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HISTORIC CIVIL ENGINEERING LANDMARKS

of Sacramento and Northeastern California

SACRAMENTO IMAGES 1776 1976

SACRAMENTO SECTION AMERICAN SOCIETY OF CIVIL ENGINEERS FOUNDED 1852 1922

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November, 1976

Plaque presented by the American Society of Civil Engineers to the Southern Pacific designating the Central Pacific Railroad as a National Historic Civil Engineering Landmark. Typical of the plaques recognizing the fifty-seven (currently) national landmarks this plaque is presently on display in the Morse Building in Old Sacramento. It will soon be permanently mounted in the vicinity of the recently reconstructed Central Pacific Depot, also in Old Sacramento.

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HISTORIC CIVIL ENGINEERING LANDMARKS

of Sacramento and Northeastern California

Prepared by

The History and Heritage Committee

Sacramento Section

American Society of Civil Engineers

In Recognition

of The United States Bicentennial

An Official Bicentennial Project endorsed by the American Revolution Bicentennial Commission of California and the Sacramento American Revolution Bicentennial Committee.

PREFACE

To quote from the *ASCE Guide to History and Heritage Programs* (1974), "The growth and development of this country and the development of American civil engineering are not only parallel, they are in fact synonymous. This is not unique to the United States of America, since essentially the same statement may be made about other nations and other times in history. The progress of civilization may be traced by its civil engineering works — from footpaths to highways, from communal springs to municipal water supply systems, and virtually all other facilities which are needed to attain and sustain an advanced state of civilization."

Cognizant of the importance of recognizing and identifying this heritage, the ASCE Board of Direction established a national Committee on History and Heritage of American Civil Engineering in 1964. Among the varied activities of the national committee is the development of the National Historic Civil Engineering Landmark program. Projects which represent a significant facet of civil engineering and which also are of national historic engineering interest may be nominated by a local section of the Society as National Historic Civil Engineering Landmarks, and after evaluation by the national committee, submitted to the Board of Direction for approval. Five of the projects appearing in this booklet have been so designated. They are now marked by bronze plaques which were presented by a national officer of ASCE at respective public ceremonies.

The local sections are also encouraged to recognize Local Historic Civil Engineering Landmarks and carry on their own history and heritage programs. Toward this end, and as part of the section's contribution to the United States Bicentennial, the Sacramento Section of ASCE has prepared this booklet. It is hoped that the booklet will be of interest and use to both the engineering community and the general public. In addition to providing background information about each project, enough information is usually given so that the project or site may be easily located. In addition to those subjects previously designated as national landmarks, the majority of the remainder may appropriately be considered as Local Historic Civil Engineering Landmarks.

Alan L. Prasuhn
Larry Wing

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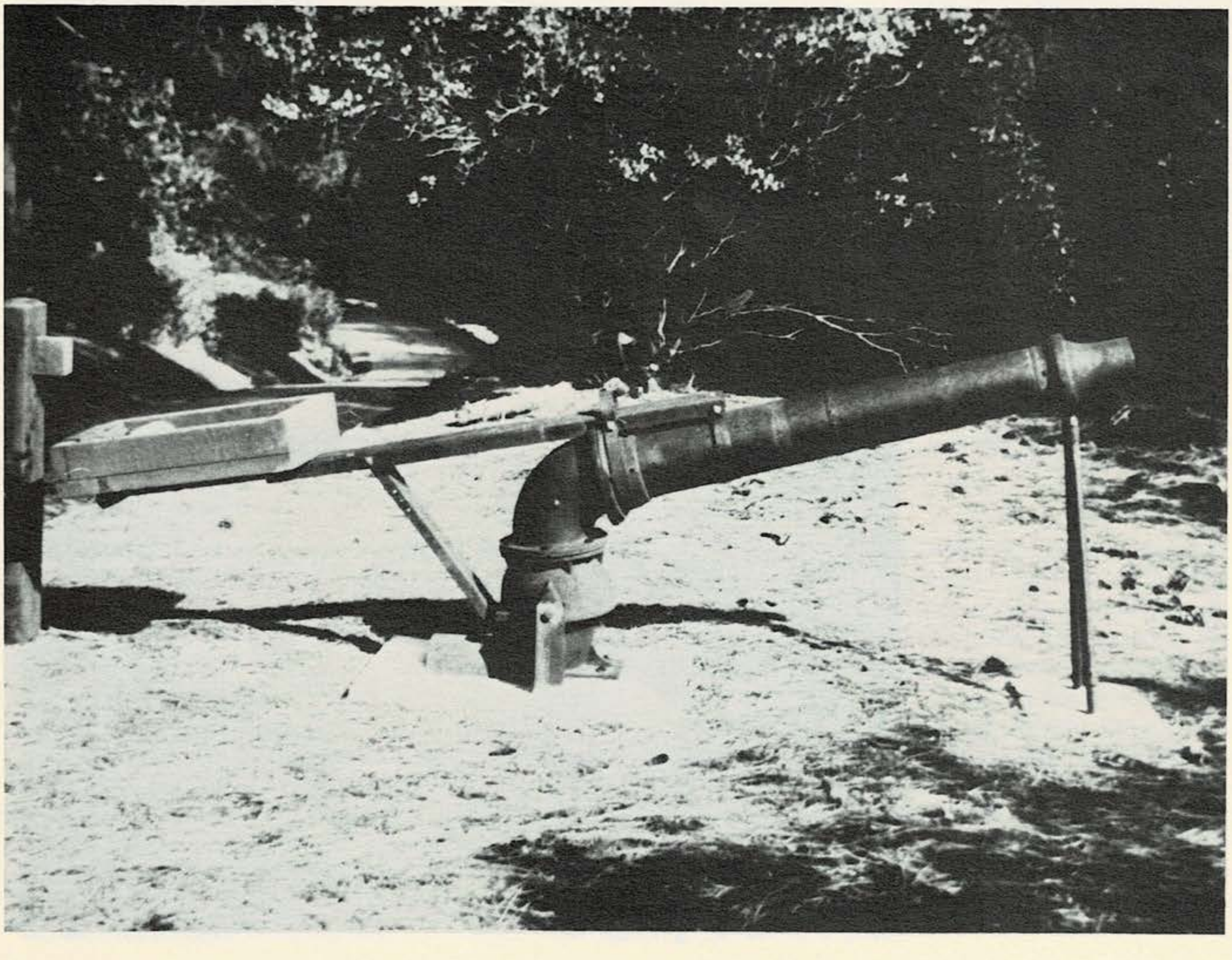
MINING

Certainly Northern California would have been settled and developed eventually, but the discovery of gold at Sutter's Mill in 1848 enormously accelerated the process. In their quest to "strike it rich," the Gold Rush miners soon demanded diversion works, ditches, and mill races. Thus it is, that some of the first large scale civil engineering activities were associated with the attempt to separate the precious metal from the otherwise "useless" earth. And never mind what happened to the detritus! Of the various mining procedures, one stands out as distinctive of Northern California:

HYDRAULICKING

Hydraulic mining or "Hydraulicking" as defined by state and federal statute, is "mining by application of water pressure, through a nozzle against a natural bank." Powerful jets of water were used to break down the natural gravel banks. The debris was washed through sluice boxes where the heavier gold separated out. Hydraulic mining was very lucrative, its peak yieldings came in the 1870's and amounted to approximately 11-13 million dollars annually. Hydraulic mining eventually contributed one-quarter of Califor-

Typical hydraulic nozzle or monitor.



nia's gold yield and was the greatest technological advance in the long history of placer gold mining. Only gold dredging, which developed in California around the turn of the century, could approach hydraulicking as a low cost mining method.

Edward E. Matteson is known as the "father of hydraulicking". Although an inventor capable of applying engineering principles to gold mining, he never formally studied engineering. Originally of Sterling, Connecticut, Matteson left wife and home to explore the California gold fields. In 1853, at American Hill Mine, a mile east of Nevada City, Matteson conceived the idea of directing a jet of water against the gravel banks of streams or hillsides. He and a friend constructed a four inch diameter, 40 foot long rawhide hose, and fastened to it a nozzle, ¾ inches in diameter, made from sheet brass. The powerful stream of water emitted from the nozzle was able to break down earth banks much quicker than a man working with pick and shovel, and tremendously speeded-up the mining process. This was the first hydraulic nozzle, or monitor.

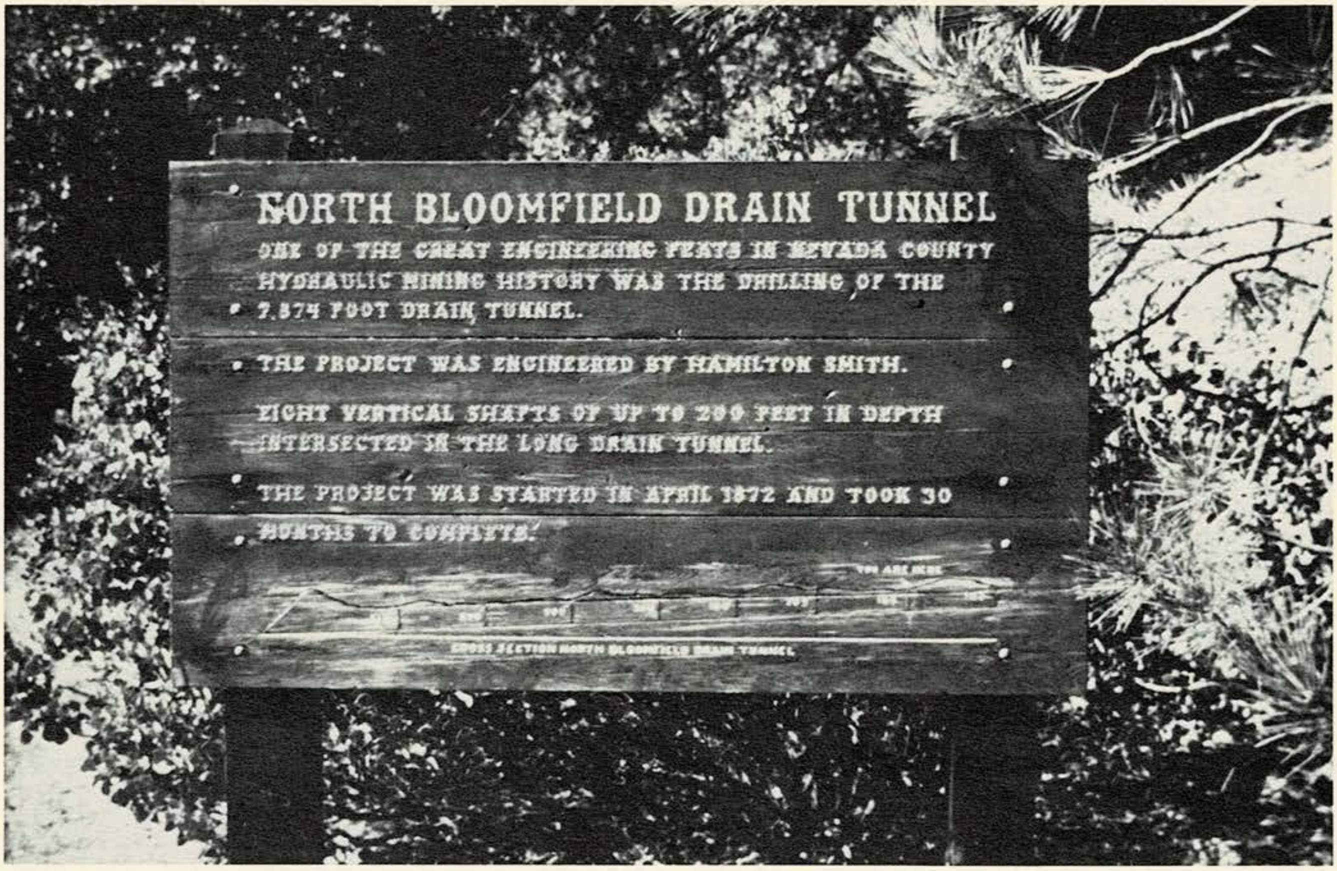
In the early 1880's a typical hydraulic monitor discharged as much as 1500 miner's inches per minute, or something like 25 million gallons in 24 hours! The term "miner's inch" is interesting in itself in that it is of California origin, and is not known to have been used in any other locality. It was a method of measurement based on the discharge through a one-inch diameter opening under a specified head. Because of its convenience, it was adopted by the various ditch companies in selling water to their customers. Unfortunately, the term is indefinite, being a variable water quantity for each water district. No one gauge was ever uniformly adopted. Depending on many factors, the miner's inch of water varied between 10.2 and 13 gallons per minute, with 11.25 gallons per minute being the most usual value.

Dams and reservoirs were used to hold vast amounts of water to permit summer mining, and ditches and flumes then carried the water to the mining sites. Here, in the design and construction of these water conveyance facilities, the Civil Engineer and Surveyor were essential ingredients.

Another unique feature of hydraulic mining in California was the use of a bedrock tunnel leading from a shaft at the low point of an hydraulic pit. Auriferous gravels, washed down by the hydraulic nozzles, were conveyed into this shaft and then through sluice boxes set in the bedrock tunnel. The tunnel pierced the higher "rim rock" at the margins of the hydraulic excavation and thus provided sufficient "fall" for the sluices which discharges their tailings into adjacent ravines and valleys at lower levels.

Hydraulicking enabled the economic extraction of gold from vast, low-grade gravel deposits or from leads buried beneath masses of barren detritus. However, the waste material created a real problem. In 1880 alone, detritus washed by hydraulic operations into the Sacramento and tributary rivers amounted to about 46 million cubic yards. The quantity discharged into the Yuba River during an eighteen month period

Hydraulic monitor being used to wear down gravel banks.



North Bloomfield Drain Tunnel marker.

Debris and gold washed from the surrounding hillsides by the hydraulic monitors, drained into this tunnel.

alone would have entirely filled the Erie Canal! Due to laws enacted by both state and federal governments, hydraulic mining was virtually prohibited in the Sacramento and San Joaquin watersheds after 1883.

Hydraulic mining, however, did more than just fill up rivers and leave scars on hillsides. The large demands for water required accurate hydrologic and climatic observations of the type much needed in the field of water resources engineering today. Hydraulic nozzles were subsequently used around the world for the mining of coal, iron ore, salt, and other materials. The wider possibilities of the hydraulic method were indeed appreciated as early as 1866 when the Central Pacific Railroad Company used high pressure nozzles for opening deep cuttings near Dutch Flat, Placer County. Much later, hydraulicking was to be preferred over steam shovels and suction dredges as a low-cost means of shifting masses of alluvium from the Pacific entrance of the Panama Canal. Even as late as the 1930's, the hydraulic nozzle was used to develop a highway cut on Route 299 at Oregon Mountain near Weaverville, in Trinity County. Here Highway Engineers used the water supply and flume that was developed for the famous LeGrange Mine.

Scars from hydraulic mining may be readily observed throughout the mountains of Northern California. One site which is easily reached is the Dutch Flat area, a few miles above Colfax on Interstate 80. The area around North Bloomfield, known as Malakoff Diggins, has been set aside as a State Historic Park. This region may be reached by following the Bloomfield-Graniteville road north out of Nevada City.

Hydraulic tailings clog the valley below.

Application of an hydraulic monitor on the Oregon Mountain highway cut near Weaverville.

DREDGING

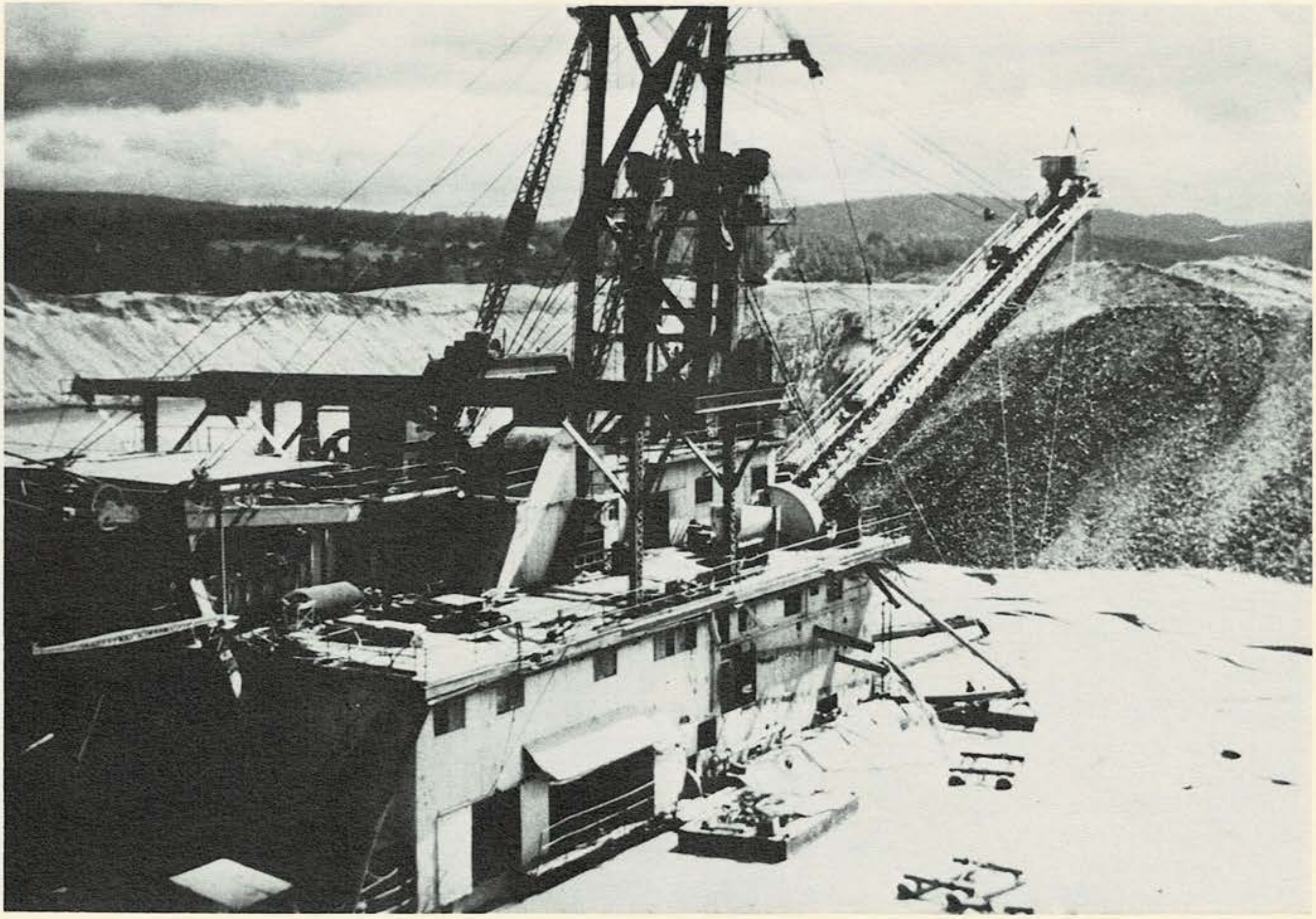
Floating dredges also were responsible for the rearrangement of the California landscape as the quest for gold continued. In the early years, the gold dredgers simply excavated the gravels and soils ahead of them, passing the material through sluice boxes on board to separate the gold. The residual was thereupon cast off the rear end, with the fines on the bottom and the coarse material at the top. The mounds of gravel and cobbles which they left behind still dot the countryside. Closest to Sacramento is the wide belt between Sacramento and Folsom along the American River and U.S. Highway 50. It should be mentioned that the last dredges used were so improved as to leave only the finer soil material on top of the spoil bank. This was accomplished by dumping the coarse materials close behind the dredge, and carrying the fines far back by belt conveyors before dumping onto the earlier deposited coarser mounds.

