is located at the northwest corner of the room. An open metal framework supporting equipment extends across the west wall. At the north side doors, the double-leaf metal doors are attached by six long side hinges and latched at the center. Above the doors, a metal fuse rack is attached below the transom, with three sets of fuses and wire connects, from which originate high-voltage wires that pass through the openings in the transom panes to the exterior. A separate set of three wires span the length of the room between symmetrically located wire connects located at the upper end walls on the east side of the room. Walls are finished in smooth stucco and subdivided into bays by structural pilasters that extend from the exterior to the interior. The outlines of original window and vent openings that were removed and filled are visible on interior walls. The room is open vertically through the Fink steel trusses with the timber bracing and underside of the pressed metal roof sheathing exposed.

1. **Character:**
   In 1913, the *Journal of Electricity Power and Gas* stated that Power Plant 2 was "a most ideal example of pure Western practice of its time."[16] This description remains true nearly a century later. The Transformer House is an embodiment of an early twentieth century industrial building designed in the Mission Revival architectural style, as is the accompanying Powerhouse No. 2. It retains the significant majority of exterior features and materials that convey its historic architectural character, including (but not limited to) stucco-clad concrete walls and columns, stepped end parapets, gabled roof, and large service openings. The powerhouse also retains interior features that convey its historic character, including an open floor plan, transfer car track at the east side, perimeter walls with recessed bays, and open truss roof system. The architectural character has been diminished by removal of distinctive original windows and vents and filling of the openings with wall surfaces. Nonetheless, the overall design of the powerhouse is generally intact. Other changes that have occurred include window replacement, door replacement, installation of a new entrance, and removal or original interior features. The Transformer House continues to operate and it serves as a superb example of a transmission facility associated with an early twentieth century California hydroelectric power plant.

[16] Van Norden, "System of Nevada-California Power Company," p. 4.

2. **Condition of Fabric:**
   The Transformer House is in good physical condition. The concrete walls are intact and the exterior stucco facing does not contain noticeable cracks or damage, including areas where windows and vents were removed and/or replaced. The pressed metal roof is intact. The interior is in good condition with the exception of the stucco-clad perimeter walls, which exhibit extensive water staining and surface damage. Also, some sections of the underside of the metal roof sheathing are rusted. The concrete foundation is intact. Windows and doors are operable.

B. Site Layout:

The terrain surrounding the Transformer House consists of steep canyon walls covered with natural vegetation. The power plant is located on a graded level area on the west bank of Bishop Creek. To the west, topography rises sharply towards Big Trees Campground Road, California State Route 168, and a distant ridge from which Penstock No. 2 approaches the plant. To the east, the terrain slopes immediately down to nearby Intake No. 3 and Bishop Creek, then rises steeply at the opposite valley wall. The Transformer House and Powerhouse No. 2 are arranged in an “L”-shaped configuration. Powerhouse No. 2 stands with its long axis running east-west and its wing extending to the north. The Transformer House is found to the north of the powerhouse with its primary axis oriented north-south. Transfer car rails set in pavement run between service openings of the two buildings which are separated by a distance of 50 feet. North of the Transformer House, a terraced pad contains transformers and chain-link perimeter fencing. Originally, the power plant complex included Powerhouse No. 2 (extant), a Transformer House (extant), four residence cottages (not extant), and two outbuildings (extant). The two accessory buildings, a garage and shed, are located to the south of the powerhouse in isolated locations. The cottages were removed in 1977. Extensive stone retaining walls remain at the west side of the site. Also, the original highway (California State Route 168) followed the northwest bank of Bishop Creek directly past all the power plant sites including Plant 2 (apparently along the route of the current Big Trees Campground Road). The new highway, which bypasses the power plants, was constructed to the northwest in 1965-1966.

PART III: OPERATIONS AND PROCESS

A. Operation:

This section describes the process that creates and transmits hydroelectric power at Power Plant 2 in the context of the chain of power plants that comprise the Bishop Creek Hydroelectric System. This section is divided into two subsections: (1) Basic Components of Hydroelectric Systems, which provides a general background for understanding the operations of hydroelectric plants; and (2) Operation of Power Plant 2, which describes how water moves through the power plant in order to drive turbines and generate electricity that is transmitted long distances.

Basic Components of Hydroelectric Systems

In a hydroelectric power generating unit, the force of moving water is used to spin a turbine (or "water wheel"). A turbine is connected via a shaft to a rotor, the moving part of an electric generator. The movement of the turbine spins the rotor within the generator and sweeps coils of wire past the generator's stationary coil, or stator, which produces electricity. Once electricity is produced, transformers raise the voltage to allow transmission over long distances through power lines.[17]

The following explanation of hydroelectric systems was included in a previously completed evaluation of eligibility for listing in the National Register of Historic Places.[18]

There are two basic types of hydroelectric systems. The first of these, low-head hydro, uses a large volume or mass of water from relatively low dams in order to turn the angled surfaces of screw-shaped turbines. The other type, high-head hydro, uses streams with relatively low volume flows, where water is diverted away from the natural stream course and elevated by artificially reduced fall far above the natural stream through a man-made canal or pipeline. At some point downstream the water is directed downslope were it achieves a very high pressure. The water at the base of the slope is directed against a bucketed wheel which receives an energy impulse by its impact.

The basic features of a high-head hydro system, of which the Bishop Creek Hydroelectric System is an example, are outlined below.

1. Water from a stream channel is separated from the natural stream using a diversion dam, headgates, screens and a spillway. The headgate regulates the flow of water, while the screens prevent debris from entering the water conduit. The reservoir behind the intake dam acts as the principal regulator of the water flow, allowing excess water to escape into the natural water channel. The dam,

[17] U.S. Department of the Interior, Bureau of Reclamation Power Resources Office, "Reclamation: Managing Power in the West – Hydroelectric Power," July 2005, unpaginated. Found at http://www.usbr.gov/power/edu/pamphlet.pdf, accessed on January 30, 2012.
[18] Diamond, Helmich, and Hicks, "Evaluation of the Historic Resources," p. 10-11.

headgate, and regulating and cleaning apparatus are all known collectively as the *intake.*

2. Following intake, water is conducted by flumes or canal systems, pipes, tunnels or siphons (pipes in the case of Bishop Creek). The length of the system varies greatly, depending on the area's topography and amount of water-pressure desired. Sluices and sandboxes are usually built into the system to allow sand and gravel, which could clog or damage the downstream equipment, to settle out of the water. *Flowlines* generally incorporate pressure-relief valves, installed at regular intervals along their length. These open and permit outside air to enter the line to prevent the line from collapsing should there be an accidental break in the pipe. A large vacuum would normally be formed by the sudden acceleration of water through a break, which could easily destroy either wood or steel pipe.

3. At the end of the canal system, a pipe is installed as nearly vertical as conditions will allow providing the water pressure needed to operate the water wheel(s). This pressure pipe is known as a *penstock.* At the top of this pipe is a small reservoir, expansion tank or standpipe (standpipe in the case of Bishop Creek) which helps to regulate and smooth the flow of water within the penstock.

4. A *powerhouse* is located at the bottom of the penstock. This consists of a building within which is housed the power generation and distribution equipment. The machinery within the building includes water wheels, generators, batteries and exciters. Exciters provide direct current to energize the electromagnets within the larger alternating current generator(s). The powerhouse also includes the distribution equipment used to initiate transmission of electricity. This equipment consists of switches, circuit breakers and related controls which are connected to a nearby transformer. The transformer increases voltage so that power can be transmitted over long distances. The powerhouse also contains a variety of other apparatus used in the operation of the system. This often includes a small generating unit to operate the powerhouse lights and equipment, as well as telephone links with other system components. Other buildings associated with the operation of the hydro system are usually located in close proximity to the powerhouse(s). These may include such facilities as administrative headquarters, garages, housing for system personnel, equipment storage sheds, pump houses, and machine shops.

5. Where there is more than one power-generating source, it is not uncommon for there to be a *control station* where the transmission of energy may be monitored and regulated. If electrical generating facilities are close by, many functions may be automated or operated from a centralized control point; the control station may serve this additional function.

6. *Transmission lines* carry power to users. Normally a step-down transformer is used near the point-of-use to reduce the voltage to normal house currents.

Operation of Power Plant 2

At Plant 2, water is transferred from Intake No. 2, an equalizing pond located upstream, by Flowline No. 2, a metal pipeline (originally a redwood stave pipe), and by Penstock No. 2, also a metal pipeline. The penstock splits into three separate feeder pipes that enter the powerhouse foundation on the south side, with each pipe directed to one of three water wheels located within the powerhouse. In the concrete floor of the powerhouse, three power generation units consisting of impulse water wheels and direct-connected generators are shaft-mounted with their common axis of spin aligned horizontally and parallel to the centerline of the building. The impulse wheels are mounted in pits located in front of the control pits, from which extremely high-velocity jets of water are directed at the wheels. Each water wheel drives a direct-connected rotating generator, which is shaft-mounted in tandem with the turbine. Tailraces convey water that passes through the powerhouse out of the building and into nearby Intake No. 3.

Electricity that is generated at Powerhouse No. 2 is transmitted via underground cables to the Transformer House, which is located approximately 50 feet from the powerhouse. Electricity reaches the Transformer House at the voltage that is produced by the powerhouse generators, which is 2,200 volts. Within the Transformer House, the transformers "step up" the voltage by running electricity through the magnetic flux that is produced at the generator cores. After the voltage of electricity is raised in order to allow for long-distance transmission, it is conveyed via overhead cables to pole lines located outside of the building, which send electricity to distant customers. The Transformer House currently feeds into two separate pole lines: the original line of the California-Nevada Power Company which runs northeast towards other plants in the Bishop Creek system; and the Sabrina line which runs westward.

B. Machines:

This section provides an inventory of extant machinery within the Transformer House, including descriptions of purposes, manufacturer names and dates of installation (as available), and information regarding changed and removed machinery (as available).

The Transformer House originally contained seven Westinghouse-manufactured step-up transformers, including two sets of three and a spare unit, which raised the voltage from 2,200 to 55,000 volts. The seven transformers were installed in a row at the center of the long room. They were elevated on concrete rails 12'0" above the floor. The 1,000-kw transformers were oil insulated and water cooled. The transformers consisted of large cylindrical metal tanks with insulated bushings that projected at the tops. Adjacent to the transformers, two sets of 60,000-volt oil switches (circuit breakers) furnished by Pacific Electric Company were connected to transmission lines that exited the north end of the building.

Sometime before 1988, the original seven transformer units were replaced with at least three newer units. The replacement units occupied approximately the same location within the building as the original units and they were similar in appearance with large cylindrical metal tanks. The newer transformers also included conservator systems with oil reservoir tanks suspended horizontally above the larger primary tanks. In 1964, the No. 2 Transformer Bank was installed in the northwest corner of the room. The No. 2 bank included a tall, open metal framework supporting a cylinder tank, a switch cabinet, and an extensive network of cables, connectors, and insulated bushings at the upper section.

In 2004, modern transformer equipment was installed and replaced most of the older equipment. At the center of the room, the three-phase No. 1 Transformer Bank was furnished by Hyundai. The core and windings of the No. 1 Transformer Bank are contained within a large metal rectangular tank with five finned radiators attached at the east side of the unit to provide cooling. The No. 1 bank also features a large metal cylindrical conservator suspended on a metal frame at the north side to maintain constant oil pressure. Three sets of high-voltage and low-voltage insulated bushings project from the top of the No. 1 Transformer Bank. Access to the interior of the machine is provided by three round metal hatches located at the west side of the machine and a rectangular hatch located at the south side. At the No. 2 Transformer Bank, three units known as Bank A, Bank B, and Bank C and manufactured by Howard Industries occupy the northeast corner. Each of the three banks is comprised of a relatively small cylindrical metal tank mounted above the floor on an open metal frame. Each of the cylinders has four finned radiators attached equilaterally around the exterior and four insulated bushings at the tops. The modern units at Bank A, Bank B, and Bank C are connected to an older transformer that was installed in 1964. The older unit is located nearer to the center of the room and consists of a metal cylinder tank with six insulated bushings and a switch cabinet mounted above the floor within an open metal framework. The tall metal framework supports an extensive network of cables, connectors, and insulated bushings. Between the No. 1 Transformer Bank and the No. 2 Transformer Bank, a master power circuit breaker (PCB) cabinet furnished by the Square D Company is found. Also, a set of three small, local transformers that provide station lights and power are located in the southeast corner of the room. At the exterior of the building, the No. 3 Transformer Bank furnished by Federal Pacific and relocated from the Morgan substation, occupies a concrete pad to the north of the Transformer House.

C. Technology:

This section describes the technology that is used by machines in the Transformer House to transmit electricity that is produced at Plant 2. This section is divided into two subsections: (1) Transmission Technology, which provides an overview of the technological innovations in power transmission which facilitated the development of hydroelectric power plants; and (2) Transformers, which describes how transformer units "step up" or "step down" the voltage of electricity to facilitate its transmission and use.

Transmission Technology

While water wheel technology provided the mechanisms for efficiently generating power at hydroelectric plants, the development of accompanying transmission technology was required in order to make commercial energy production into a practical industry. The perfection of the induction motor in the 1890s permitted economic use of alternating current in both industrial and domestic settings, thus solving a major stumbling block in development of a universal power system. Direct-current generators and motors had been perfected in the early 1880s (Pearl Street Station, New York, 1882). However, direct-current power plants possessed a major drawback in that power could be delivered only a short distance (usually within a one-mile radius of the power source) before current leaks, fire hazards and projected high costs made more distant transmission unfeasible. High-voltage poly-phase alternating current systems during the same era offered the potential advantage of longer-distance transmission, but lacked a perfected electrical motor which could be operated directly from this power source. A complex of costly electrical equipment was required to transform A.C. to D.C. power during this early period, making it impractical for large-scale applications. The development of a practical induction motor between 1887 and 1900 made poly-phase alternating current the power of choice at the turn of the century. No profound developments in electrical energy generation have since intervened to make this power supply system obsolete.[19]

Transformers

A transformer is a machine with no internal moving parts that transfers energy between circuits via electromagnetic induction. A “step-up” transformer increases the voltage of electricity and a “step-down” transformer decreases voltage. In practice, electricity is first produced at a power plant and then sent to a nearby step-up transformer, which raises the voltage while reducing the current proportionately. From the step-up transformer, transmission wires carry the higher-voltage electricity over long distances to power consumers, where step-down transformers at substations and other distribution points decrease the voltage and restore current for end uses.

A transformer is comprised of a soft iron core and at least two sets of insulated coil windings, a “primary” coil connected to input voltage and a “secondary” coil linked to output voltage. When an alternating current is applied, the primary coil receives electricity and produces magnetic flux in the iron core. Electricity passes through the changing magnetic fields of the core and becomes output voltage at the “secondary” coil. The number of times that the primary coil and the secondary coil are wrapped around the soft iron core (“turns”) determines how the voltage is changed between input and output. In a step-up transformer, which increases voltage, the primary coil has fewer turns than the secondary coil. A step-down transformer, which decreases voltage, contains a primary coil with more turns than its secondary coil.

[19] Diamond, Helmich, and Hicks, “Evaluation of the Historic Resources,” p. 11-12.