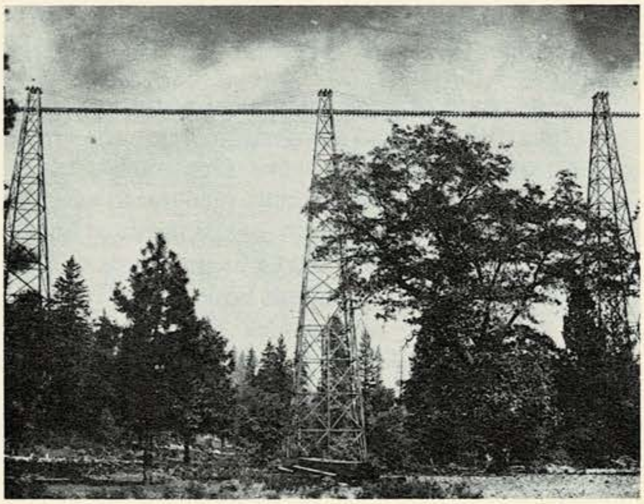
BIG GAP FLUME

The transport of large amounts of water, sometimes over long distances and across difficult terrain, created additional engineering problems. One notable solution was the Big Gap Flume, recently recognized as a State Historic Landmark, and easily one of the most impressive engineering feats of the Gold Rush Era. In order to divert water from the South Fork of the Tuolumne River to the town of Big Oak Flat, where it was needed, a flume had to be constructed across a canyon known locally as Big Gap.

Designed by two engineers and completed in June of 1859, the Big Gap Flume had a height of approximately 280 feet above the ground, a total span of 2200 feet, and a center to center distance between each tower of about 200 feet. The flume was supported by two wire cables approximately three inches in diameter, while the secondary cables were composed of ten

An early gold dredge with large cobblestone pile visible at the rear.



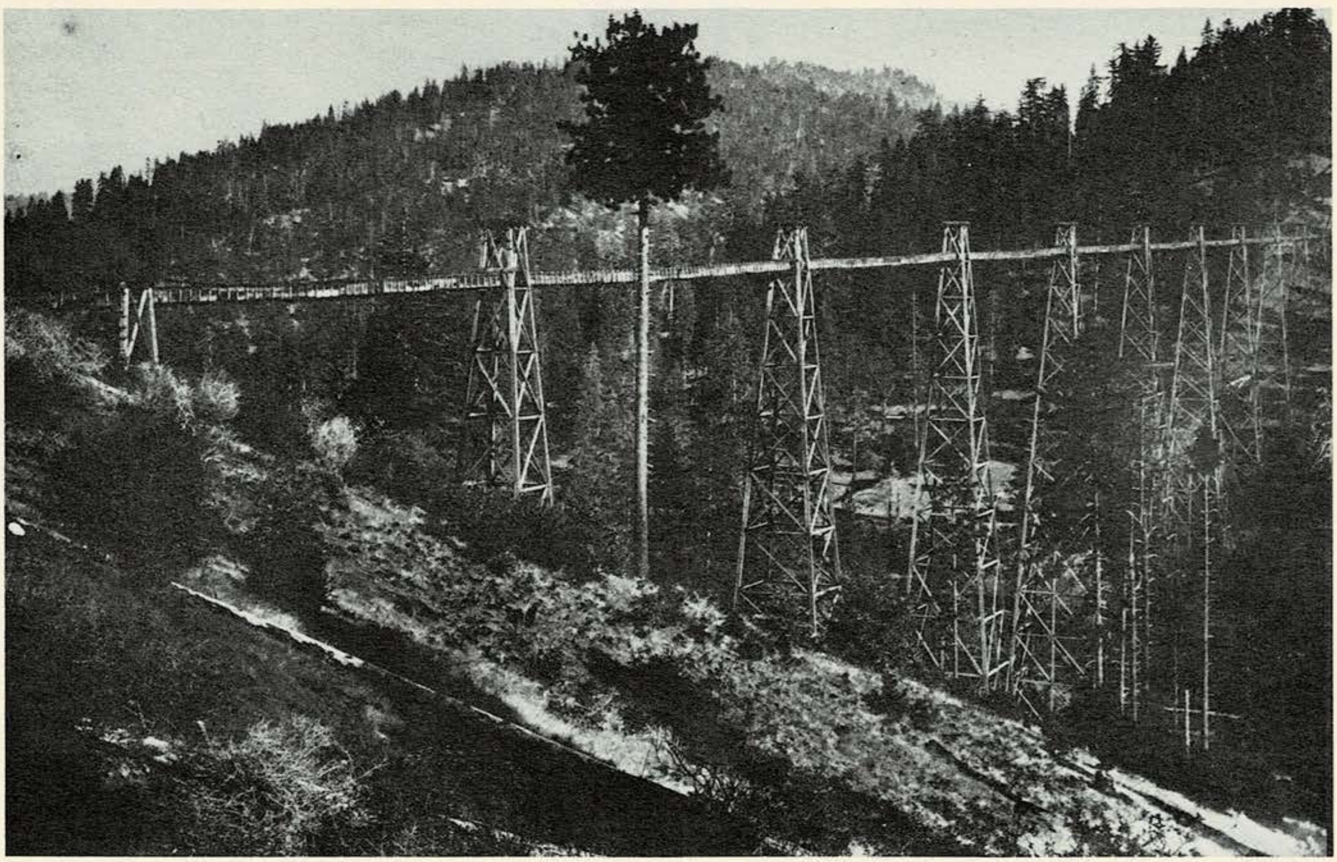


Suspension towers supporting the Big Gap Flume.

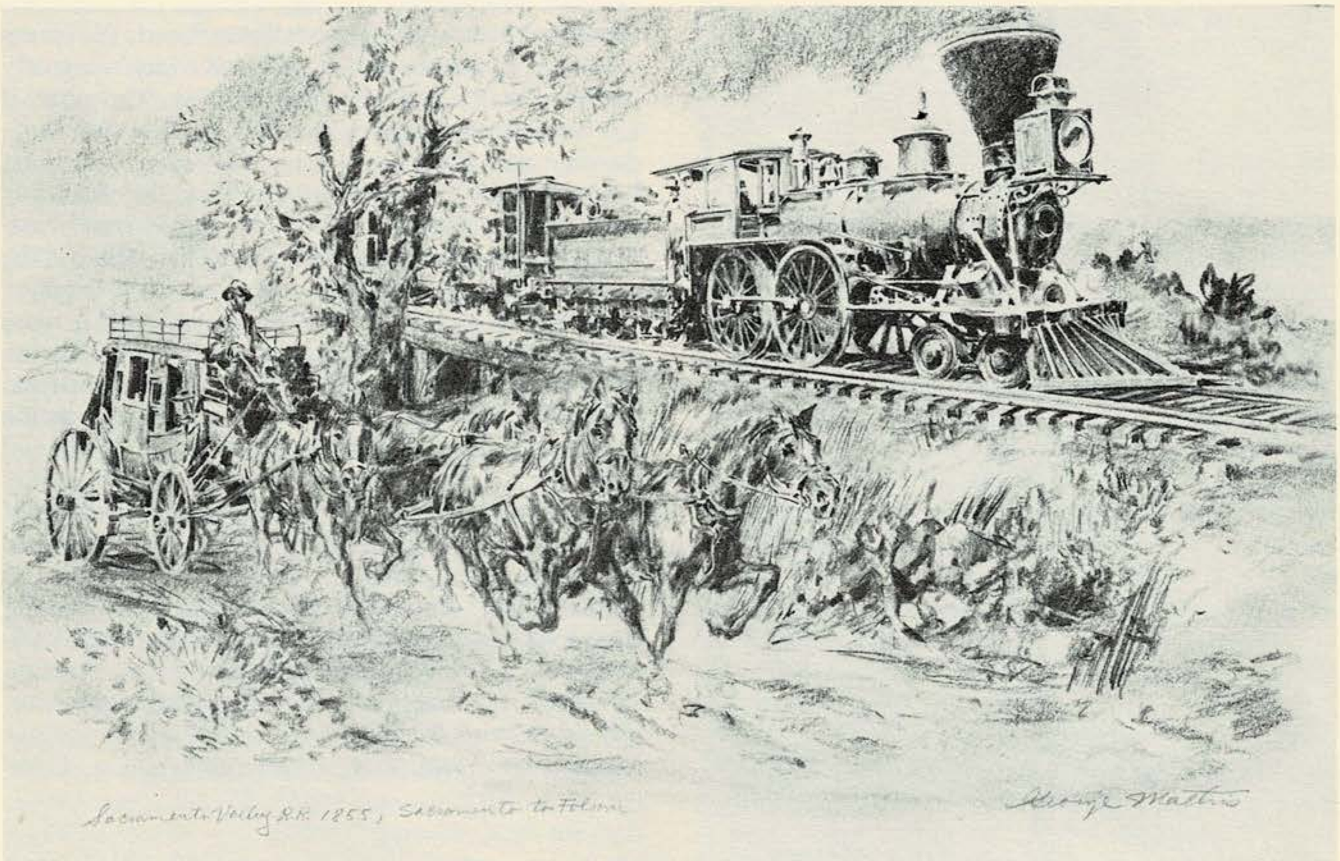
parallel strands of iron wire with a diameter of 1/8 inch. Indeed large for their time, the concrete foundations of the two largest towers were almost 10 feet thick.

According to Carlo M. DeFerrari, Tuolumne County Historian, "when the ditch was running a full head of water, the weight of each two hundred foot section of suspended flume must have been tremendous. Considering the weight of the lumber, iron work and taking into consideration the extra weight due to waterlogging, it is safe to say that each section must have weighed in excess of 25 tons." Many people predicted that the Big Gap Flume wouldn't last over one year. It amazingly survived nine years, and didn't collapse until the summer of 1868. The site is located about a quarter of a mile east of the present day Buck Meadows on State Highway 120 which runs east out of Stockton.

The 2200 foot flume carried water 280 feet above the valley floor.



RAILROADS

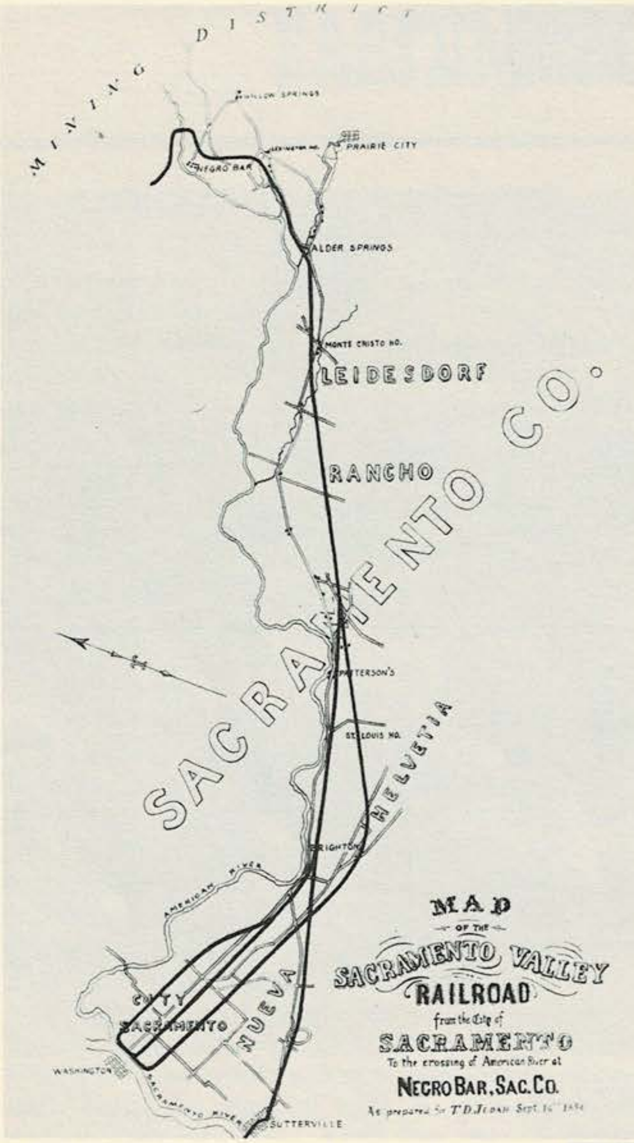


Representation of the Sacramento Valley Railroad by Artist, George Mathis.

THE SACRAMENTO VALLEY RAILROAD

California's first railroad, the Sacramento Valley Railroad (SVRR), was incorporated on August 16, 1852. The line was surveyed by Theodore Judah, who went on to greater fame as the surveyor of the Central Pacific's Sierra route. The original line was 22.9 miles long and was laid to a gauge of five feet. Although the line was opened to Folsom on January 1, 1856, the formal opening celebration did not occur until February 22, 1856. In 1859, SVRR built a twelve mile branch from Perkins Station to the Sacramento River, known locally as the Freeport Railroad. Later, this branch was abandoned by the Central Pacific Railroad, which had purchased the SVRR on August 16, 1865. Also in 1865, the sizeable shops of the Sacramento Valley Railroad were dismantled by the Central Pacific and moved to Sacramento and the line was relaid to standard 4′ 8½″ gauge.

The western terminus of the SVRR was at Second and R Streets in Sacramento. Much of the line is still in existence today. Beginning at the terminus, the line goes east up R Street and joins the Southern Pacific's main valley line to Stockton at Brighton, under the U.S. Highway 50 Bridge. Beyond Brighton, the line, known as the Southern Pacific's Placerville Branch, parallels Folsom Boulevard to Folsom, California. A plaque on the corner of the warehouse south of the tracks at Third and R Streets commemorates this railroad.

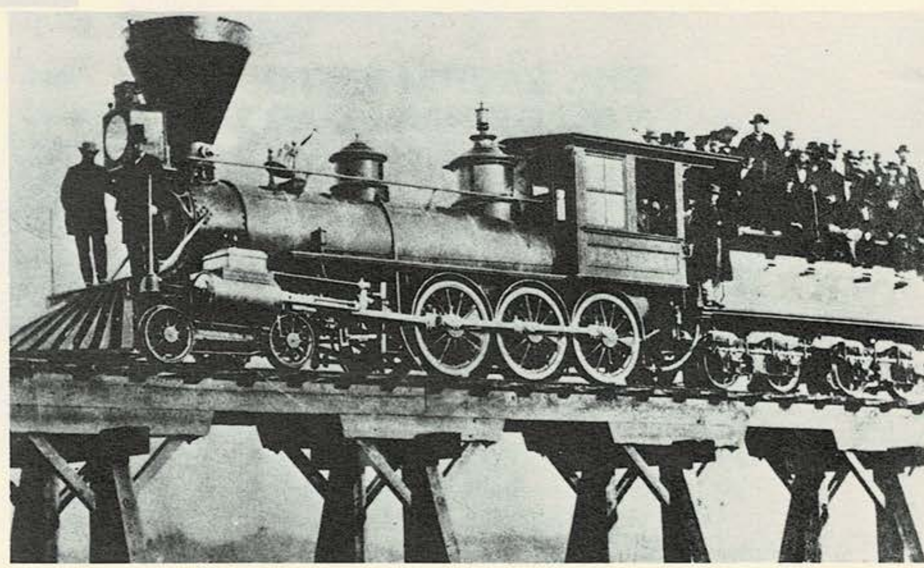


Theodore Judah's map of the Sacramento Valley Railroad.

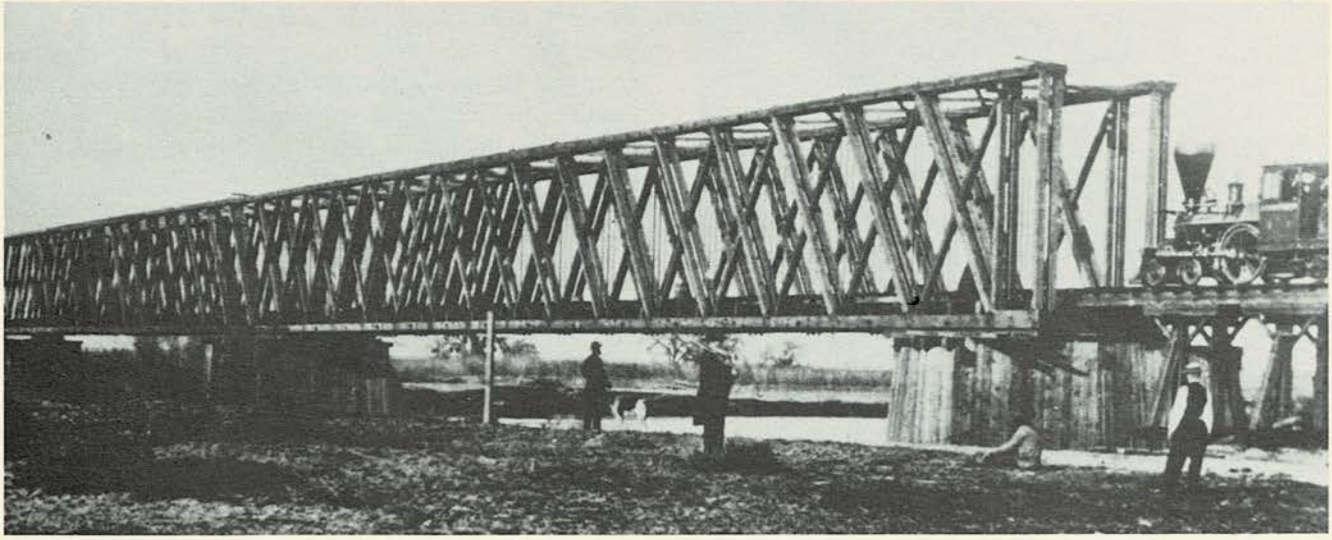
CENTRAL PACIFIC RAILROAD

A more convenient link to the East than the existing roads was required to supply the needs of the growing California population. Therefore, a transcontinental railroad was conceived, the Central Pacific (CP). Much has been written about this railroad, the parent system of a vast network of rail lines which ultimately became the Southern Pacific Railroad. The original CP was incorporated on June 28, 1861, by four Sacramento merchants, who knew little about railroads, but a bit more about business. In fact, they had only two assets — they were all Yankee traders and businessmen from New England and they had obtained the services of an exceptionally competent Civil Engineer who convinced the financiers that he knew a route throught the Sierra adequate for a rail line. In lasting tribute to this engineer, Theodore Judah, his original survey through the Sierra is still in use today as the Southern Pacific's main line to the east. Judah had surveyed many portions of his route long before any thought was given to a railroad. In fact, Judah himself had originally planned his route as a wagon road through the mountains.