Some of the energy involved in changing voltage within a transformer is lost to heat. Since transformer capacity increases in cooler conditions and fails at excessively high temperatures, reducing waste heat is a primary consideration. Therefore, the working parts of a transformer – the iron core, the primary coil, and the secondary coil – are typically submerged in high-grade insulating oil within an enclosed tank. Oil in contact with the core and windings rises as it absorbs heat and flows outward and downward along tank walls, where it is cooled by radiating heat to the surrounding air. External radiators may be attached to the transformer tank to provide greater surface area for cooling. A conservator system may be used to pressure-seal the transformer tank. The conservator is a tank filled with oil and an air bladder located above the main transformer tank that is completely filled with oil. The conservator reacts to changes in oil pressure in the transformer tank by expanding/contracting the bladder and moving a proportionate amount of oil, which equalizes pressure in the transformer tank.[20]

[20] U.S. Department of the Interior, Bureau of Reclamation Power Resources Office, "Reclamation: Managing Power in the West – Transformers: Basics, Maintenance, and Diagnostics," April 2005, p. 2-8, 35-41. Found at http://www.usbr.gov/pmts/client_service/recent/studytransformers.pdf, accessed on January 30, 2012.

PART IV: SOURCES OF INFORMATION

A. Primary Sources:

Clerico, Robert and Ana Beth Koval. "An Architectural and Historical Evaluation of Structures Associated with the Bishop Creek Hydroelectric Power System, Inyo County, California." Prepared for Southern California Edison Company, Rosemead, CA: Intermountain Research, December 1986. Located in SCE company archives at 4000 Bishop Creek Road, Bishop, California.

Diamond, Valerie, Stephen G. Helmich, and Robert A. Hicks. "Evaluation of the Historic Resources of the Bishop Creek Hydroelectric System." Prepared for Southern California Edison Company, Rosemead, CA: Theodoratus Cultural Research, Inc., July 1988. Located in SCE company archives at 4000 Bishop Creek Road, Bishop, California.

Myers, William A. *Iron Men and Copper Wires: A Centennial History of the Southern California Edison Company*. Glendale, California: Trans-Anglo Books, 1986.

Poole, C. O. "Hydraulic and electric features of stations No. 2 and No. 3 of the Nevada-California Power Company – Tailrace water of former discharges directly into intake of latter." Pages 19-26 in *Power Development and Transmission Systems of The Nevada-California Power Company and the Southern Sierras Power Company*. Reprinted in 1915 from *Electrical World*, New York, 1914. Located in SCE company archives at 4000 Bishop Creek Road, Bishop, California.

________. "Hydroelectric Development on Bishop Creek, Cal." Pages 3 -7 in *Power Development and Transmission Systems of The Nevada-California Power Company and the Southern Sierras Power Company*. Reprinted in 1915 from *Electrical World*, New York. 1914. Located in SCE company archives at 4000 Bishop Creek Road, Bishop, California.

Southern California Edison Company. Eastern_Hydro_Facilities_Data. Microsoft Excel databases transmitted on October 19, 2011. Located in SCE company archives at 4000 Bishop Creek Road, Bishop, California.

__________. "Southern California Edison Hydro Generation Division." October 25, 1983. Appended April 26, 1988 and October 11, 1990. Located in SCE company archives at 4000 Bishop Creek Road, Bishop, California.

Taylor, Thomas T. "Bishop Creek Hydroelectric System." HAER No. CA-145. Historic American Engineering Record, National Park Service, U.S. Department of the Interior, 1994.

U.S. Department of the Interior, Bureau of Reclamation Power Resources Office. "Reclamation: Managing Power in the West – Transformers: Basics, Maintenance, and Diagnostics," April 2005. Found at http://www.usbr.gov/pmts/client_service/recent/studytransformers.pdf, accessed on January 30, 2012.

Van Norden, Rudolph, W. "System of Nevada-California Power Company and the Southern Sierras Power Company. Part 1 – Power Plants." Pages 1-20 in *Properties and Power Developments of the Nevada-California Power Company and the Southern Sierras Power Company*. Reprint from the *Journal of Electricity Power and Gas*. Volume XXXI. Numbers 1-2. July 5-12, 1913, by Technical Publishing Company (San Francisco). Located in SCE company archives at 4000 Bishop Creek Road, Bishop, California.

__________. "System of Nevada-California Power Company and the Southern Sierras Power Company. Part 2 – Transmission and Distribution System." Pages 20-36 in *Properties and Power Developments of the Nevada-California Power Company and the Southern Sierras Power Company*. Reprint from the *Journal of Electricity Power and Gas*. Volume XXXI. Numbers 1-2. July 5-12, 1913, by Technical Publishing Company (San Francisco). Located in SCE company archives at 4000 Bishop Creek Road, Bishop, California.

Drawings available from Southern California Edison Company (located in SCE company archives at 4000 Bishop Creek Road, Bishop, California):

California Electric Power Company. "Transformer House General Arrangement." April 4, 1956, first revised September 25, 1956; most recent revision December 9, 2004, Sheet 2 of 4, SCE Drawing No. 570882-4.

Nevada-California Power Company. "Elevation of Southeasterly Side." March 1908, Sheet 2 of 5, SCE Drawing No. 214490-0.

__________. "Elevation Transverse and Longitudinal Sections." March 14, 1932, SCE Drawing No. 210491.

__________. "Plans for Transformer House To Accompany Power House No. 2. Elevation of Northeasterly End." March 1908, Sheet 1 of 5, SCE Drawing No. 214492.

__________. "Roof System Transformer House No. 2." March 1908, Sheet 5 of 5, SCE Drawing No. 214488-0.

__________. "Transformer Plan," March 1908; Revised March 2, 1932 and May 22, 1956, Sheet 3 of 5, SCE Drawing No. 214489-2.

Southern California Edison Company. "General Plan – Transformer House & Line Getaway." July 2, 1930; first revised June 24, 1966; most recent revision December 9, 2004, SCE Drawing No. 570864-10.

_________. "Transformer House Electrical Equipment Plan". February 14, 1956; first revised July 29, 1964; most recent revision May 4, 2005, SCE Drawing No. 570881-10.

_________. "Transformer House Electrical Equipment Section Evaluation." February 16, 1956; first revised July 21, 1966; most recent revision December 9, 2004, SCE Drawing No. 570883-8.

Photographs available from Southern California Edison Company:

B. Secondary Sources:

Poole, C. O. "Conclusion of the description of the Southern Sierras transmission system – The steam plant at San Bernardino – Typical outdoor substations – Imperial Valley line." Pages 44-47 in *Power Development and Transmission Systems of The Nevada-California Power Company and the Southern Sierras Power Company*. Reprinted in 1915 from *Electrical World*, New York. 1914. Located in SCE company archives at 4000 Bishop Creek Road, Bishop, California.

________. "Further details concerning the transmission system of the Nevada-California Power Company – The substations at Goldfield, Tonopah, Miller's, Manhattan and Rhyolite." Pages 38-39 in *Power Development and Transmission Systems of The Nevada-California Power Company and the Southern Sierras Power Company*. Reprinted in 1915 from *Electrical World*, New York. 1914. Located in SCE company archives at 4000 Bishop Creek Road, Bishop, California.

________. "Transmission system of the Nevada-California Power Company – Details of construction of the lines in service – The stations at Palmetto, Silver Peak and Alkali." Pages 35-37 in *Power Development and Transmission Systems of The Nevada-California Power Company and the Southern Sierras Power Company*. Reprinted in 1915 from *Electrical World*, New York. 1914. Located in SCE company archives at 4000 Bishop Creek Road, Bishop, California.