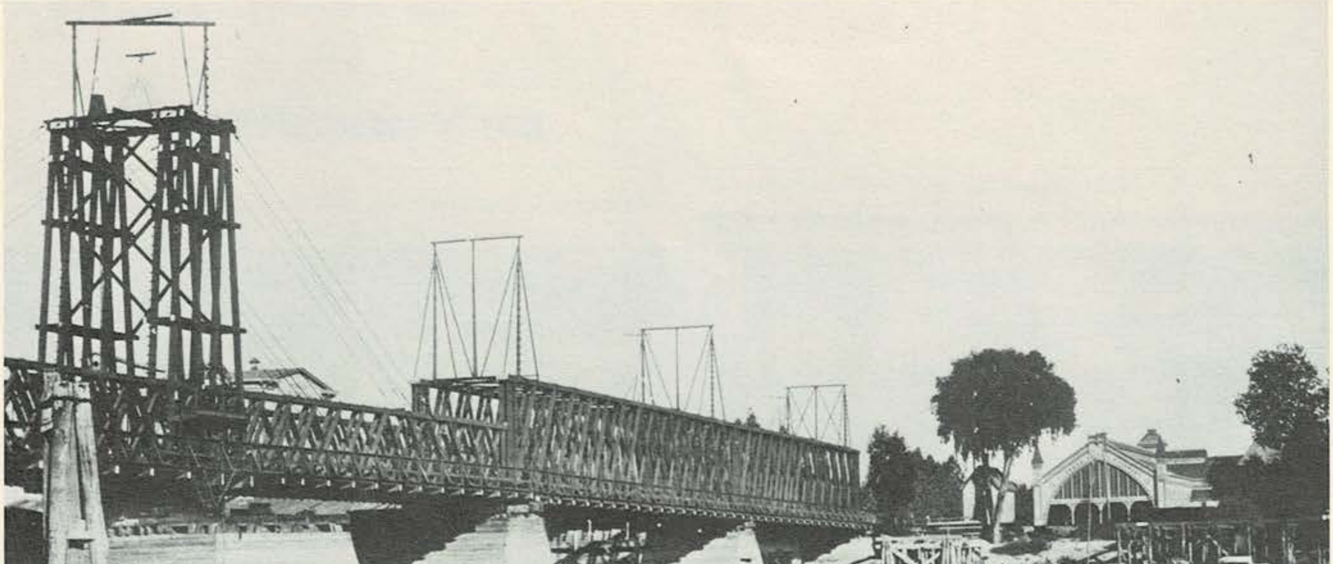
The original Central Pacific portion of the line ran from Sacramento eastward to Promontory, Utah, totalling about 690 miles. Ground breaking took place on January 8, 1863, at Front and K streets in Sacramento, and was completed on May 10, 1869 at the historic "gold spike" ceremony at Promontory Point, Utah,



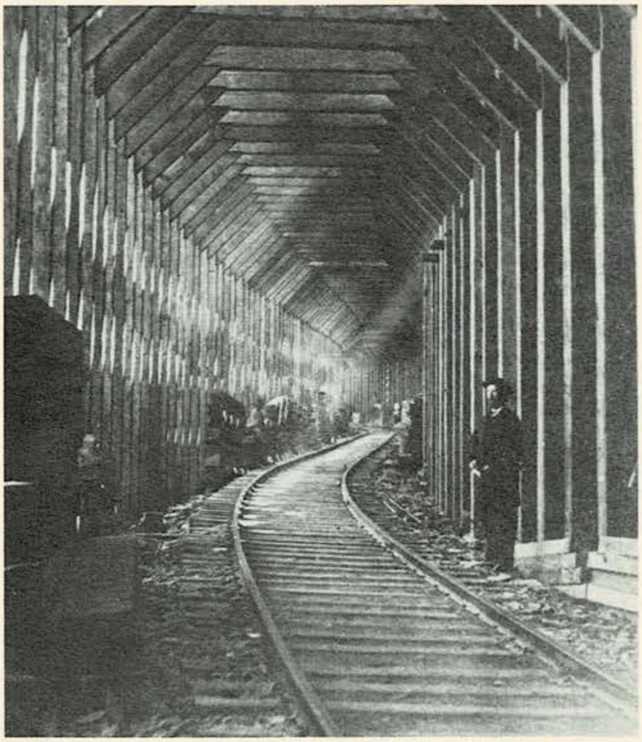
The "John Conness" on the day of its initial trial by the Central Pacific, March 16, 1865.



The Central Pacific's first crossing of the American River was immediately adjacent to its present crossing near Cal Expo.



Construction by the Central Pacific of the predecessor to the I Street Bridge.


Snowshed around Crested Peak, near Donner Summit.

where it met with the Union Pacific. Later that same year, the CP bought an additional 52 miles of track from the Union Pacific Railroad to complete Central Pacific rails into Ogden, Utah. Regular service commenced on the line between Sacramento, and Omaha, Nebraska, on May 13, 1869.

In 1867, experimental snowsheds were built in the Sierra, and by October, 1869, about 37 miles of wooden sheds had been built at a cost of over two million dollars. It was, as one veteran railroader said, "like railroading in a barn." Even with the snowsheds, the record snowfall of 1889-1890 blocked the line over the Sierra for two and one-half weeks. In March, 1902, construction began on the 103 mile Lucin Cutoff, which saved 44 miles of main line length. The cutoff crosses the Great Salt Lake where the lake is 28 miles across, and almost 13 miles of this crossing is on trestle.

Between 1914 and 1925 the line was double tracked, the last obstacle being the 10,332 foot summit tunnel in the Sierra. This tunnel was bored for double track, but it was found that the new westbound grade was too steep for efficient operation, so eastbound trains now roll through a summit tunnel wide enough for two tracks.

Aerial view of Southern Pacific complex taken in 1925.

The Central Pacific was built almost totally by hand labor. Grading, excavations, tunneling, were all accomplished using hand carts, shovels and picks. When Crocker could not keep his Irish work crews on the job, he imported Chinese laborers. They performed so well that he eventually imported more than 7000. They drilled tunnel faces by hand; they hung in wicker baskets and chipped a ledge for track around Cape Horn; and later, using hand carts, they filled in many trestles to make them safer and more fire resistant.

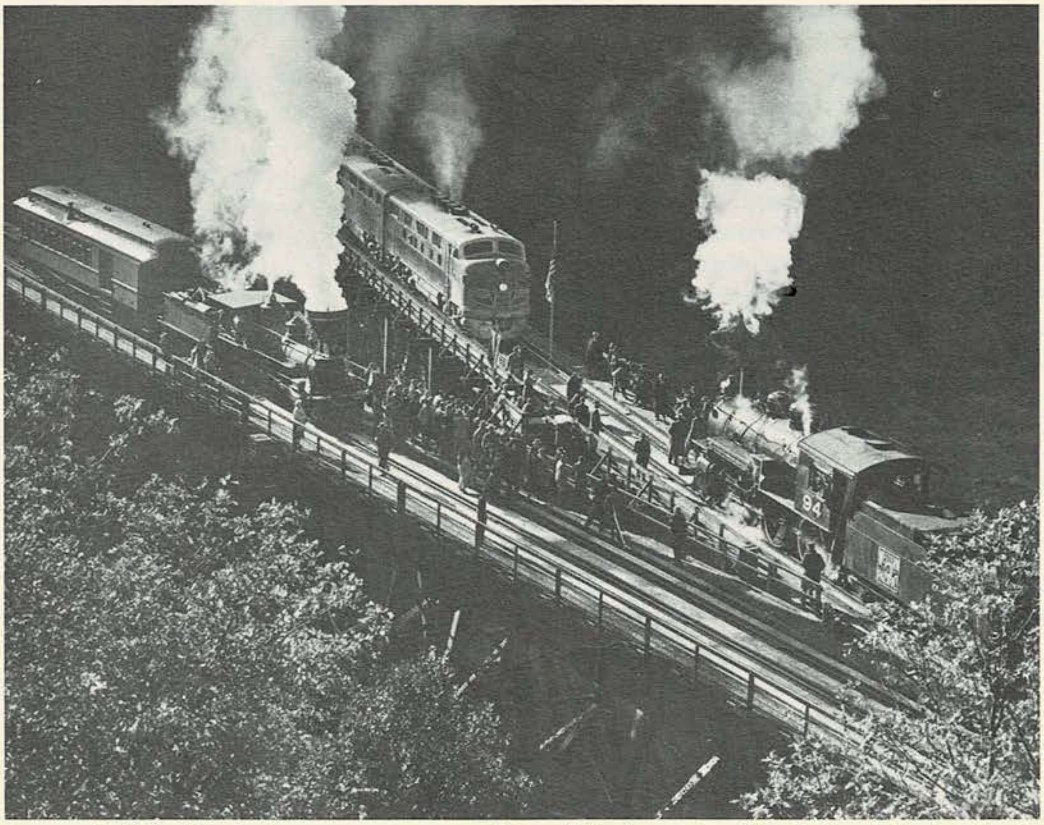
Driving along Interstate 80 today, the motorist may see many portions of this truly National Historic Civil Engineering Landmark. A few miles east of Colfax, the highway winds up the so called Great Ravine while high overhead the rail line crosses both ravine and road and shortly thereafter passes around the famed Cape Horn. On the eastern side of Donner Summit, remnants of the snow sheds remain although timber has given way to reinforced concrete. By following old Route 40 over the summit, a closer vantage point may be obtained.

WESTERN PACIFIC RAILROAD

It was the Southern Pacific Railroad (then the Central Pacific) which created the impetus necessary for the construction in 1906 of a competing rail line across the Sierra. In order to combat the monopolistic tendencies of a single railroad, the businessmen of the San Francisco Bay Area rallied round the idea of a competing line, especially when it was rumored that George Gould, son of Jay Gould, would secretly back construction of a competitor for the Central Pacific-Union Pacific alliance. Gould controlled the Denver and Rio Grande Western railroad, with which the Western Pacific would (and does) connect when it was completed.

The Western Pacific runs from Salt Lake City to Oakland, by way of Beckwourth Pass and the scenic Feather River Canyon. In the original contract, Gould specified that grades were not to exceed 1%. This was to help lower operating costs, and thus be more competitive with the Southern Pacific. Although adding to the engineering difficulties, this was done, and this grade was maintained, even when eleven miles of main line were relocated for construction of the Oroville Dam in 1964.

Arrival of Western Pacific's first passenger train in Sacramento.



Western Pacific's 40th Anniversary commemorated by an historic meeting of the California Zephyr, No. 94, and The Geneoa, on the Keddie Wye. The latter two engines are now on display in Old Sacramento.

Freight train passing itself on the Williams Loop five miles east of Quincy.

On State Route 70, seven miles west of Quincy, California, the Keddie Wye may be seen. The Keddie Wye is named after the surveyor of the Western Pacific, Arthur Keddie. Two legs of the Wye span Spanish Creek and the Feather River respectively, while the third leg is tunneled through a granite bluff. The third line from the Wye connects with the Burlington Northern Railroad at Bieber, California, to form a part of the "Inside Gateway," (again, in competition with the Southern Pacific, this time their line from Portland, Oregon, to Oakland.)

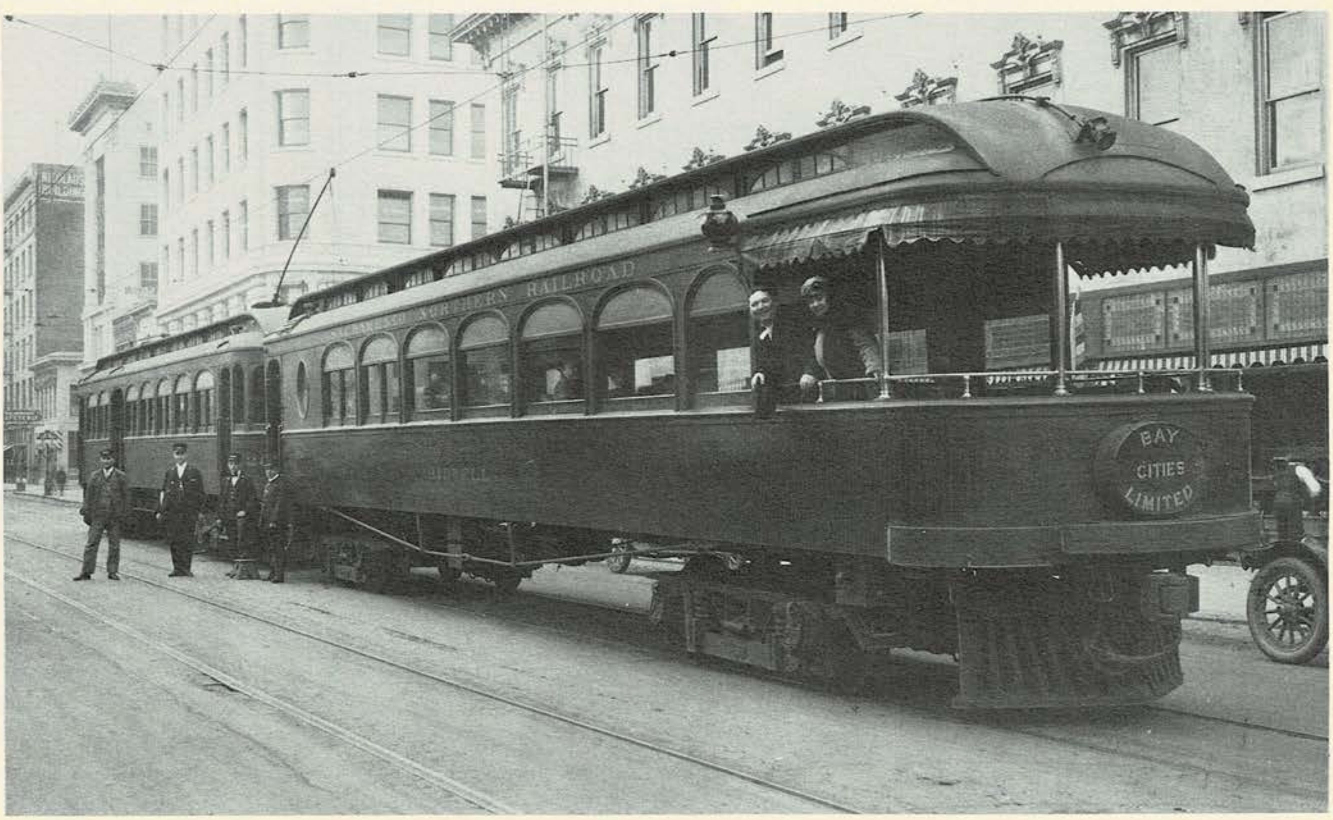
The most interesting and spectacular portion of the line may be seen from State Route 70, between Oroville and Hallelujah Junction, where Route 70 ends at U.S. Route 395. This includes the Feather River Canyon, with the Keddie Wye and Beckwourth Pass.

THE SACRAMENTO NORTHERN RAILROAD

The Sacramento Northern Railroad, at its peak, connected Chico and Oroville with Oakland, via the state capitol at Sacramento. The main line run of 185 miles was the longest interurban passenger run in North America. Its 300 plus miles of trackage covered the largest geographic area of any interurban line in the West, although Southern California's Pacific Electric did have more traffic and track miles.

The "North End" was composed of the Northern Electric, a more or less "typical" interurban line that operated on 600 volts DC (outside third rail) between Sacramento and Chico, with major branches to Woodland, Oroville, and Colusa. The main line was opened for traffic in the summer of 1907. The Woodland branch was laid down in 1912, with the connection to Colusa being completed the following year.

Sacramento Northern's finest, pausing in Sacramento before daily run to Oakland.



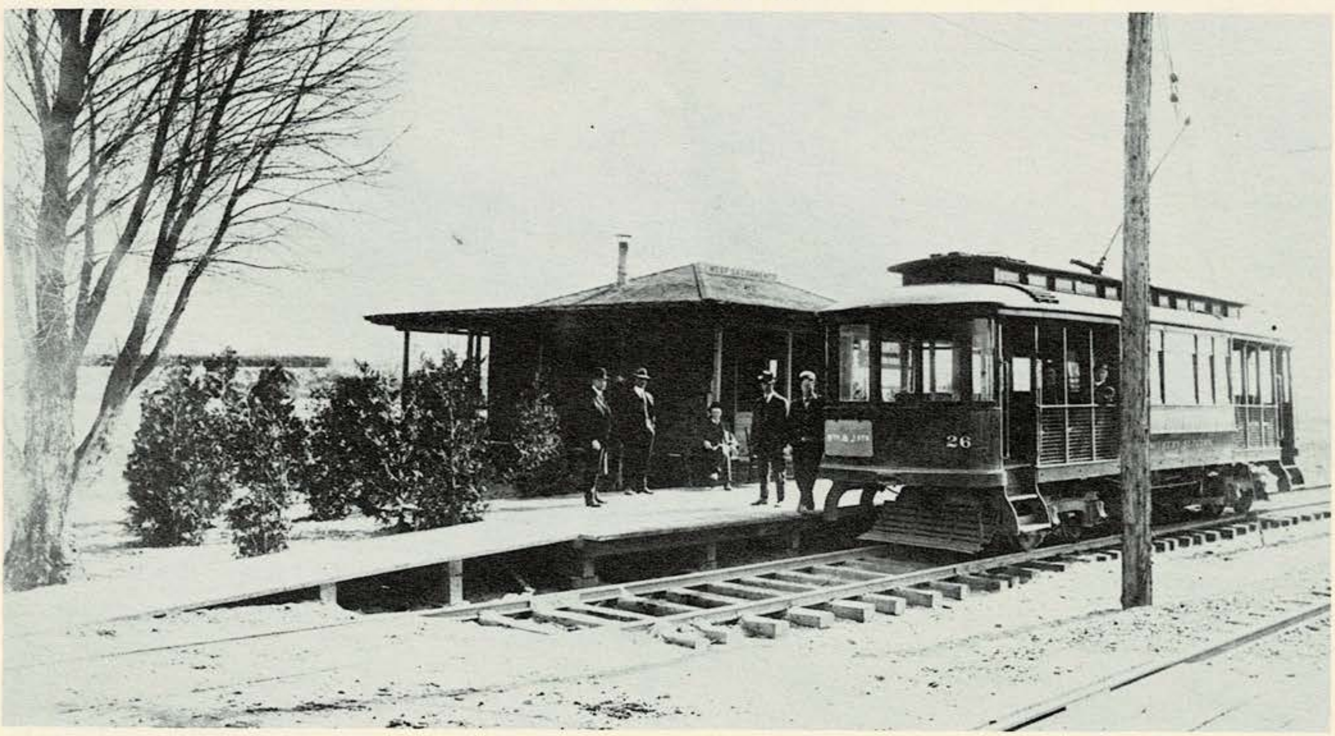
The "South End" began as the Oakland, Antioch, and Eastern, with through traffic between Oakland and Sacramento beginning in September, 1913. This 95 mile main line was powered by 1200 volts DC overhead wire (later raised to 1500 volts). The only major branch was to the Vacaville-Fairfield Area from Creed, about 30 miles southwest of Sacramento.