________. "Transmission system of the Southern Sierras Power Company and the vast territory covered by its lines – Control station in Owens Valley – Details of towers and cables." Pages 40-43 in *Power Development and Transmission Systems of The Nevada-California Power Company and the Southern Sierras Power Company*. Reprinted in 1915 from *Electrical World,* New York. 1914. Located in SCE company archives at 4000 Bishop Creek Road, Bishop, California.

White, David R. M. "Management Plan for Historic and Archaeological Resources Associated with the Historic and Archaeological Preservation Plan for the Bishop Creek Hydroelectric Project (FERC Project 1394), Inyo County, California." Prepared for the Southern California Edison Company, Rosemead, California: March 1989. Located in SCE company archives at 4000 Bishop Creek Road, Bishop, California.

C. Likely Sources Not Yet Investigated:
An inquiry was made to The Huntington Library, Arts Collections, and Botanical Gardens (The Huntington) located in San Marino, California, regarding the availability of construction drawings for Bishop Creek plants that may be stored in the Southern California Edison Records, 1848-1989 (SCE Records). According to The Huntington personnel and finding aids, the SCE Records do not contain indexed construction drawings. However, a vast volume of materials is indexed in the SCE Records in a variety of categories that include: Administrative Records; Department/Division Records; Financial Records; Generation, Distribution, and Transmission Records; Project Records; Research Files; Topical Records; and Oversize Materials. These materials could potentially yield additional information related to the historical development of Bishop Creek power plants. This information could be gathered by conducting a thorough review of materials indexed in the SCE Records.

In addition, the Huntington maintains a Digital Library that includes a Southern California Edison Photographs and Negatives Collection (SCE Photograph Collection). This SCE Photograph Collection contains numerous historical photographic images of SCE facilities that could potentially yield additional information related to the historical development of Bishop Creek power plants. This information could be gathered by conducting a thorough review of photographic images indexed in the SCE Photograph Collection.

Other potential sources of information that could be investigated include current and former power company employees, who may have knowledge of the historical development of Bishop Creek power plants which may not be contained in available documents, drawings, or other materials. This information could be gathered by contacting and conducting interviews with individuals who potentially have this knowledge.

Appendix A: Images

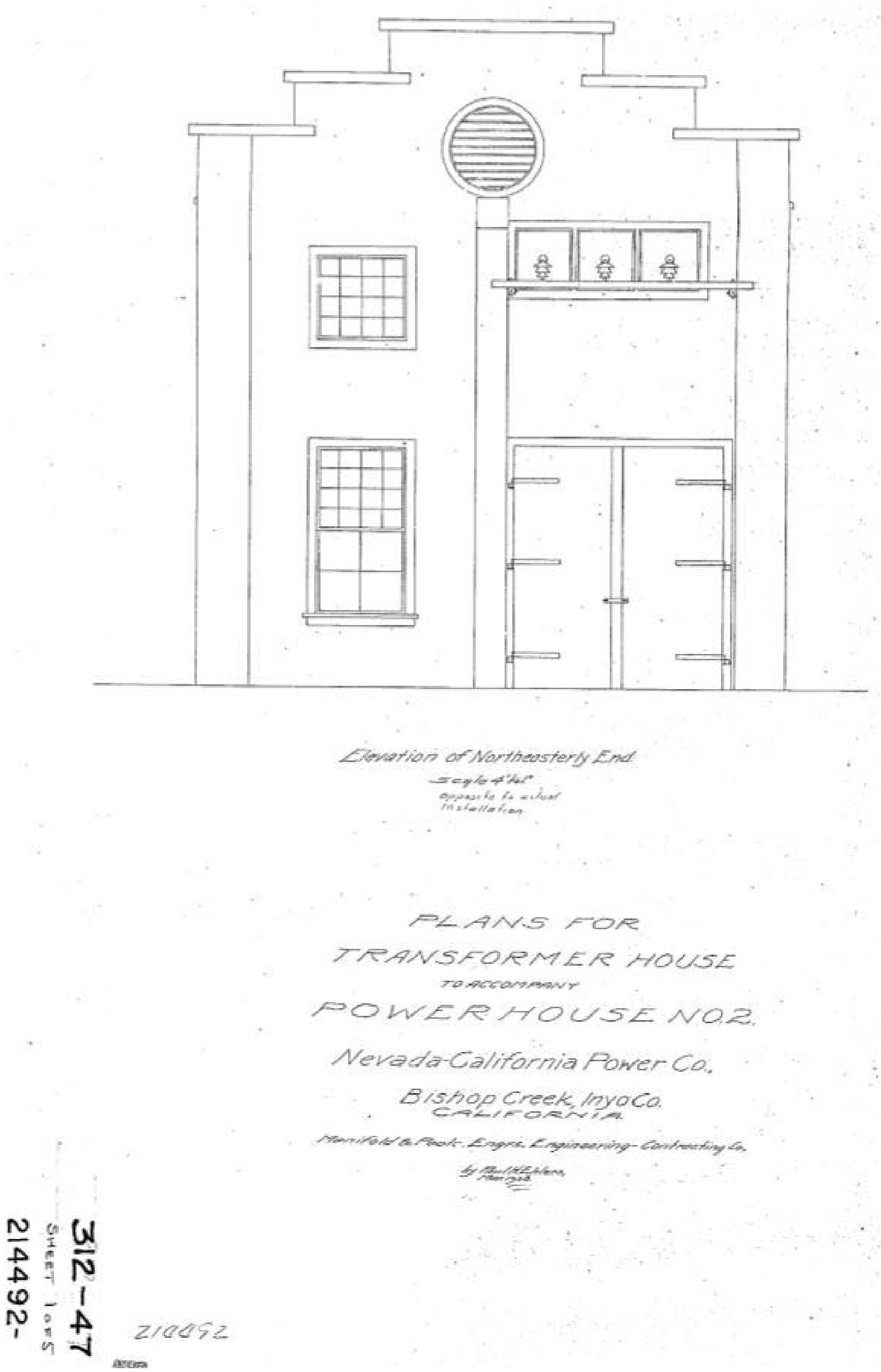

Figure 1: Nevada-California Power Company, "Plans for Transformer House to Accompany Power House No. 2, Elevation of Northeasterly End," Sheet 1 of 5, March 1908. SCE Drawing No. 214492.