While topography of the North End can only be called typical for an interurban line, the "South End" was anything but! Leaving Shafter Avenue in Oakland, the line proceeded up a 4.6% uncompensated grade to achieve the crossing of the Contra Costa Hills. This grade, over a mile long, then eased to 2.6% before entering the 3458 foot Redwood Peak Tunnel, one of the longest interurban tunnels in the United States.

Due to the diversity of topography and the nature of the territory, water crossings were many and varied. There were conventional plate girder bridges, steel trusses, and timber trestles. The Lisbon Trestle across the Yolo Bypass south of Sacramento was over two miles long. In 1925, the bents of the trestle fell over like a row of dominoes under the weight of a trainload of steel. At Oroville, the Northern Electric crossed the Feather River on a two span covered bridge. The longest bridge built by the interurban was the original M Street Bridge across the Sacramento River at Sacramento. Built in 1911, the bridge included two 175 foot fixed spans and a 400 foot steel truss swing span. The structure was replaced in 1935 by the present Tower Bridge, which includes a 209 foot steel truss lift span. The largest bridge used by the Sacramento Northern was the San Francisco-Oakland Bay Bridge used for a few years before abandonment of passenger service, about 1940.

The Sacramento Northern exists today as a fragmented set of tracks connected by track rights over the Southern Pacific, Western Pacific, and Santa Fe railroads. Roadbeds and trestle abutments can be found in many places along the old line especially along Route 70 between Sacramento and Marysville. The old substation is still standing at East Nicolaus. Much of the early equipment is preserved today at the California Rail Museum located along the former main line at Rio Vista Junction. It may be reached by car on State Route 12 about halfway between Rio Vista and Fairfield.

Passengers boarding at Sacramento Northern's West Sacramento Station in 1914.



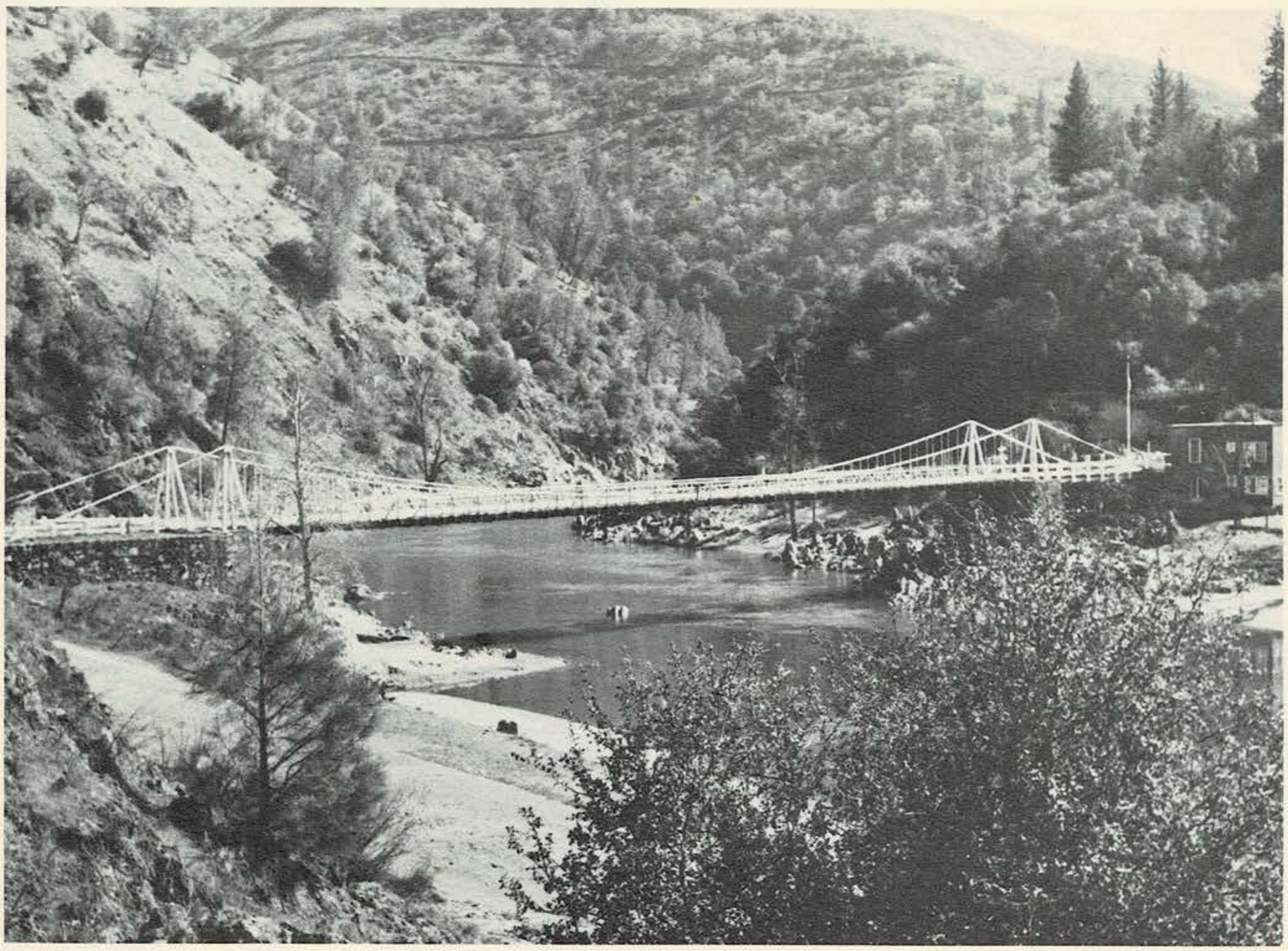
BRIDGES

BIDWELL BAR SUSPENSION BRIDGE

Traveling through Northern California in the 1850's you would hardly expect to find many of the rivers spanned by suspension bridges. Nevertheless, these relatively complex structures, using materials developed only ten or so years previously, were designed, shipped from New York, and assembled on the site by the hardy pioneers. Suspension bridges were located at Whiskey Bar, Rattlesnake Bar, Condemned Bar, Comanche, Bidwell Bar, and other gold rush areas. As the only remaining artifact of that time and design, the Bidwell Bar Suspension Bridge was designated a National Historic Civil Engineering Landmark in 1967.

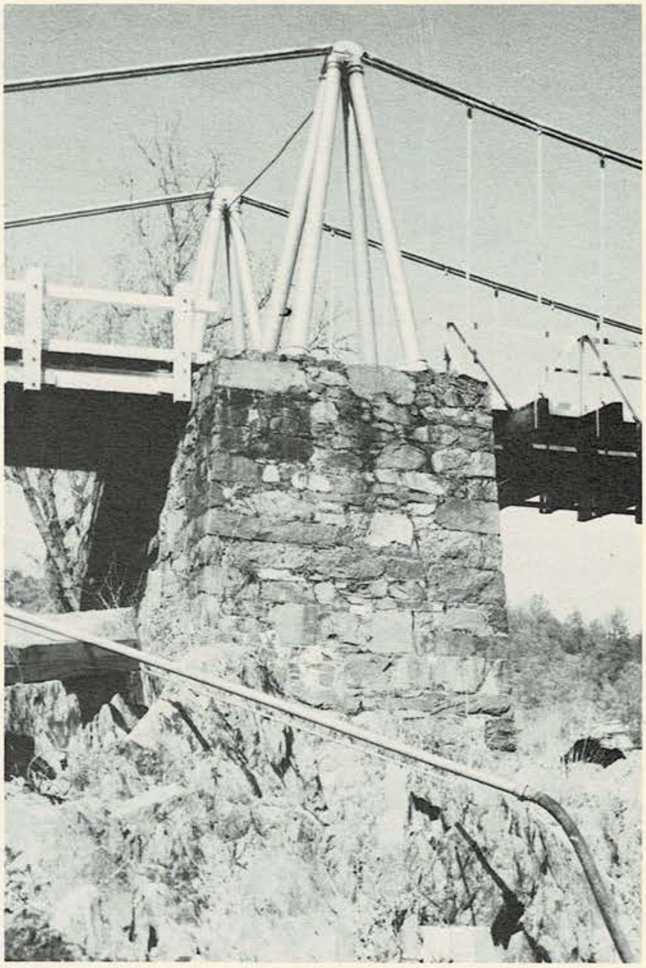
The Bidwell Bridge was constructed during 1855-56 as a toll crossing of the Feather River about 10 miles northeast of Oroville. The four suspension cables, each several inches in diameter, were composed of approximately 300 No. 10 gauge wires laid in parallel strands. They were then spirally wrapped with additional No. 13 gauge wire and protected against rust by a thick coat of yellow paint. Wires of this type had been made in sufficient quantity only since the mid-1840's. The four cables, two per side, were supported on each end by towers, each of which consisted of

Bidwell Bar Suspension Bridge, first permanent crossing of the Feather River.



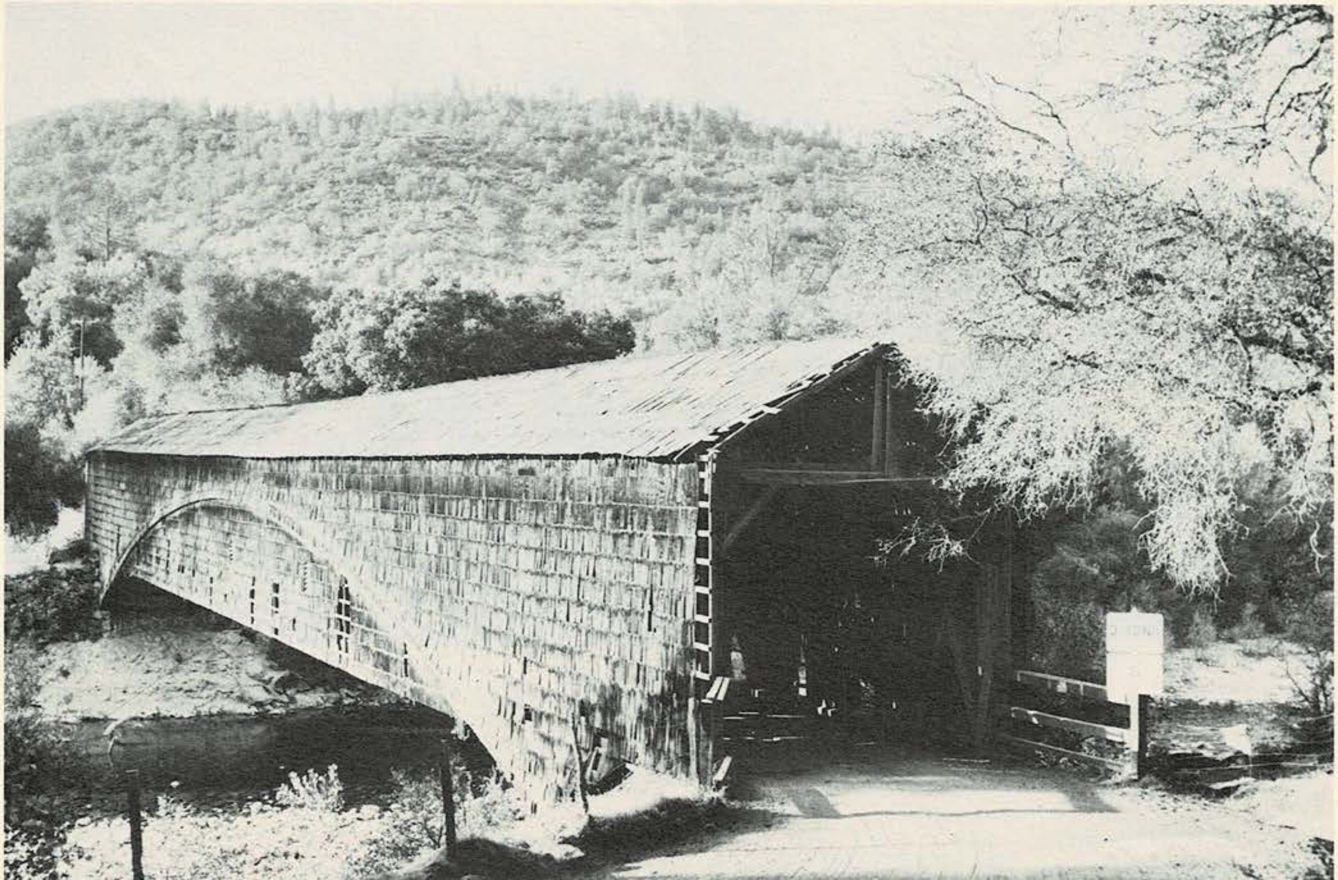
four cast iron posts tied together at the top by a cast iron cap and tapering outward toward their base to form a four-sided pyramid. The cables were anchored to bent wrought iron bars buried deep in the foundations. Estimated to sustain a load of 100 tons on its 210 foot span, the Bidwell Bridge was the first permanent crossing of the Feather River.

The bridge was dismantled in 1964 because of the construction of Oroville Dam and Reservoir. The components have been stored, however, and the State of California will reconstruct the bridge in 1977, at an historical park near its original location, as part of the recreational facilities of Oroville Reservoir.



Detail of tower and cables at Bidwell Bar.

Bridgeport Covered Bridge, a bit of New England?



BRIDGEPORT BRIDGE

Oldest of the existing bridges in this series, and looking as if it were lifted out of New England, is the Bridgeport Covered Bridge spanning the south fork of the Yuba River about 14 miles northwest of Grass Valley. It was built in 1862, only 16 years after the Donner Party disaster, and 14 years after gold was discovered at Coloma. With a span of 230 feet, it is the longest extant single-span covered bridge in the west, and possibly in the nation.

Built by David I. Wood to support heavy freight wagons, the bridge was a key link in the Virginia Turnpike Company toll road connecting Virginia City and the Comstock Load with Marysville and the Sacramento Valley. Its design is a combination Warren truss and arch, known as a Burr arch-truss. This design by Theodore Burr of Torrington, Connecticut, was repeated hundreds of times and was for a period the most popular type of timber bridge. The Bridgeport Bridge was constructed entirely of timber except for wrought iron vertical members and cast iron bearing blocks. Because of its historic and engineering significance, the bridge has been designated as a National Historical Civil Engineering Landmark, and a plaque is prominently displayed. It is also a California Registered Historic Landmark.

It served as a toll bridge for its first 29 years and as a public crossing ever since. Recently the county road was relocated and a new crossing built just upstream. A side road still winds down to the old bridge which remains open to traffic. The bridge was restored a few years ago and is now ready for the next 100 years of California history. The bridge may be reached by taking Route 20 east from Marysville or west from Grass Valley, and then turning north on either Pleasant Valley or Bitney Springs Road.

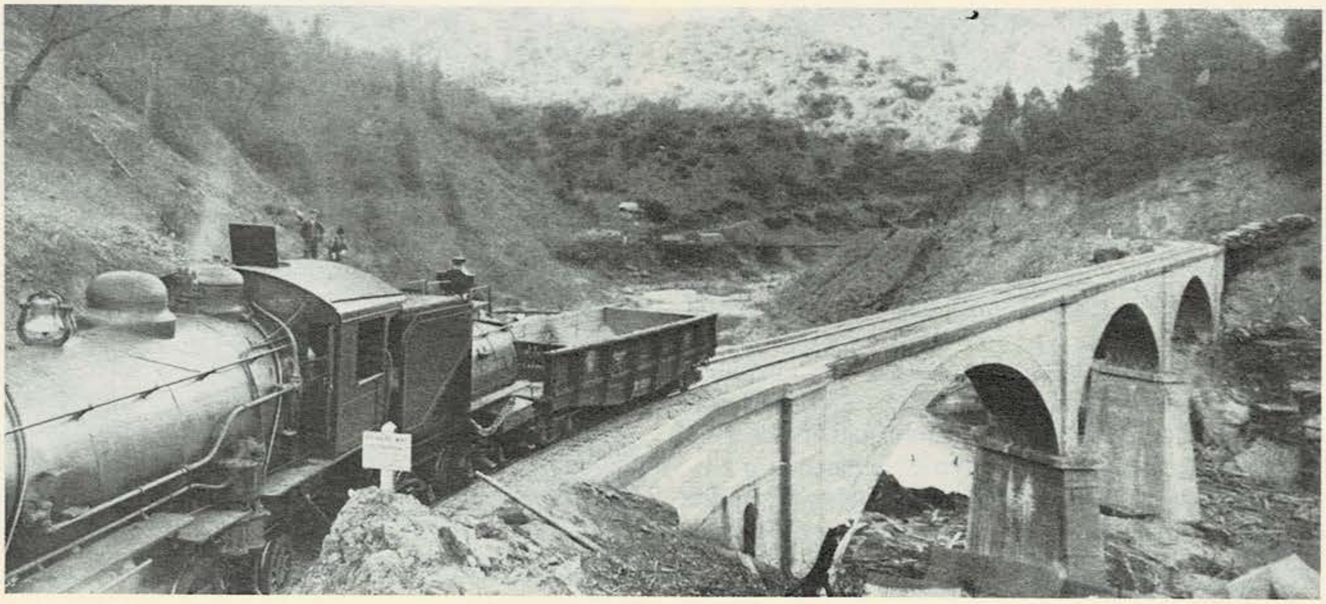
Interior of Bridgeport Bridge showing arch and truss design.