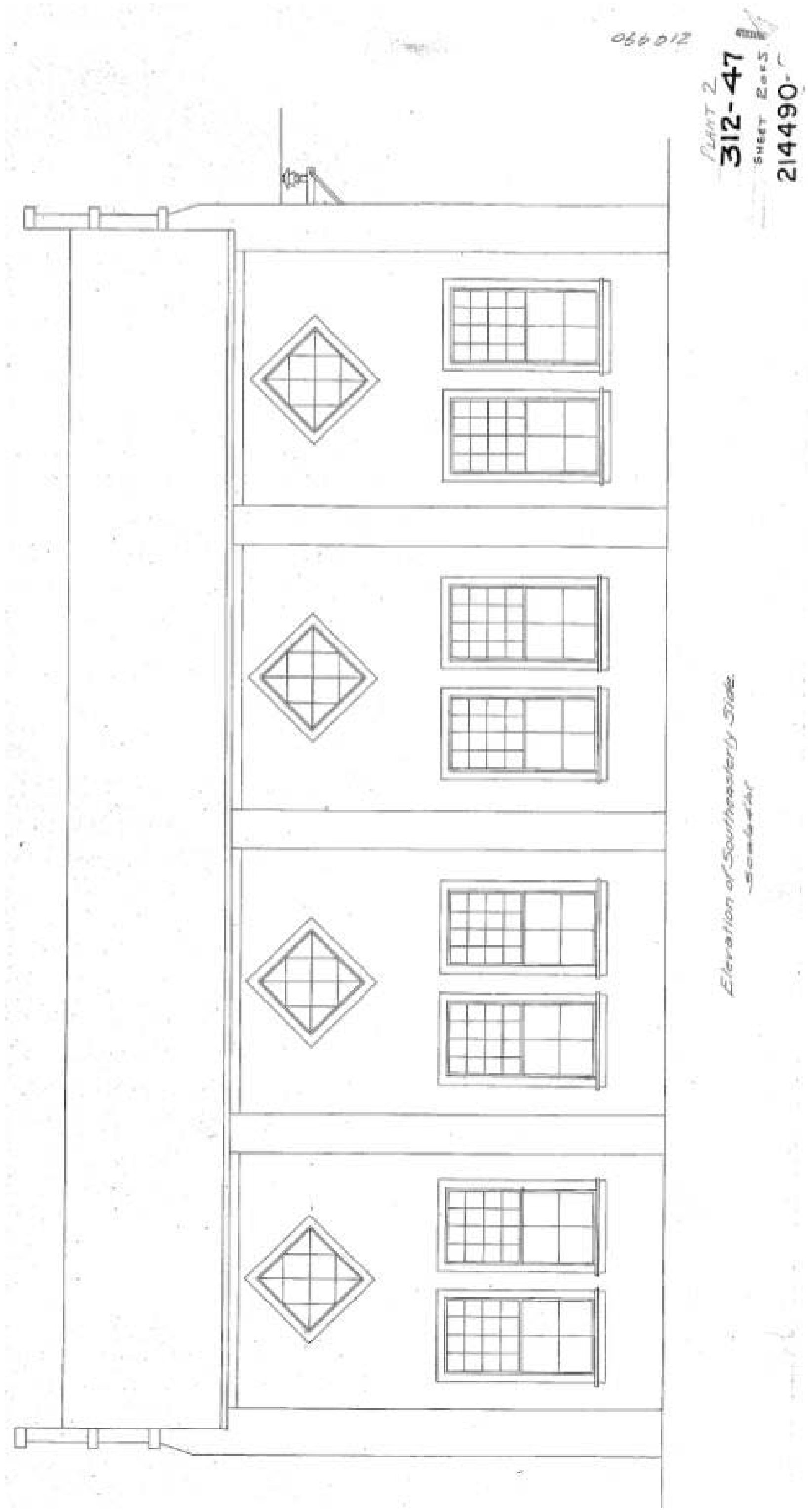

Figure 2: Nevada-California Power Company, "Elevation of Southeasterly Side," Sheet 2 of 5, March 1908. SCE Drawing No. 214490-0.

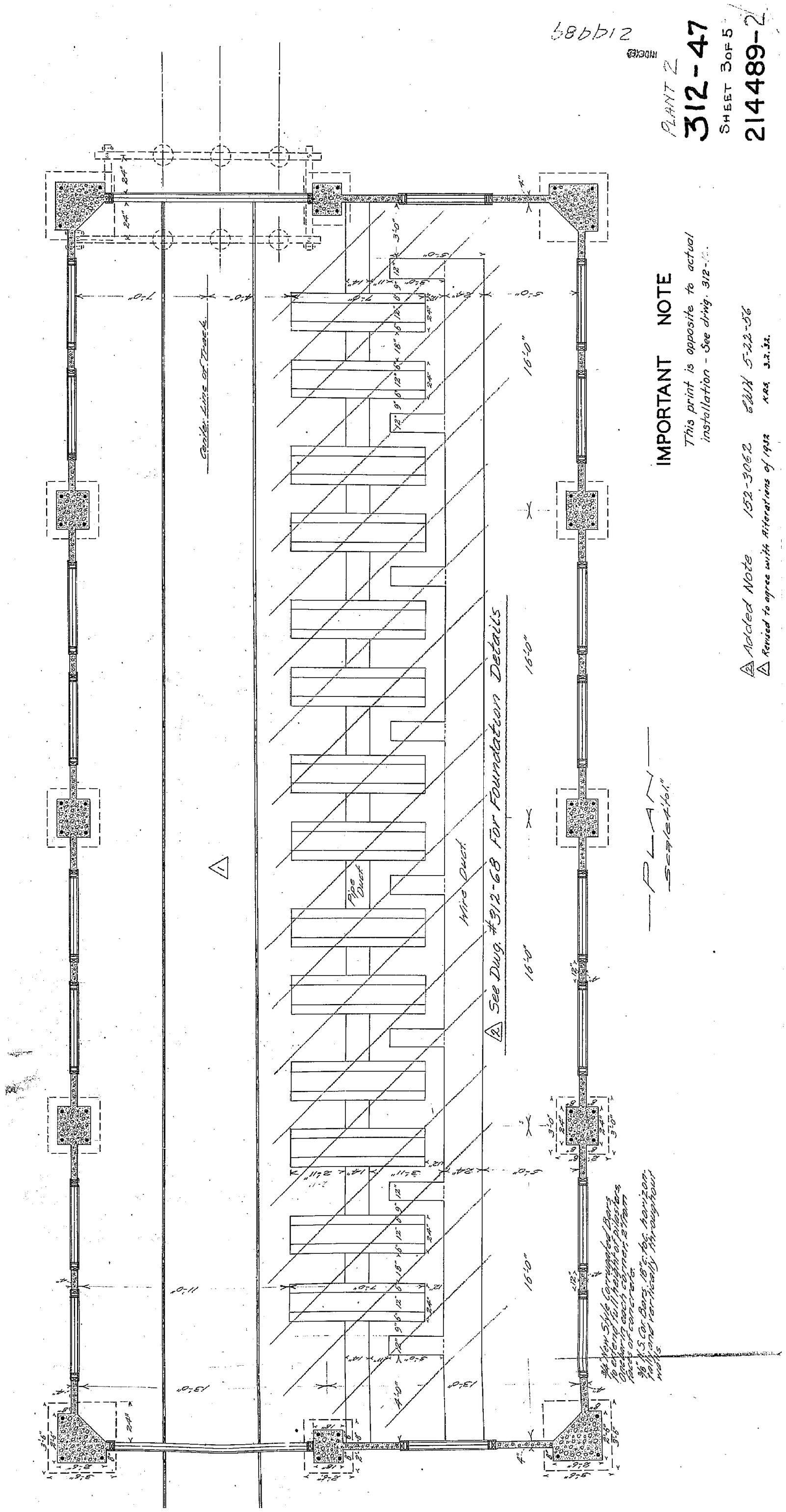

Figure 3: Nevada-California Power Company, "Plan," Sheet 3 of 5, March 1908; revised March 2, 1932 and May 22, 1956. SCE Drawing No. 214489-2.