AUBURN CONCRETE ARCH BRIDGE

In 1910 the newly formed Mountain Quarries Company of San Francisco, which was a subsidiary of Pacific Portland Cement, contracted the Duncanson-Harrelson Company to construct a railroad bridge to cross the American River just below the confluence of the North Fork and the Middle Fork, near their limestone quarry. The bridge was a single track structure, 482 feet from abutment to abutment. The Placer County approach is 72 feet in length, while the El Dorado County approach is 100 feet long, making the overall length of the structure about 650 feet. It is 15 feet wide and 70 feet high with three 140 foot solid barrel skewed arch spans. At the time of its construction in 1911 this structure bore the distinction of being the longest span concrete arch railroad bridge owned by a private concern. It continued to serve as a railroad bridge until about 1940 after which it was used as an equestrian crossing.

The bridge is located approximately a mile east of the City of Auburn on State Route 49, and about three miles upstream from the Auburn Dam site. Although massive, the arch bridge is plain in appearance but yet possesses a gracefulness that is in perfect harmony with its rugged surroundings. There is also something to be said about the stability of this structure. Modern bridge builders have constructed no less than three highway bridges upstream from this grand old structure, and each time the modern bridges have been ripped out by torrential floods while this structure remains unscathed by the ravages of the elements. In 1965 the Highway Department used the bridge as a detour while a new bridge was being built to replace one washed out in the great flood on the American River in 1964.

With the filling of the lake behind Auburn Dam, this landmark will be inundated along with several miles of the rugged canyon country. It will remain a silent witness to the strength and tenacity that so characterized the early builders of this country.



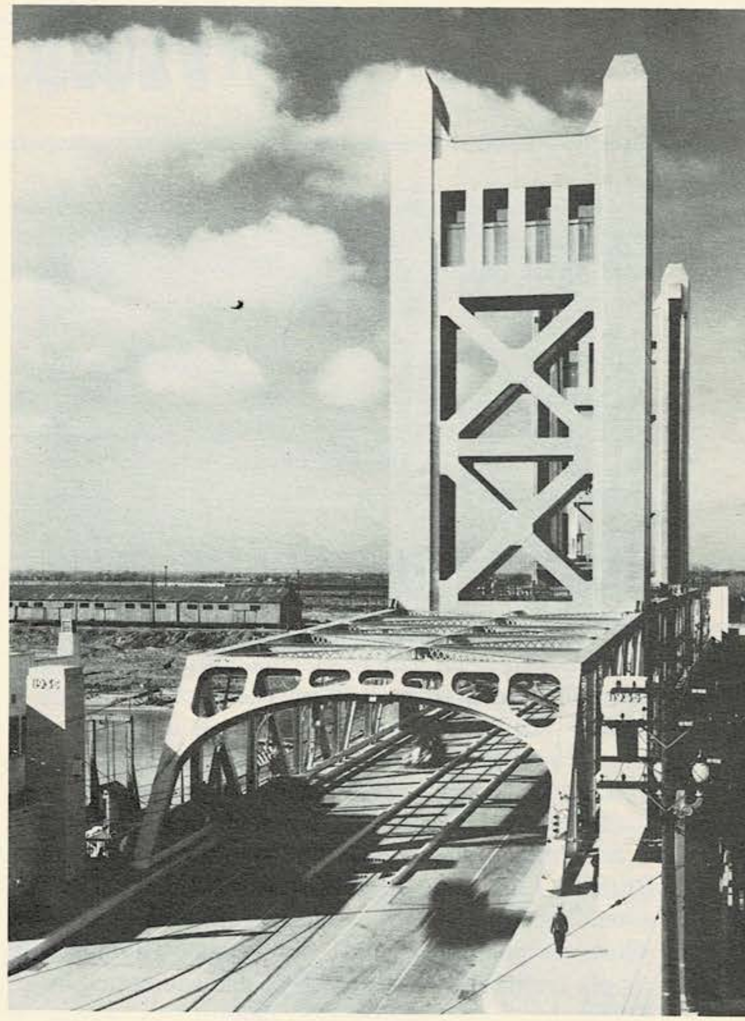
The heavy Mallet compound engine shown here, required that the Auburn Concrete Arch Bridge be carefully designed.

SACRAMENTO BRIDGES

There are many other historic bridges throughout Northern California. Because of their accessibility, mention will only be made of those which are within sight of Old Sacramento. The Southern Pacific has long maintained a Sacramento River crossing at the north end of what is now Old Sacramento. The present crossing, known as the I Street Bridge, was built in 1911 to carry not only their double track main line railway, but also an 18 foot roadway. The double-deck structure is the heaviest swing bridge in the United States. The movable portion is 390 feet 3 inches long and weighs 3374 tons.

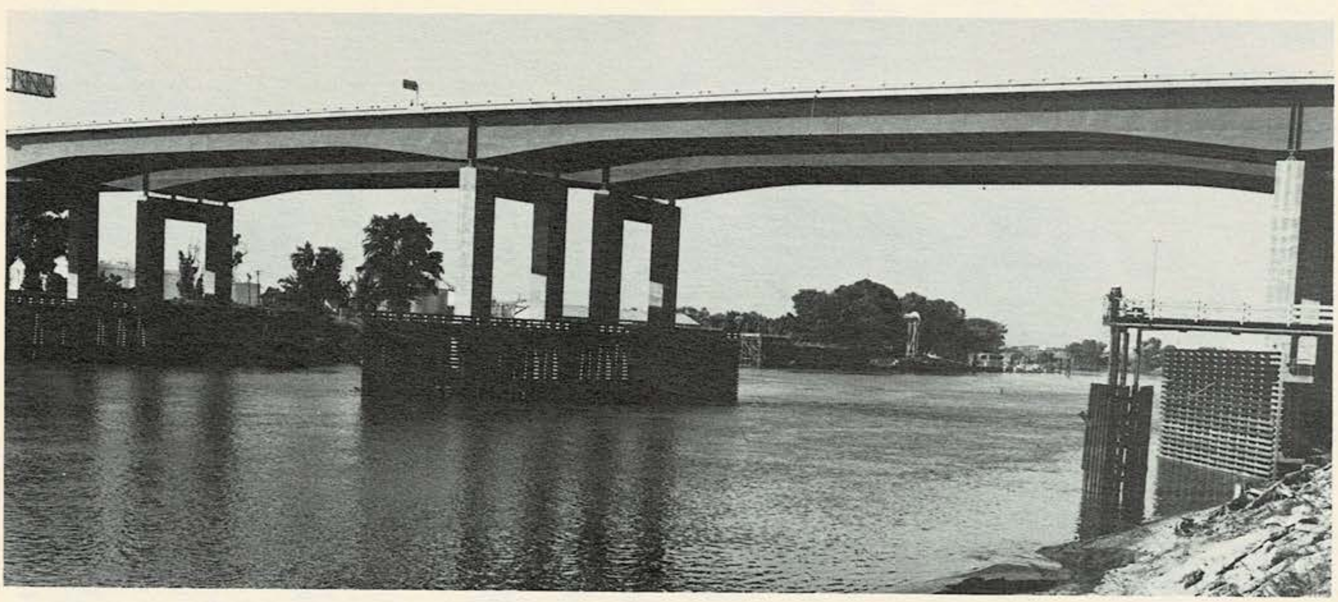
The I Street Bridge, built in 1911 to carry both railroad and highway.

A somewhat more recent bridge spans the river at the south end of Old Sacramento, at the foot of Capitol Mall. This is the Tower Bridge built in 1935 to replace an earlier bridge on the site. In 1936 it received "The Most Beautiful Bridge" of the year award from the American Institute of Steel Construction. The vertical lift bridge has an overall span of 737 feet. The moveable portion is 209 feet long and raises to a height of nearly 100 feet above maximum high water. From this location one can see off to the south the still newer Pioneer Bridge which now carries Interstate 80 traffic smoothly over and through Sacramento.



Tower Bridge on opening day, January 5, 1936.

The modern Pioneer Bridge, July, 1967.



FLOOD CONTROL

The Sacramento River has always been both a blessing and a curse to the City of Sacramento and surrounding area. Throughout geological ages the river annually overflowed its banks creating an inland sea up to 30 miles in width, and in the process, forming the rich farmland enjoyed in the Central Valley today. As a transportation link to the gold fields, it was the lifeblood to the young city growing on its banks. From the start, however, the inhabitants have also had to fight to keep the river out of the city. One effort was to raise the city.

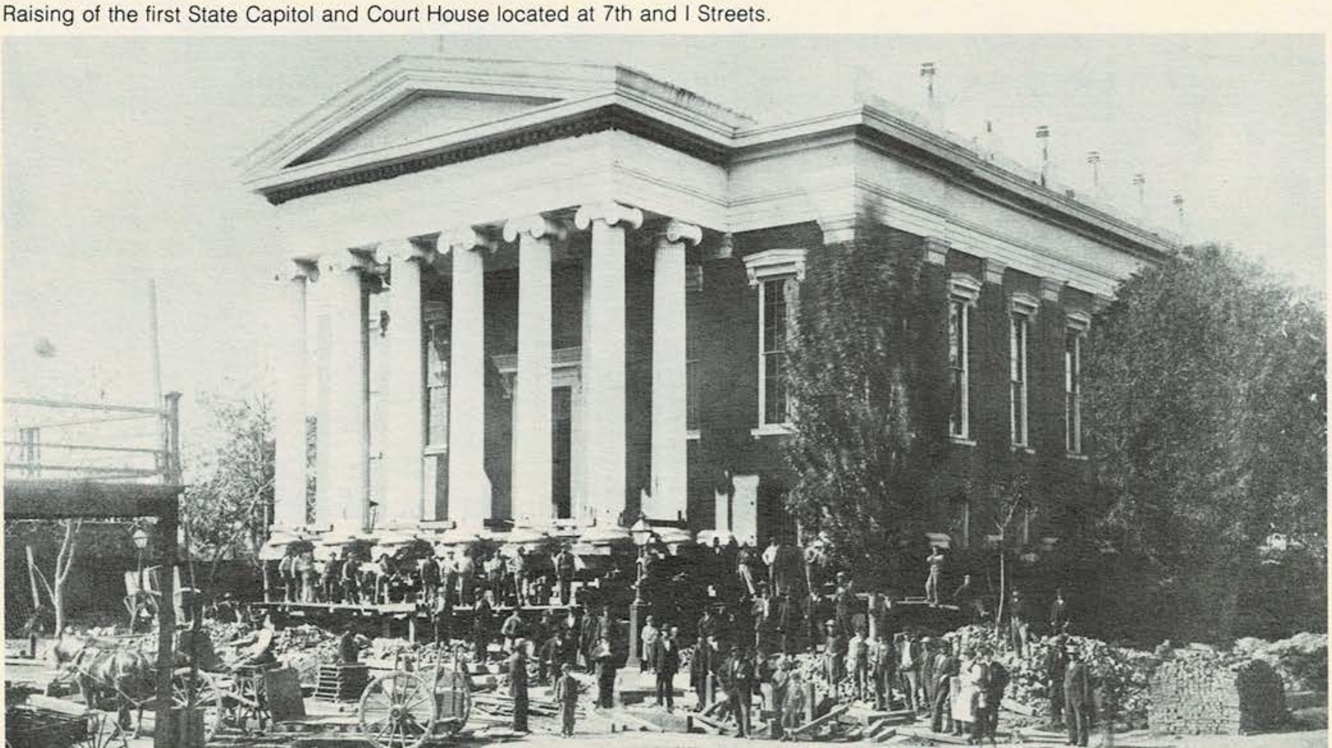
Flooding in the 1850's, dramatized the need for flood control measures.

HILLS IN SACRAMENTO

Observing visitors to downtown Sacramento are often curious about the sagging alleys and the sunken parking lots, often with brick cubicles under the street sidewalks, in a town that is otherwise as flat as a miner's flapjack. The answer to their queries is the tale of how Sacramento raised itself out of the mud over a twenty-year period that began during the Gold Rush days and ended more than a hundred years ago.

Sacramento was born at the beginning of the Gold Rush in 1848 and, because of its location on rivers extending from San Francisco Bay into the mountains where the gold was found, soon became an important supply point for both the northern and southern mines. Except for the advantage offered by ready access to the river, the site of the budding city was a most unlikely one. The land was below the level of high water in the river and the area was laced with many sloughs.

Raising of the first State Capitol and Court House located at 7th and I Streets.



In 1852, after several years of flooding and while the City was still under water, a plan was proposed to lift Sacramento out of the mud and above the flood waters. The proposal was to raise the level of Sacramento by filling in the main streets with sand and gravel as far as the Public Square at Tenth Street, which was above high water. A short levee would close the gap to create a high and dry business district. The property owners would then fill in their property at their own expense and raise their business establishments to the level of the new street grades.

Eventually approval was obtained and the work was started. The main streets were raised one to five feet extending from the river to as far as Eighth Street and the cross streets were raised to match. Most of the fill was brought in by carts from the American River sandbars. One contractor built a railroad consisting of 2500 feet of track, but the rail operation proved to be too expensive and eventually carts took over the job.

After more devastating floods, further improvements to the downtown streets were begun in 1863. Two special trains of ten cars, each car carrying ten tons of gravel, ran daily between Folsom and Sacramento. As the work of raising the streets progressed, the property owners turned to the business of raising their buildings to the high grade. Most of the work of raising the buildings was done with screw jacks. Hydraulic jacks were also used, but most contractors favored the former. One of the largest buildings was the St. George Hotel, which was raised eight feet using 250 jacks. The building measured 76 by 160 feet and weighed 1900 tons. The work took from August until October and cost $4,700. The largest job was Toll's Hotel at Seventh and K Streets. It was raised seven feet using 430 jacks, 8000 blocks, and required seventy-four men.

During 1867 Sacramento was again flooded, resulting in a flurry of street raising which totaled thirteen blocks in 1868, the year which marked the beginning of the end of the street raising program. In 1872 most of the essential work had been done. Even by present day standards the City of Sacramento undertook a tremendous job in raising the business district out of the mud and above the flood waters. By the standards of a hundred years ago and with the equipment then available, the project was a phenomenal demonstration of the dedication of the business community to survive and to bring prosperity to itself and to the city as a whole.

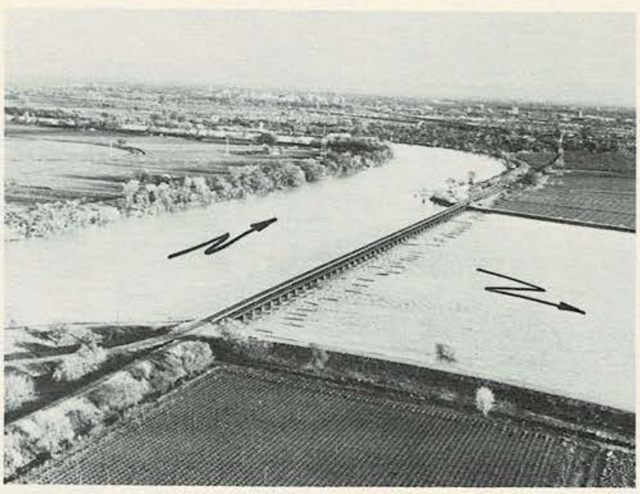
Much of the evidence of the grade raising program has been obliterated by later improvements. Some entire blocks have been raised even with the surrounding streets, thus hiding the fact that the streets had been raised above the original ground. In the last 25 years a redevelopment program has drastically altered much of the old business section. Old buildings have been removed and replaced with modern buildings after recontouring the area. Such changes will no doubt continue with the passage of time until the entire project will be buried in the past and known only to those familiar with the early history of Sacramento.

LEVEES, WEIRS, FLOODWAYS

Raising the city improved conditions; however, as is usually the case, a variety of efforts has been required to keep the valley cities dry. A major factor is the storing of large quantities of floodwater temporarily in the relatively recent large reservoirs — Shasta (1945), Folsom (1956), and Oroville (1968), to list a few.

Of far more historic interest is the line of defense along the river itself — the levee. Levee construction began in Sacramento about 1850 with a levee running from the sand hills at Sutterville to the Sacramento River, along the river and around South Slough to the American River and up the river to high ground. In front of the city the levee was five feet high, twenty feet wide at the base, and ten feet wide at the top. Many levees followed, and in the course of time the face of the earth was greatly altered. Some features, like China Slough, disappeared altogether. Far too modest, these early levees were frequently breeched.

The Sacramento Weir during the 1950 flood. Flow directions in both the river and bypass are shown.

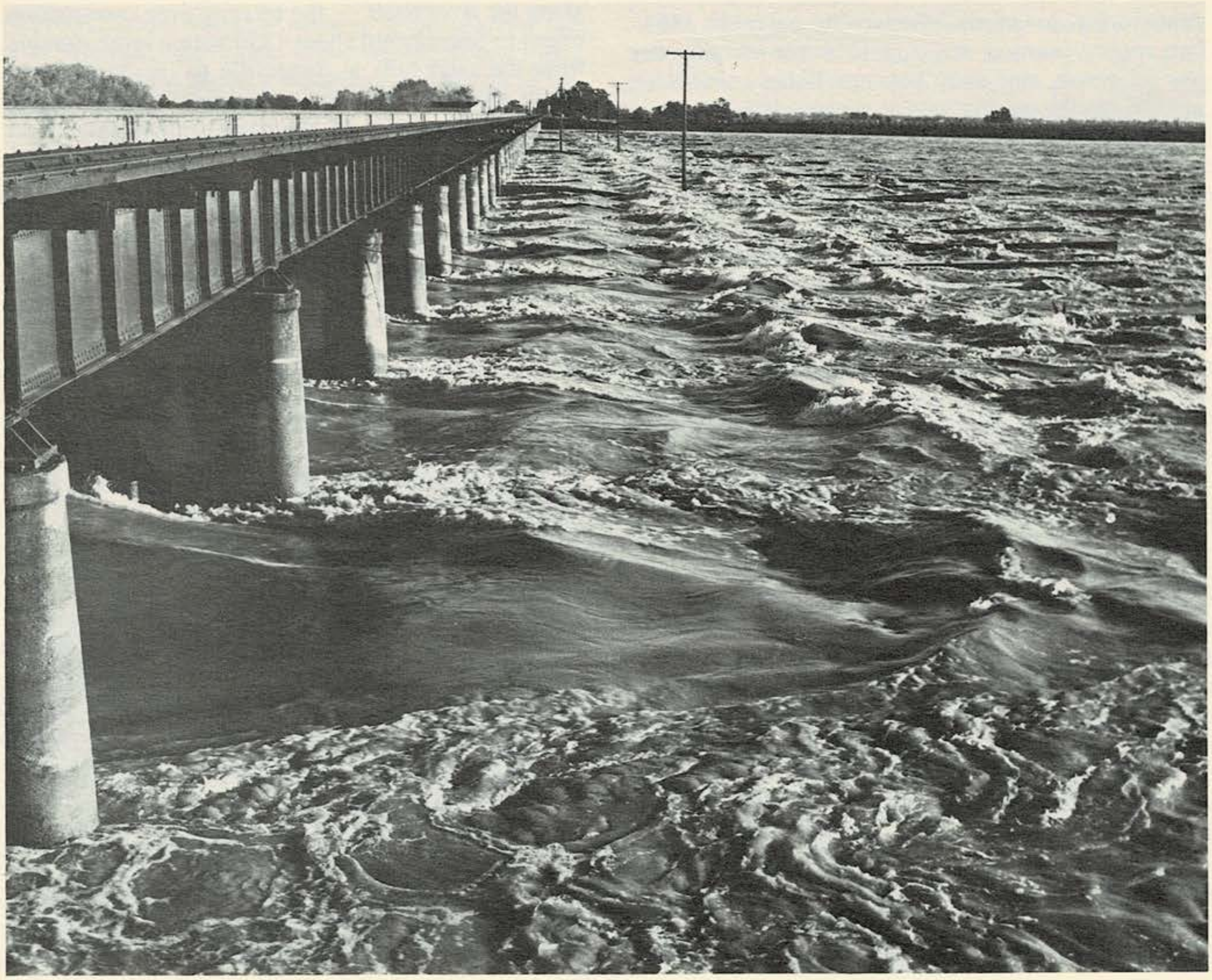


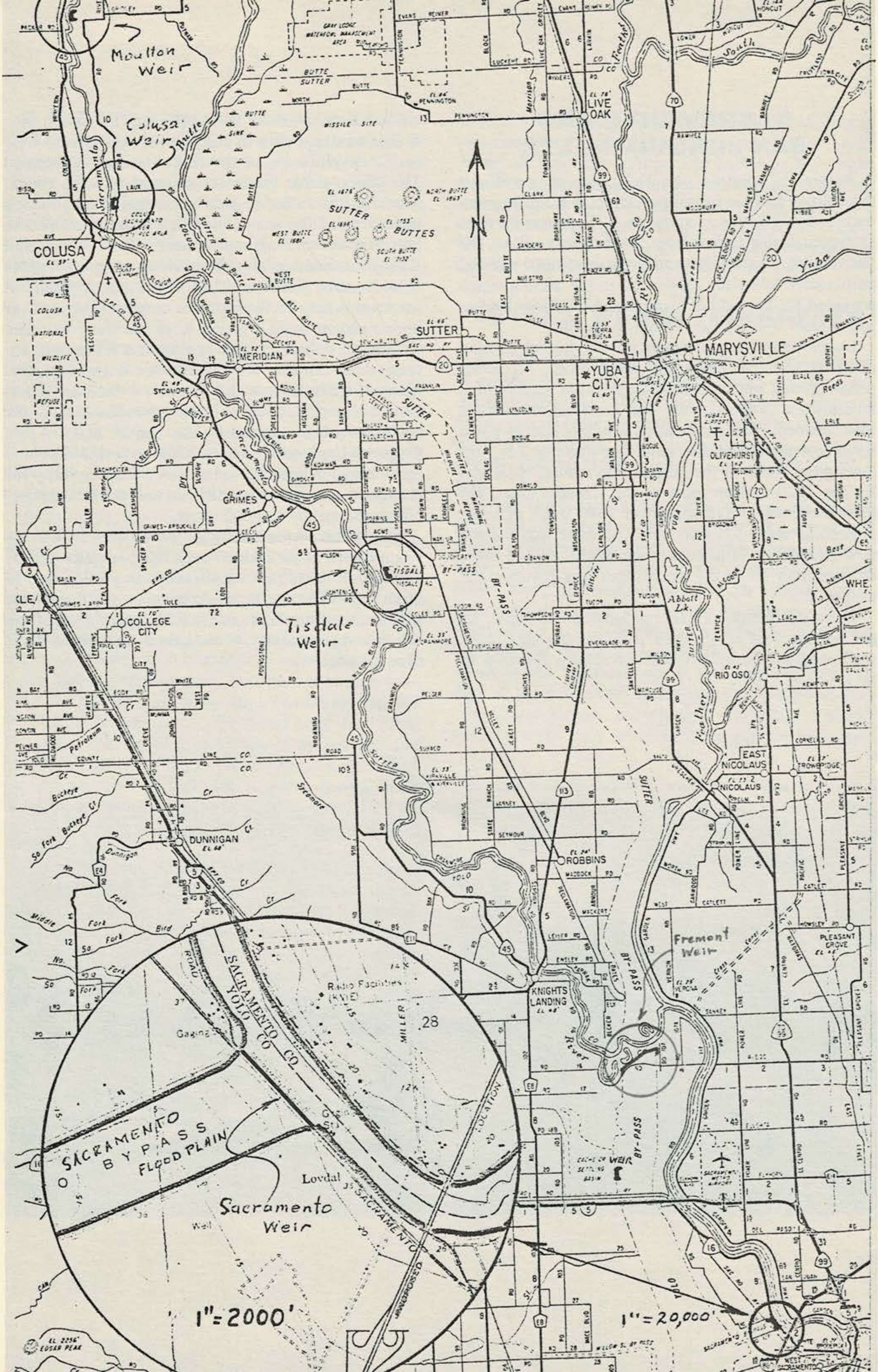
The United States Army Corps of Engineers has played a major role in the control of the Sacramento River. Activity first began in the San Francisco Harbor in 1868, and along the Sacramento River in 1888. The latter was initially a program of snag removal to improve navigation. After years of study, a comprehensive flood control plan was proposed in 1910 and subsequently approved. This called for federal, state and local cooperation to enlarge existing levees as well as to construct new levees along the river. Since the flood flows are far in excess of what can be carried even between the levees, relief channels such as the Yolo bypass were included in the plan. The bypasses required their own levees as well as headwork structures to divert the river water into them. For this latter purpose five weirs were included in the plans.

The second of these weirs, the Sacramento Weir, with a crest length of 1830 feet, was built by the City of Sacramento in 1917. The other weirs were completed as follows: Tisdale (1908) length 1155 feet; Fremont (1924) length 9120 feet; Moulton (1932) length 500 feet; and Colusa (1933) length 1650 feet. The entire layout of the flood control plan is shown on the accompanying map.

Map of Sacramento Valley showing the weir and bypass system. (Adjoining page)

Sacramento Weir in operation. The Sacramento Northern tracks to Woodland cross over the weir.




Moulton Weir
Colusa Weir
Tisdale Weir
Fremont Weir
Sacramento Weir
SACRAMENTO BYPASS FLOOD PLAIN
1"=2000'
1"=20,000'
COLUSA
SUTTER BUTTES
SUTTER
MERIDIAN
YUBA CITY
MARYSVILLE
LIVE OAK
GRIMES
COLLEGE CITY
DUNNIGAN
ROBBINS
KNIGHTS LANDING
OLIVEHURST
RIO OSO
EAST NICOLAUS
NICOLAUS
PLEASANT GROVE
Radio Facilities (KVIE)
Lovdal
28

SACRAMENTO AND SAN JOAQUIN DELTA

Before reclamation, the Delta was an enormous area of tule and reed swamps subject to frequent inundations by both the Sacramento — San Joaquin river system and tidal inflow from San Francisco Bay. The potential of the rich Delta soil was developed rapidly, particularly following legislation in the 1850's which provided for the sale of swamp and overflow land to individuals who would attempt to reclaim it.

Levee construction began on the higher ground utilizing Chinese labor and hand tools. As lower marsh ground was reclaimed the size and height of the levees grew proportionally and reclamation districts were formed. The reclamation scheme was to put a levee around each of the island-like tule marshes, following the banks of the meandering natural channels. By the 1920's when most of the sizeable areas had been reclaimed, there were over 1100 miles of levee protecting some 420,000 acres of what may be the most productive farm land in the world. At one time, 80 percent of the world's asparagus was grown in the Delta.

The construction of such reclamation systems, an engineering feat in its own right, is perhaps overshadowed by the efforts that have been required to hold and maintain the levees through the years. Hydraulic mining, begun in the Sierra about the same time as the development of the Delta, ultimately dumped 1½ billion cubic yards of sediment into the rivers. Much of this settled in the Delta, significantly raising water levels. The very soil which makes the Delta so attractive causes even more trouble. The rich peat soil slowly oxidizes in the air resulting in a continuous subsidence of both land and levee. Land originally at sea level is now 25 feet or more below, requiring ever higher and stronger levees to keep the water out. The occasional breech or overtopping of a levee dramatically demonstrates the magnitude of the struggle. Many of the levees are still privately owned and maintained. However, over the last six decades much of the burden has been carried by the United States Army Corps of Engineers who, in addition to building and maintaining many levees, has direct responsibility for the maintenance of the channels and the general improvement of the flow of water.

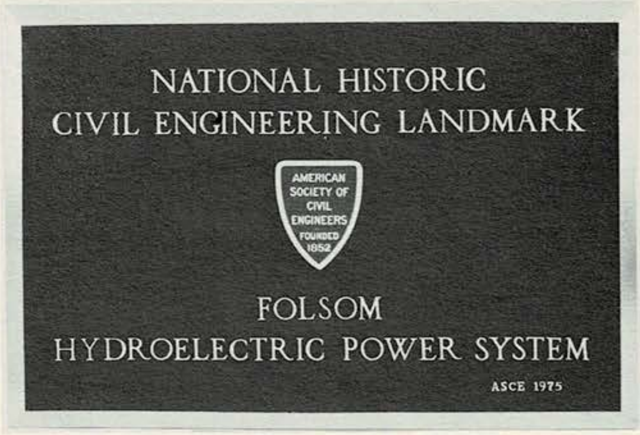
The Delta levee system can best be seen by driving around some of the Delta islands and noting the different degrees of protection afforded. In particular, observe the difference in levels between the water outside and the farm land inside. Full appreciation of the extent and complexity of the system requires a flight over the area.

Levee repair, slope dressing and rip-rapping at Merrit Island on the Sacramento River.

HYDROELECTRIC POWER

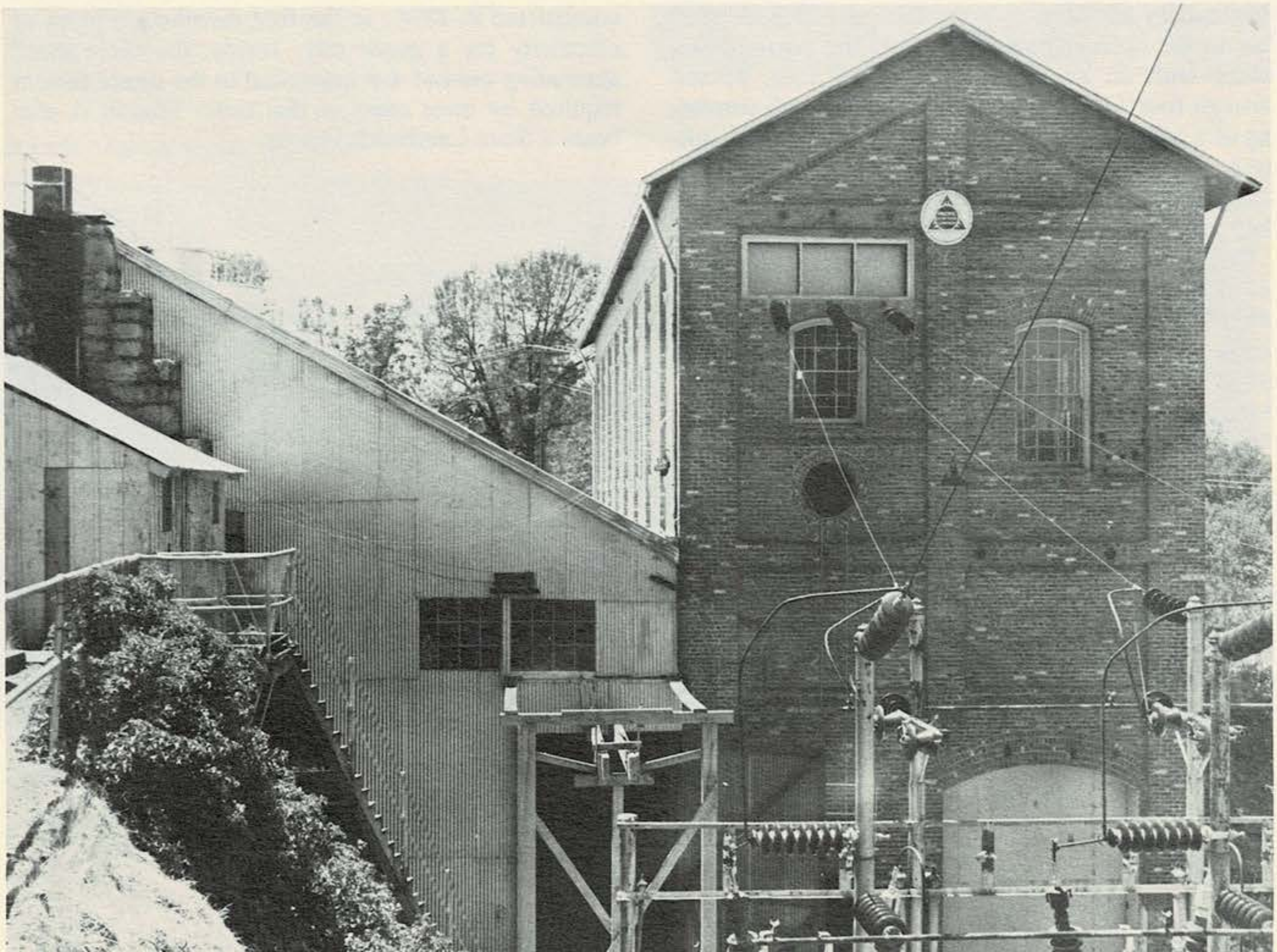
FOLSOM HYDROELECTRIC POWER SYSTEM

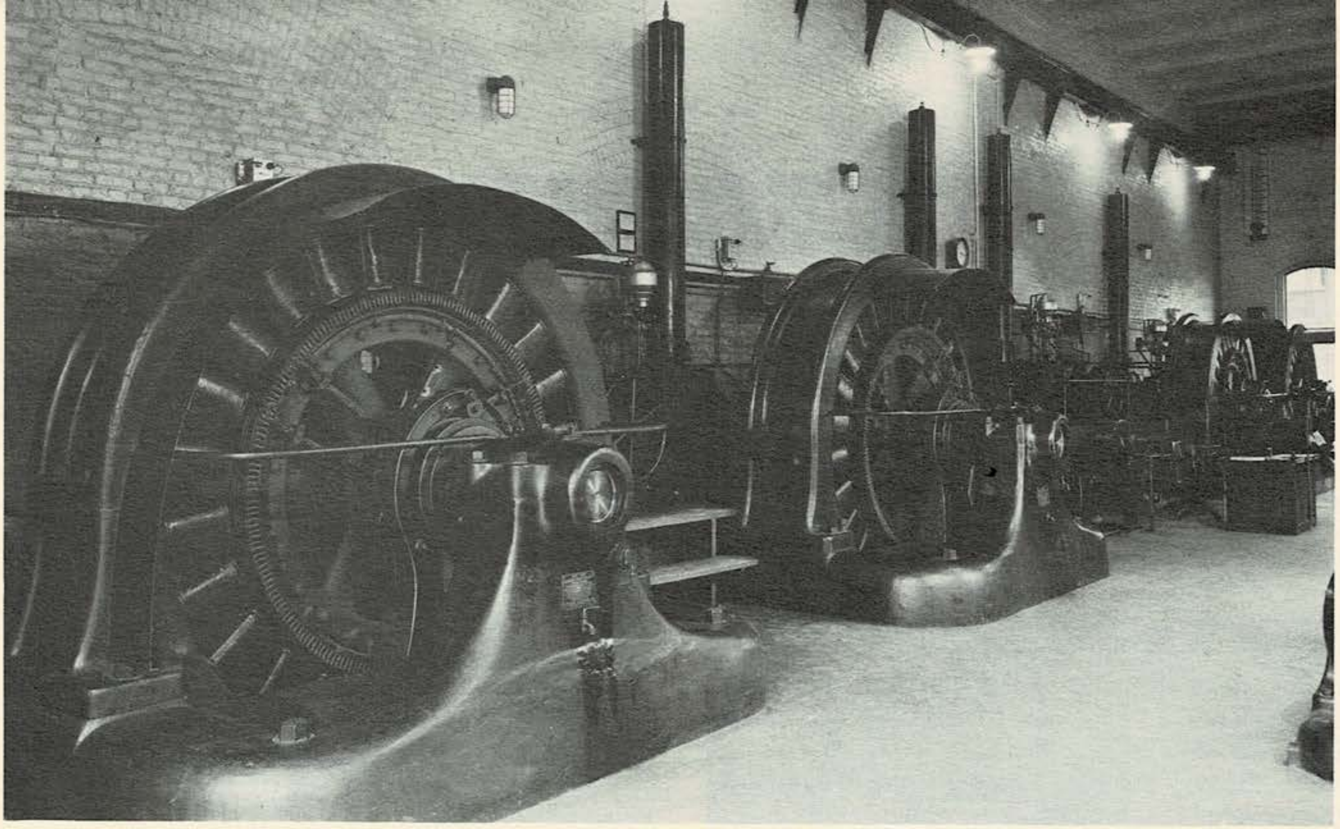
With the abundant source of water and head available in the Sierra, it is no surprise that this part of the country was a leader in hydropower development. Overlooking the American River and just below the town of Folsom sits the Folsom Powerhouse. Commencing on July 13, 1895, electrical power generated here was transmitted at 11,000 volts over the then unprecedented distance of 22 miles to power the streetcars of the Sacramento Electric Gas and Railway Company as well as other commercial and private uses. Although preceded by a scattering of hydroelectric power plants throughout the country, Folsom was the first long distance transmission of high-voltage, 3-phase alternating current for significant commercial uses. This has earned for the system the designation of a National Historic Civil Engineering Landmark. The powerhouse, which is 93 feet long and 30 feet wide, was constructed of granite blocks and bricks salvaged from the roundhouse and railroad shops of the pioneer Sacramento Valley Railroad.



Plaque presented by ASCE on the 80th Anniversary of the Folsom Powerhouse.

Folsom's Pioneer Powerhouse.





Interior view of Folsom Powerhouse showing the four 750 kw generators.

The water was supplied by a canal leading from a 650 foot long and 87 foot high masonry dam, first through a small powerhouse at the Folsom State Penitentiary and then on for a total distance of 8835 feet to the Folsom Powerhouse. At the powerhouse, water with an available head of 55 feet, passed through four 1100 horsepower turbines, each consisting of a pair of horizontally mounted McCormick runners. These were directly connected to four 750 kilowatt generators, then reported to be the largest of their type in the world.