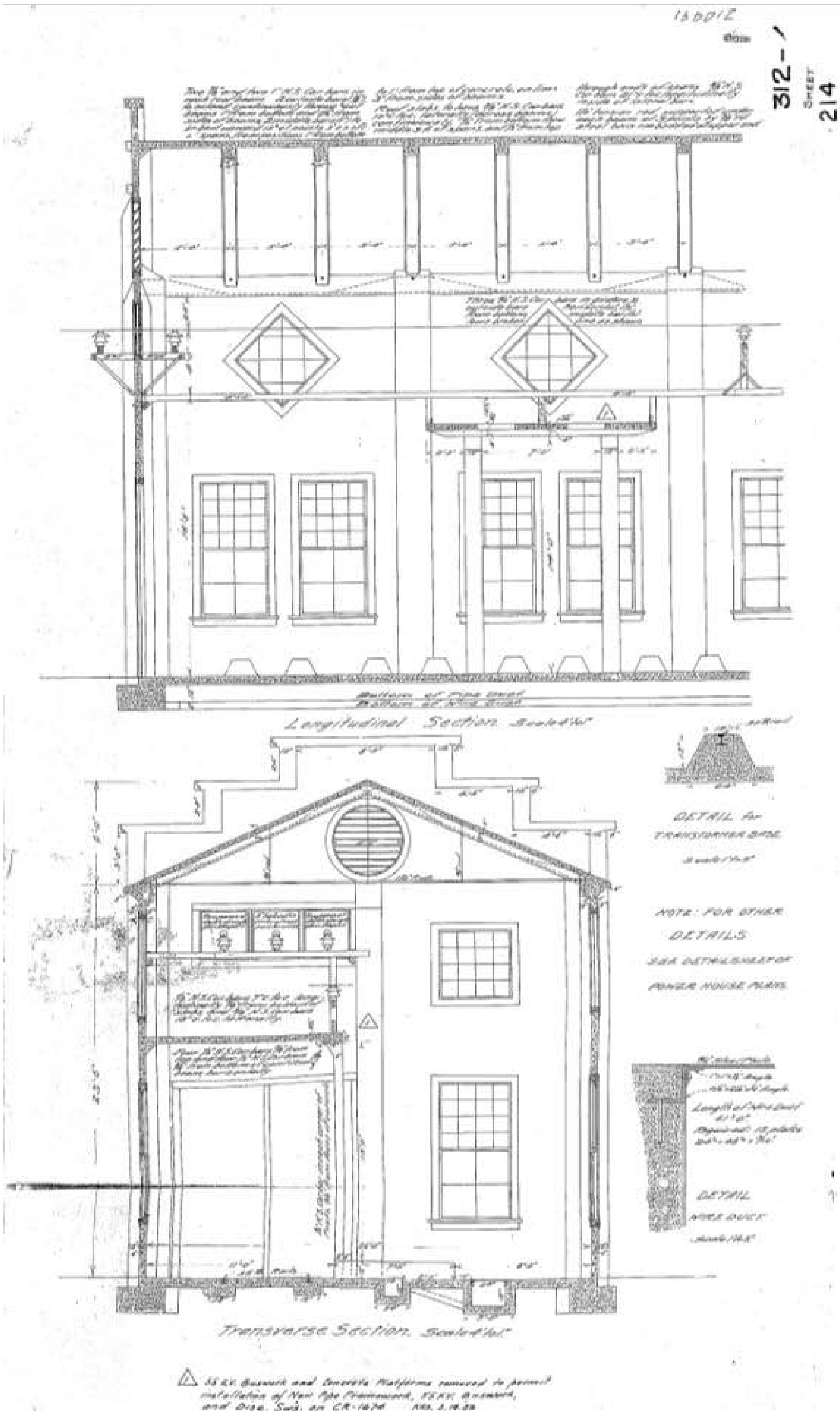

Figure 4: Nevada-California Power Company, "Elevation Transverse and Longitudinal Sections," Sheet 4 of 5, March 1908; revised March 14, 1932. SCE Drawing No. 210491.

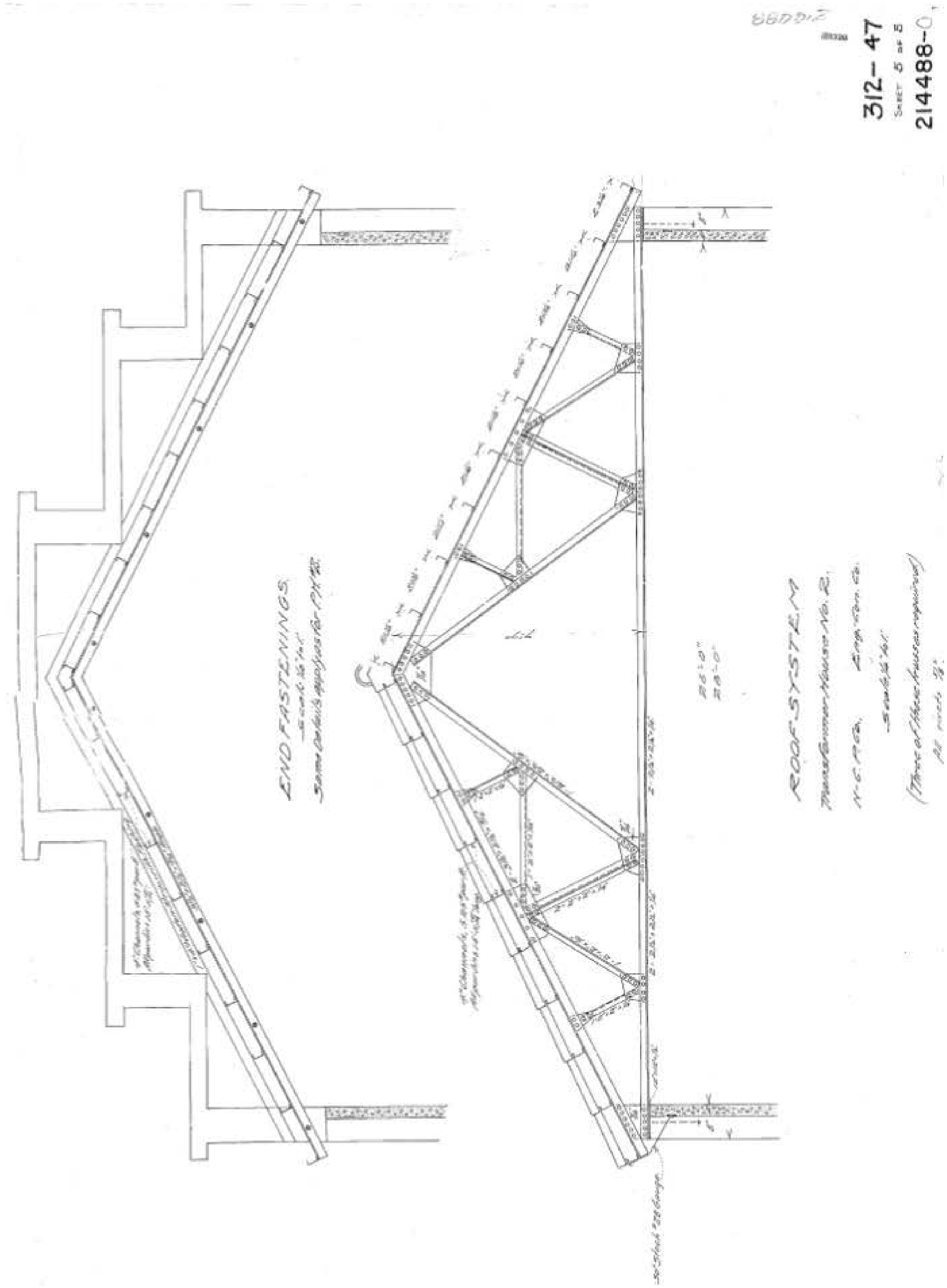

Figure 5: Nevada-California Power Company, "Roof System Transformer House No. 2," Sheet 5 of 5, March 1908. SCE Drawing No. 214488-0.