The spent water was discharged into the tailrace for return to the American River. In 1897 a smaller powerhouse was constructed on this channel to generate an additional 750 kilowatts. This powerhouse is of interest primarily because of its unique 26-strand rope drive which transmitted the energy from the turbine to the generator which was upon higher grade.

The Folsom Powerhouse stands today much as it did in 1895. Although the lower powerhouse was taken off line in 1920, the main powerhouse continued in operation until 1952 when the dam was removed to make way for the new Folsom Dam. The powerhouse is now part of the State Park System and open to the public. The powerhouse bears State Landmark Plaque No. 633 and is also listed in the National Register of Historic Places.

The Folsom power was transformed and distributed in an historic building located at Sixth and H Streets in downtown Sacramento. Known as Station A, it was constructed in 1894, as the first distribution point of electricity for a major city. Inside, the three-phase alternating current was converted to the direct current required by most users at that time. Station A also bears a State Landmark Plaque.

Station A, built in 1894, and still in use in downtown Sacramento today.

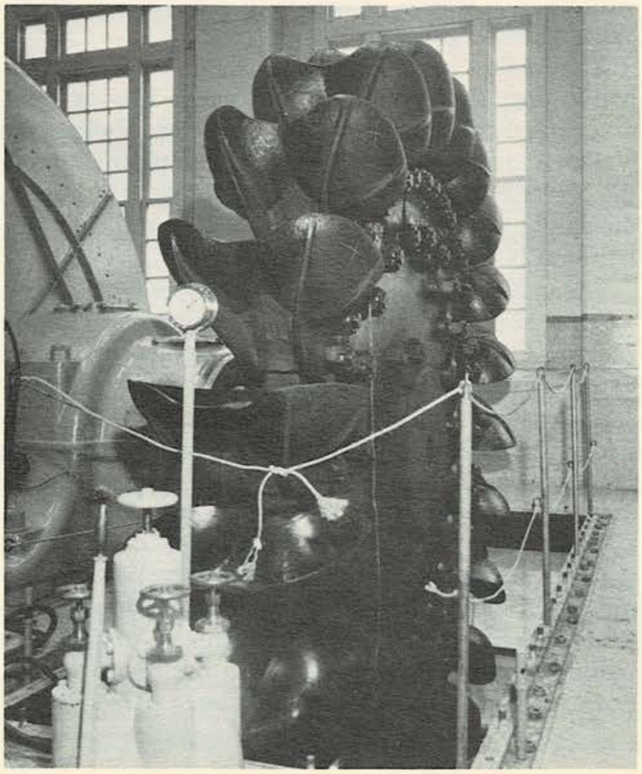
THE WHEEL THAT WON THE WEST

Even before water was used to generate electricity it was harnessed to drive the various machinery required by mining operations. When not using steam, the mills of the Mother Lode were usually powered by the Knight Wheel from Knight's Foundry in Sutter Creek. These early water wheels however were relatively inefficient. It remained for a Camptonville millwright by the name of Lester A. Pelton, who had served his apprenticeship in Knight's Foundry, to develop what is perhaps the greatest advance in hydropower technology. In an attempt to develop more power from a jet of water, he experimented with various shape buckets fastened to the rim of a wheel. Water splashing back from one bucket would continuously strike the next bucket, impeding its progress and reducing the wheel's efficiency. The story is told that it was only when he was over visiting a Camptonville neighbor that the solution came to him. It seems that the neighbor was using a garden hose to drive a stray cow out of his clover patch. When the jet struck the cow directly on its sharp nose bone the water divided evenly with none splashing back. Upon observing this, Pelton is said to have exclaimed: "Wonderful! Wonderful! Just the idea I have been looking for. I'll put a splitter in the center of my buckets. With this there will be no back water to retard the speed, and there will be a clear power gain because the nozzle can keep up full pressure until the water leaves the bucket's sides." What followed is known throughout the world as a Pelton wheel.

For a little more information on the man and his invention, the following is taken from *History of Hydraulics* by Rouse and Ince: "Lester Allen Pelton (1829-1908) left his home at Vermillion, Ohio, at the age of 20 to join the gold rush. Unsuccessful at mining, he turned at Camptonville, California, to the construction of stamp mills and related machinery, including a number of the impulse wheels with cup-shaped buckets then in common use. It is said that he endeavored through the winter of 1878 to improve the efficiency of such wheels by splitting the buckets, constructing different forms by hand from oyster cans. During the following year he made at least one trip to the University of California, where a model was constructed, tested, and awarded a university prize. His improved form of wheel was patented in 1880, and the rights were later sold to the company formed to exploit it, Pelton remaining with the company for some years as a consultant. The Franklin Institute published an extensive report on the Pelton Wheel in 1895 and awarded its inventor the Elliott Cresson medal for his contribution to scientific progress."

With the advent of electricity, it was only natural that the Pelton Wheel be hooked up to generators so that the power of the flowing water could be delivered at will throughout the country. The Pelton Wheel remains today as one of the basic types of turbines particularly suited to high-head installations. In recognition of the contribution made by Mr. Pelton to both the mining and hydroelectric industries, the American Society of Civil Engineers has designated the site of the invention of the Pelton Waterwheel as a National Historic Civil Engineering Landmark. A bronze plaque so indicating, was placed in Camptonville on May 4, 1974. This site may be reached from Sacramento by taking Interstate 80 east to Auburn and there turning north on State Route 49. Continuing on Route 49, Camptonville is about 22 miles north of Nevada City. Here several markers as well as relics of early Pelton wheels may be seen.

Pelton Wheel installed in the Caribou Powerhouse on the Feather River.



POWER FROM THE TRUCKEE RIVER

Power development of the Truckee River followed the Folsom Powerhouse by only a few years. However, here the turbines are still spinning and the generators humming. Although no longer capable, by themselves, of lighting the streets of Reno, the small powerhouses provided ample electric service to northwestern Nevada at a time when electric service was still unavailable in many parts of the "more civilized" East.

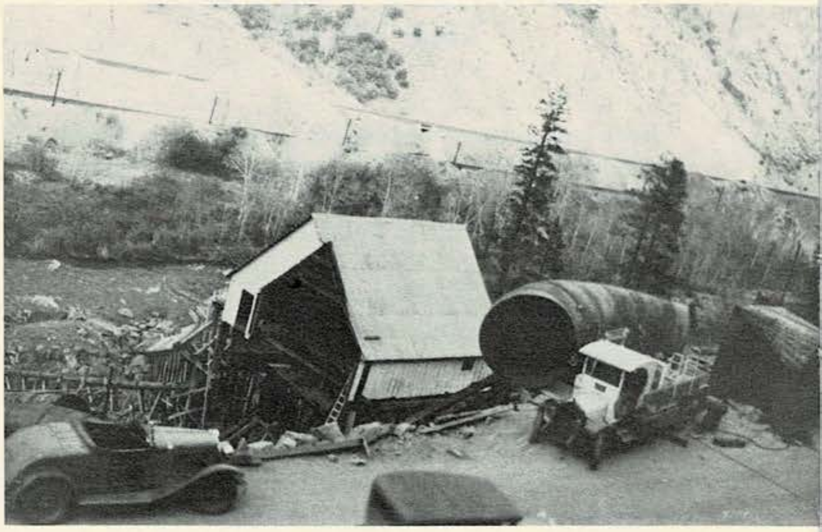
Construction for Farad, the first hydroelectric power plant on the eastern slopes of the Sierra was begun on January 2, 1900, by the Truckee River General Electric Company. Located at Floristan, California, about 18 miles above Reno on the north bank of the Truckee River, it was built, not for the future casinos of the "Biggest Little City in the World," but rather to pump water from the gold and silver mines of the Comstock Lode in Virginia City. Current first flowed over the 33-mile, 22,000 volt transmission line on September 29, 1900, with regular service commencing on October 20, 1900.

Power is developed from a head of 84 feet which drops the water through two McCormick type turbines with 27-inch wheels. These in turn drive two 750-kw Westinghouse generators.

The 84-foot head is obtained from a two-inch thick native pine flume which draws water from a small diversion dam a mile and a half upstream. Sacramento Valley and Bay Area motorists on their pilgrimages to the Nevada attractions parallel the flume as it follows the course of the Truckee River, all the while clinging tenaciously to the canyon wall.

Located downstream from the Farad plant and three miles upstream of Verdi, the Truckee River General Electric Company opened the Fleish powerhouse on the south side of the river in 1905. An 8-foot diameter steel penstock connected this powerhouse with its delivery flume. Here a 3000 hp Victor turbine drove a 2000 kw generator which also helped supply the ever increasing demands for electric power in Virginia City.

During this period other firms built small hydroelectric plants along the Nevada portion of the Truckee River to feed power into the Reno area. With time, the individual companies merged into the Sierra Pacific Power Company which serves the area today.



Penstocks ready for placing at the Farad Powerhouse.

View in 1933, of Farad Powerhouse and penstocks.

FEATHER RIVER'S STAIRWAY OF POWER

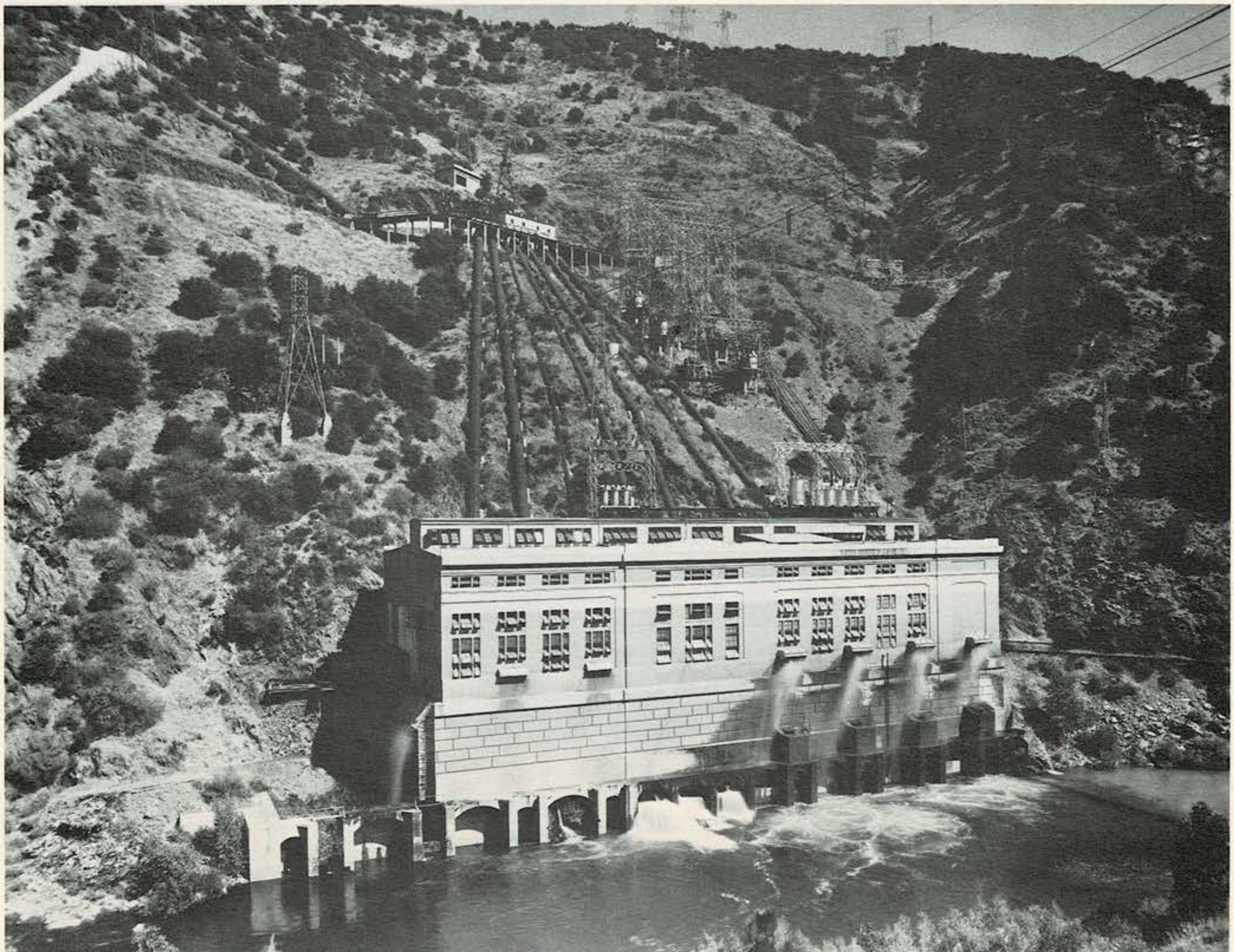
Although the Sierra abounds with historic hydroelectric powerhouses of all sizes and types, of particular interest is the chain of dams and generating stations along the Feather River. The system is now owned and operated by the Pacific Gas and Electric Company. Some of the units are of recent construction; nevertheless, the concept is of historic interest and the development is a classic example of the utilization of a mountain watershed for the production of pollution-free electrical power.

Reached by State Route 70 from Oroville, the stair-step system is spread out along the length of the Feather River and its tributaries. There are presently nine powerhouses with accompanying dams. Together they have the capability of providing electricity for a million people. The lowest and earliest unit was at Big Bend. Built in 1908, it developed 70,000 kilowatts from a water drop of 465 feet and utilized a three mile tunnel constructed earlier by a mining company. The site of this powerhouse now lies buried beneath the waters of gigantic Oroville Reservoir which in its own right was awarded the Outstanding Civil Engineering Achievement of 1969.

Currently bottom on the stairway is Poe Powerhouse. Built as recently as 1958, water is brought to it through 6.3 miles of tunnel. Moving upstream the next two powerhouses are Cresta and Rock Creek with 4 and 6.5 miles of tunnel respectively. An interesting feature of the tunnel between Cresta Dam and Cresta Powerhouse is a bridge, visible a short distance below the dam, which connects two segments of the tunnel and carries the water over a tributary stream.

Essentially across the river from Rock Creek powerhouse sits the Bucks Creek powerhouse put on line in 1928. Developing power from the waters of Bucks Lake situated high above, the water thunders downward at over 200 miles per hour! The vertical distance of 2557 feet is the greatest descent anywhere in the United States and was at one time the highest head in the world. Next to the two long penstocks are the

Big Bend Powerhouse now flooded by the waters of Oroville Reservoir.

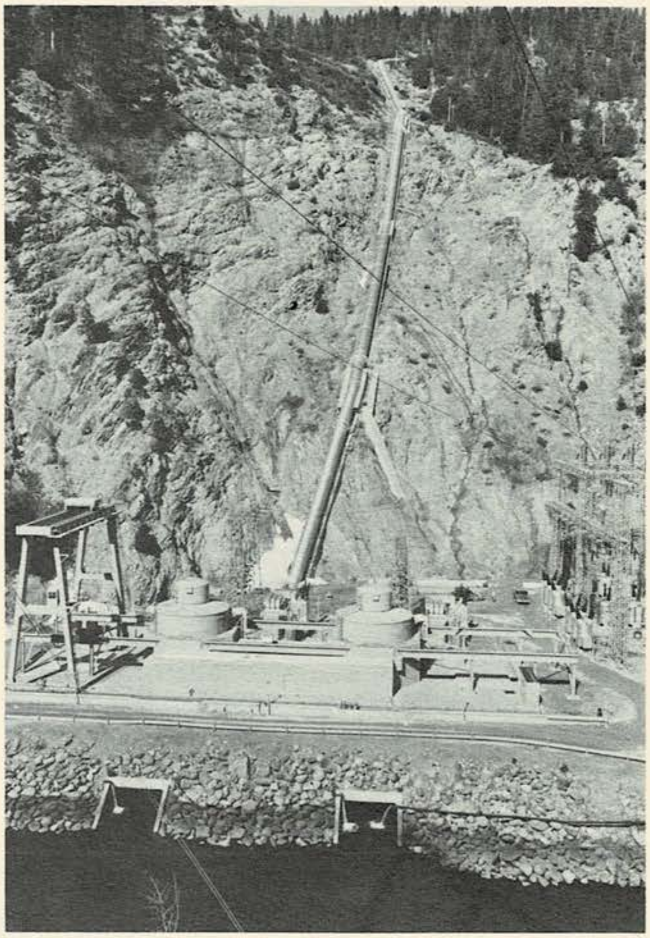


tracks of a steep cable railway which formerly was used to ferry people and equipment between the powerhouse and head works above. The functions of the railway have now been replaced by a helicopter.

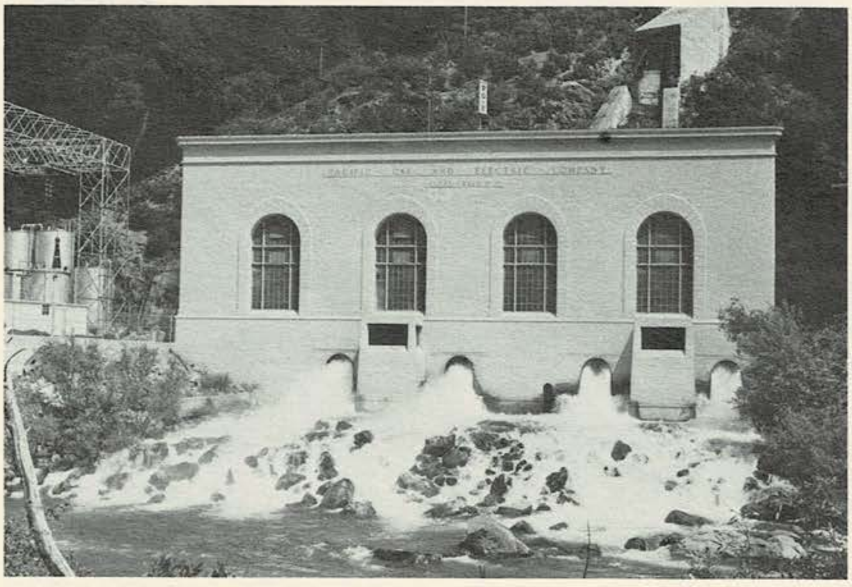
Next upstream is the newest addition to the system, the Belden powerhouse. Leaving State Route 70 and following the North Fork of the Feather River you shortly pass under the enormous dip, known as an inverted siphon, on the 6.3 mile line carrying water to the Belden unit. Continuing upstream on the North Fork brings you to the two powerhouses at Caribou. Sitting side by side and both receiving water from Butte Lake above, they represent a study in contrasts as well as serving as an indicator of the state of the art. Caribou 1, built in 1921, is a conventional completely enclosed powerhouse developing 75,000 kw of electricity, while its more recent (1958) and powerful (110,000 kw) next door neighbor, Caribou 2, is far more utilitarian with its generating units exposed to the elements.