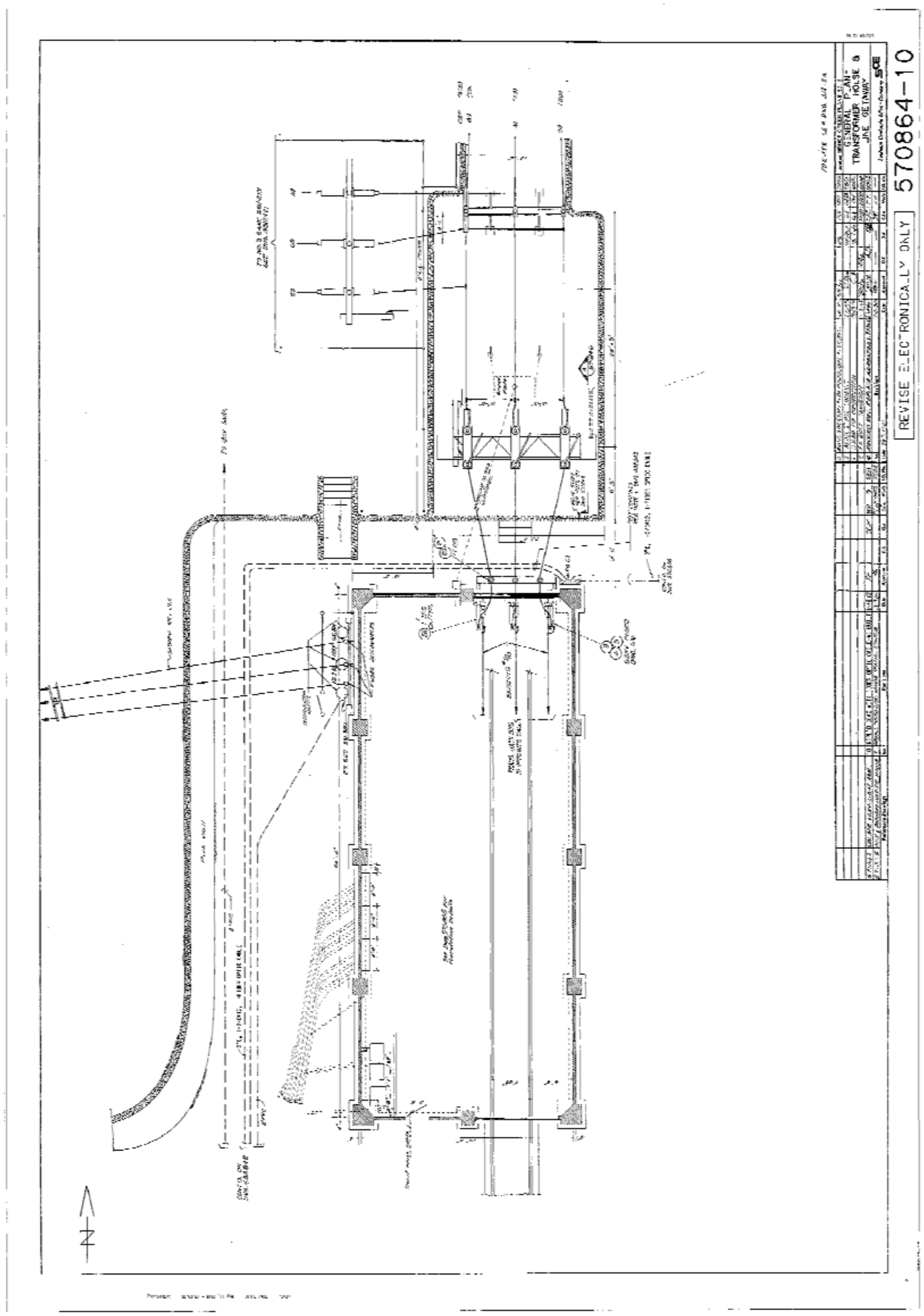

Figure 6: Southern California Edison Company, "General Plan – Transformer House 8 Line Getaway," July 2, 1930; first revised June 24, 1966; most recent revision December 9, 2004. SCE Drawing No. 570864-10.

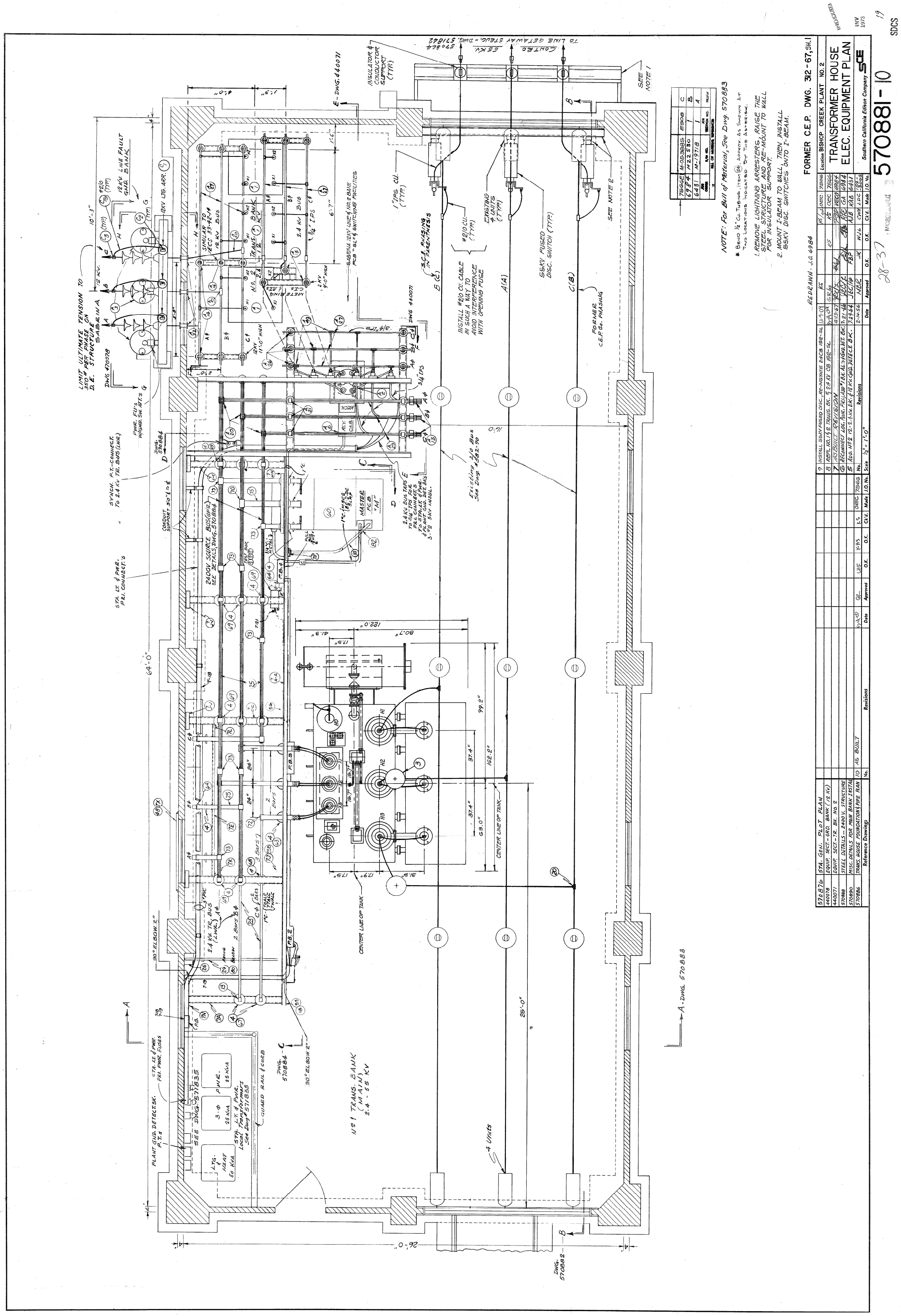

Figure 7: Southern California Edison Company, "Transformer House Elec. Equipment Plan," February 14, 1956; first revised July 29, 1964; most recent revision May 4, 2005. SCE Drawing No. 570881-10.

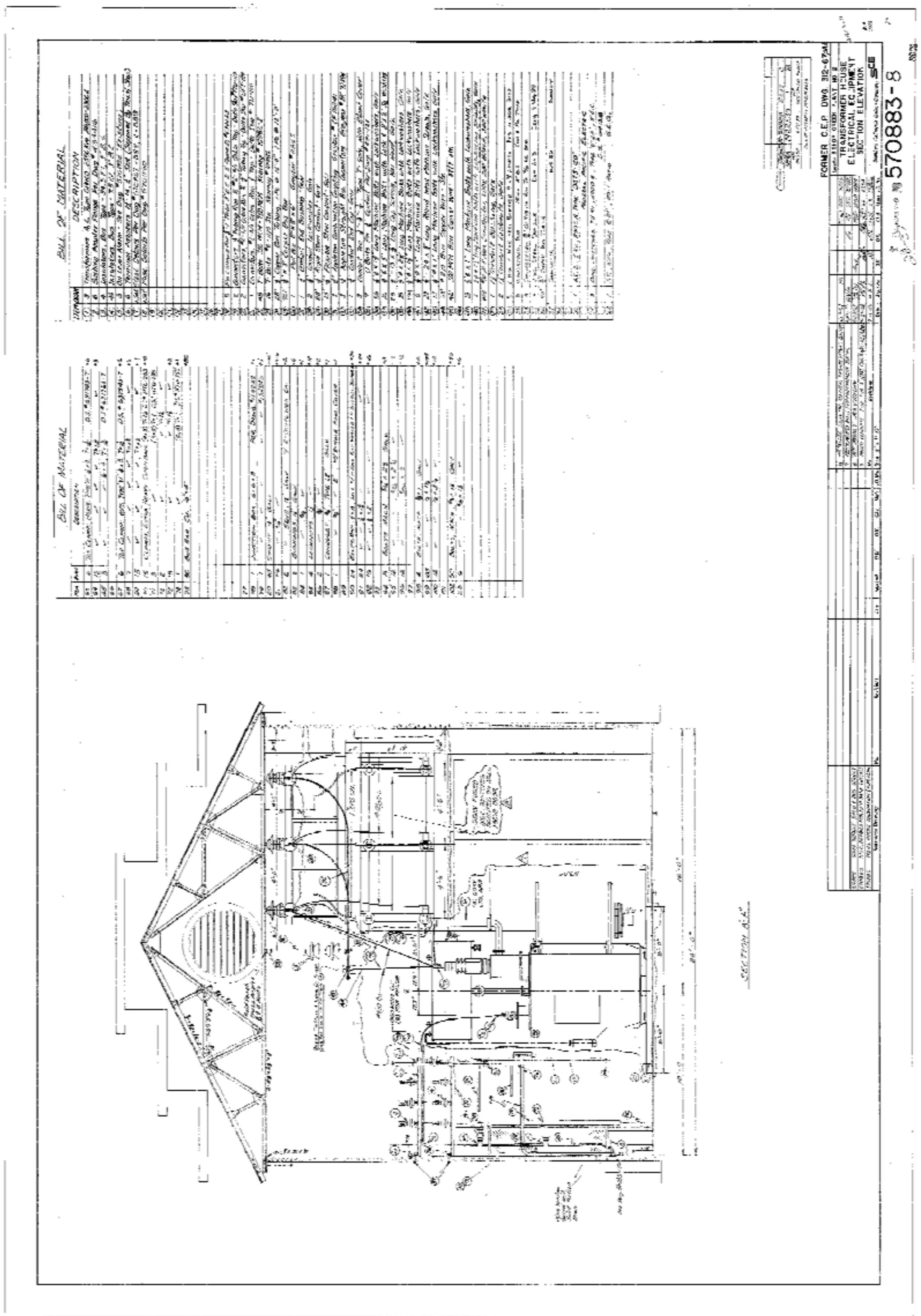

Figure 8: Southern California Edison Company, "Transformer House Electrical Equipment Section Elevation," February 16, 1956; first revised July 21, 1966; most recent revision December 9, 2004. SCE Drawing No. 570883-8.

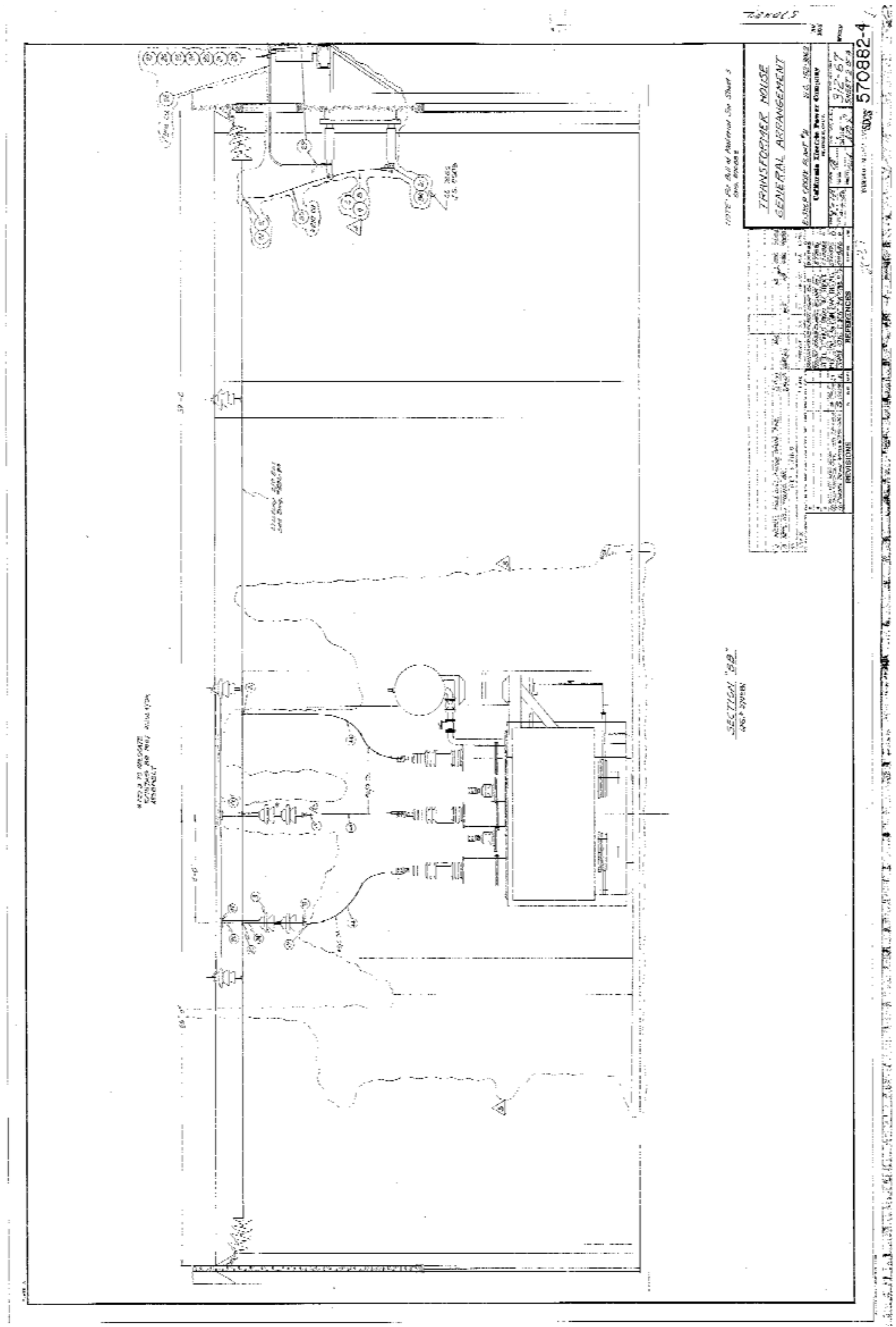

Figure 9: Southern California Edison Company, "Transformer House General Arrangement," April 4, 1956; first revised September 25, 1956; most recent revision December 9, 2004. SCE Drawing No. 570882-4.