On the upper end of Butte Lake, the Butte Lake powerhouse receives power from the water of beautiful Lake Almanor, created in 1913 to provide a regulated flow for the system. Sitting on the shore of Lake Almanor on State Route 147 is the uppermost generating unit of the stairway. The small (4800 kw) Hamilton Beach powerhouse, built in 1921, recovers power from Mountain Meadows reservoir.

In addition to power development, the multipurpose project represents a recreational mecca to thousands. Spread throughout the region are sites for camping, fishing, boating, and a host of other activities.



Caribou Two Powerhouse with the more recent style of unhoused generators.



Bucks Creek Powerhouse with penstocks and large thrust block in background.

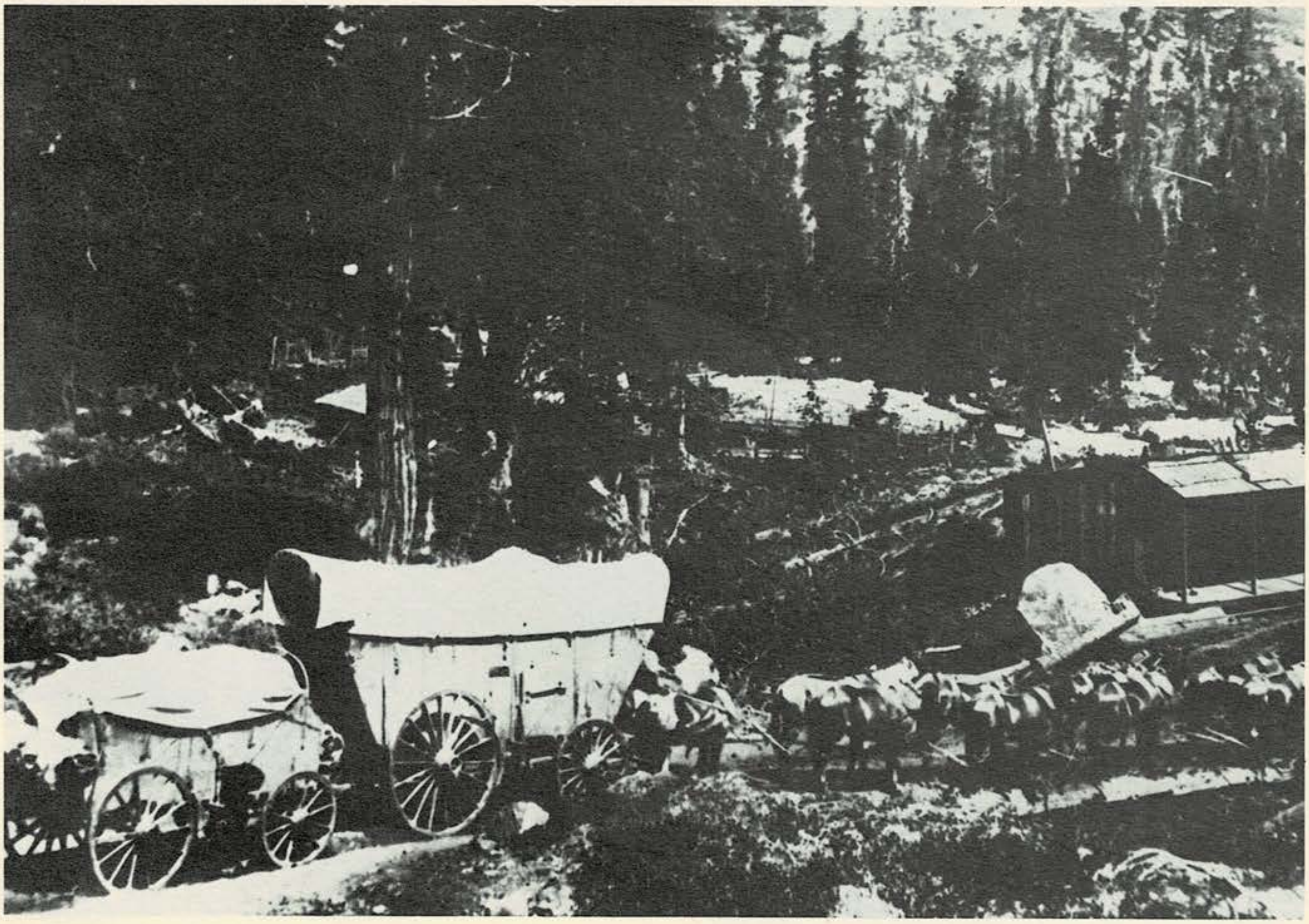
HIGHWAYS

U.S. ROUTE 40

U.S. Route 40 has a long and memorable history. It served as one of the early wagon train routes; in fact, its summit is now named after the ill-fated Donner party — a wagon train which reached the eastern faces of the Sierra in the late fall of 1846 and was trapped by early snow. Following the discovery of gold in 1848, the route received even heavier traffic. It was this same route and mountain pass that was later chosen by Judah for the Central Pacific.

The first known survey of this route was made in 1860 by S.G. Elliott and in March, 1861, the Lake Pass Turnpike Company was organized. However it was not until officials of the Central Pacific Railroad saw the advantages of building a toll road ahead of their track, that significant progress was made. The Central Pacific then formed the Dutch Flat and Donner Lake Wagon Road Company, which by the fall of 1862, had already completed a few miles of road. In June of 1863, work was resumed, but road work was interrupted in November by heavy snow. Finally, in June, 1864, the road was opened to traffic and on July 16, the California Stage Company began operating stages over it. But in July, 1869, the summit tunnel was completed and the Central Pacific Railroad became the easiest and fastest way of crossing over the Sierra.

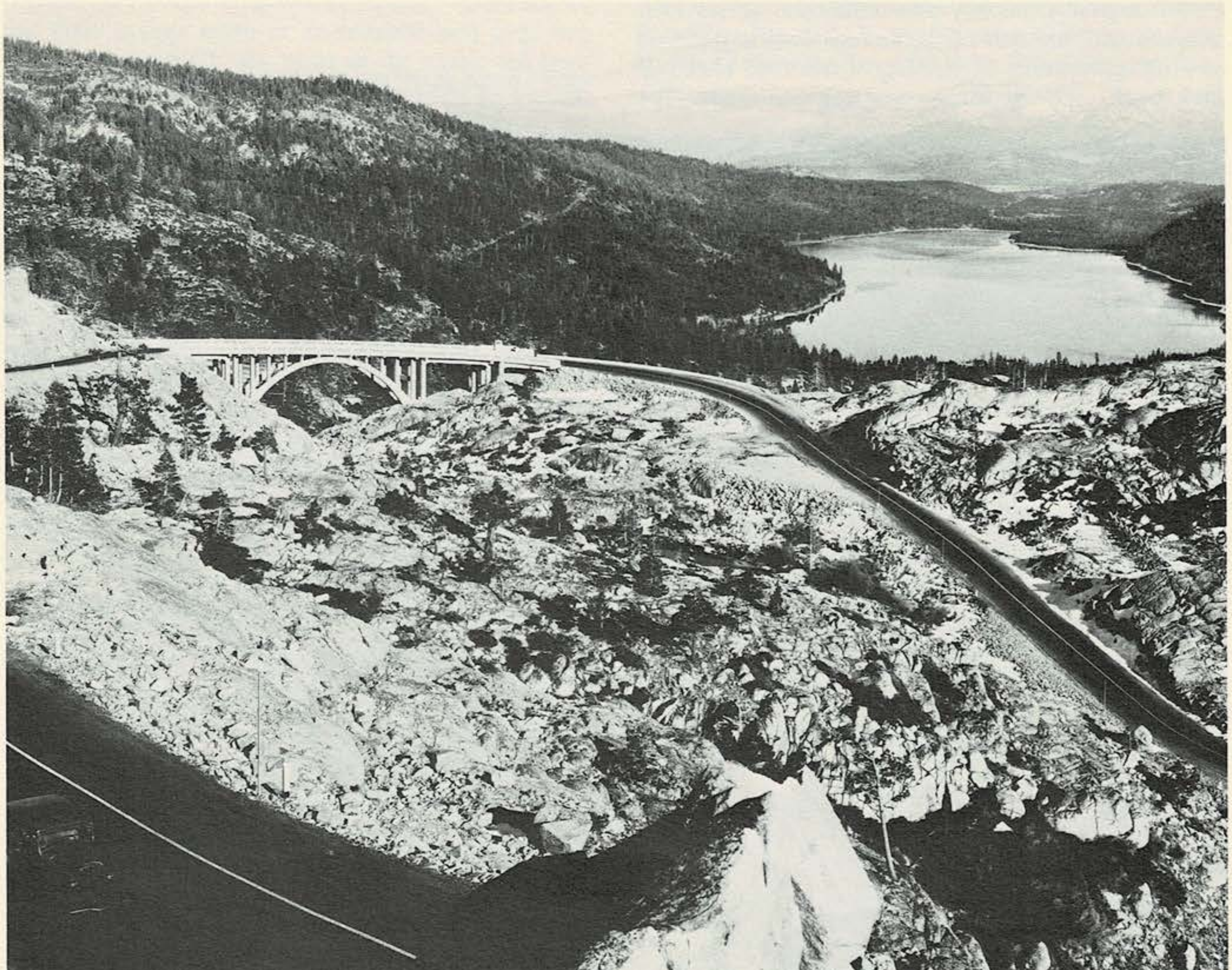
Freight wagon at Halfway House near Cisco on the Dutch Flat-Donner Lake Wagon Road.



In March, 1909, the legislature finally saw fit to appropriate funds for the location survey and construction of a state highway from Emigrant Gap through the Truckee Pass (Donner Summit) to the west end of Donner Lake. The Highway Engineers found the existing road in exceedingly poor condition, and did as much as possible with the money allocated for improvements. Finally, a law was passed placing a tax on gasoline which boosted highway construction.

Due to the construction of Interstate 80, U.S. Route 40 became a thing of the past. However, many short remnants still parallel Interstate 80, some of which are shown on highway maps. This includes the particularly picturesque stretch from Norden, over the summit and down to Truckee, which is open in the summer after the snow melts. Much recognition should be given to the California State Highway System and its engineers who "over seemingly insurmountable obstacles of nature" performed amazing engineering feats to accomplish this task of great magnitude.

A 1933 view of Route 40 overlooking Donner Lake.



The modern Interstate 80 passing Donner Lake 33 years later.

U.S. ROUTE 50

The route from Placerville to Carson Valley, now known as U.S. Route 50, was developed and used not to bring men and supplies into California, but rather to carry them out of the area. In July and August of 1848, the Mormons opened this wagon route from Placerville over the Sierra as they were leaving California. Further development of the trail followed the discovery of silver in the Comstock Lode, in what was then Western Utah Territory. The various improvements were made by private companies which created a toll road for the freight and passenger traffic to the Virginia City area. From 1860 to 1865, this Placerville route served as the most important route to the Comstock. The route reached its peak use in 1863, and then continued to be economically important until 1866, when competition from the Central Pacific Company, coupled with a depression in the mining area, ended its importance. Tolls were collected from users of this road, however, until the rights were purchased by El Dorado County and it was declared a public highway in 1886. On March 26, 1895, an act was approved creating the "Lake Tahoe State Wagon Road," which included the Placerville Road from the junction of the Newton and Placerville roads, near Smiths Flat, to the Nevada County line. On February 28, 1896, it became the first State Road in California.

During the legislative session of 1899 the sum of $25,000 was appropriated for the improvement of the road and structures thereon. The first major work done on this road, other than ordinary repairs, was the construction in 1901 of an 80 foot stone arch bridge over the South Fork of the American River at Riverton. In 1917, the road was incorporated into the State Highway System. The most important changes to the road were the replacing of the old Meyer's Grade on the east side of the summit and the Slippery Ford Grade between Strawberry and Camp Sacramento.

The highway runs east out of Sacramento, and continues into the foothills to Placerville. From Placerville it winds through the Sierra and then down the steep escarpment from Echo Summit to South Lake Tahoe. From South Lake Tahoe the road continues to Carson City, then across Nevada and Utah to Salt Lake City.

Early transportation over the mountain passes.

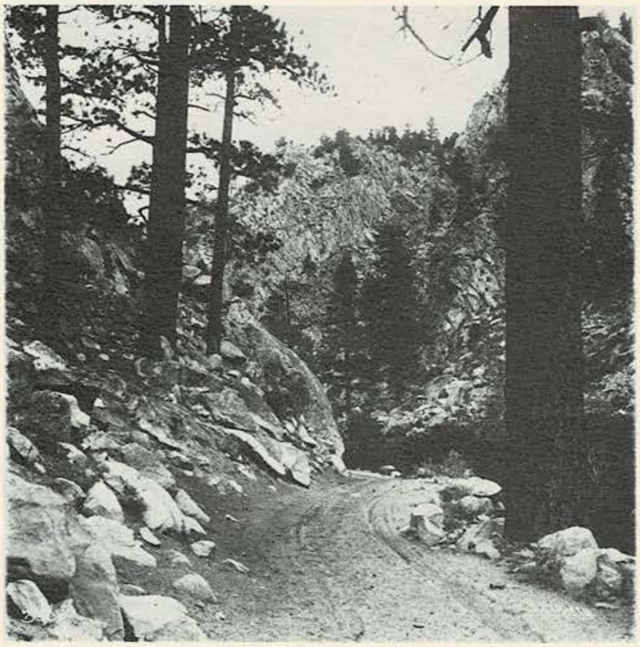
A pioneer surveying and route location crew.

STATE HIGHWAY 108

In 1862 the first route was laid out from Sonora to Mono County. The route was first known as the Clarks Fork Route, but the section along the Clarks Fork was abandoned in favor of the present route which traverses Sonora Pass. In 1864 the state legislature of California granted the first of what was to be many franchises for a toll road from Sonora to Aurora in Nevada. After the franchises were relinquished or revoked, the road was finally completed by the state as per the terms of the original franchises.

In 1901 the legislature made that portion of the Sonora and Mono Toll Road between Long Barn and Bridgeport a state highway, (now State Route 108), but appropriated no funds for its maintenance or improvements. The report of the Department of Highways states: "The 61 miles of this road from Long Barn to the junction was, in July 1901, in a very bad state of repair; the 22 miles over granite formation was nothing more than a creekbed, while all bridges on the route were either in rotten condition or else fallen down."

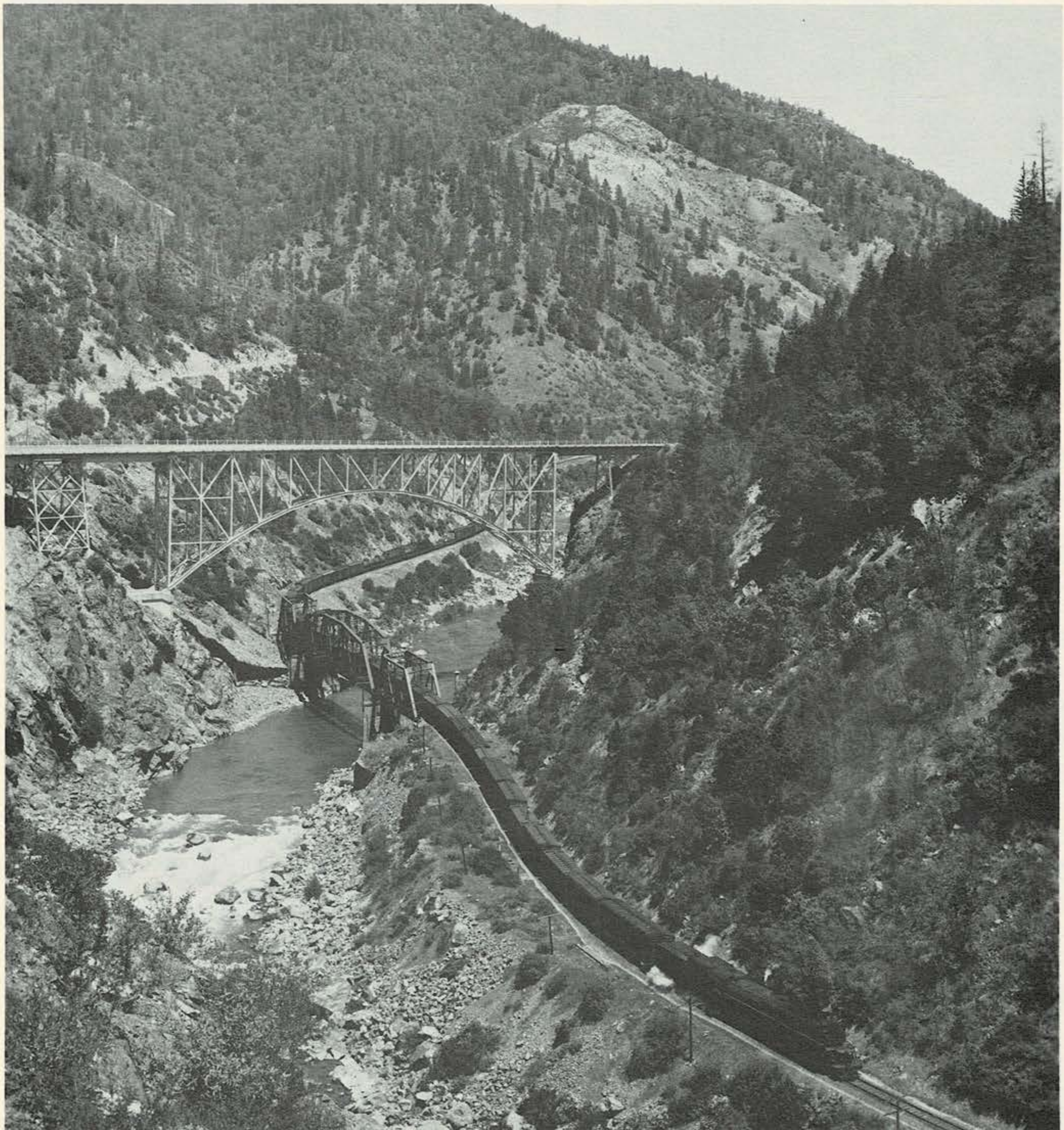
Forerunner to the modern highway of today.



The legislature of 1905 appropriated $20,000 for the construction of bridges, culverts and grading on the Sonora-Mono Road with maintenance of $4,000 per annum. In 1906 much work was done in cooperation with the Union Construction Company. As the 16 foot wide road was constructed, all protruding rocks were cut out, along with timber and brush. Since that time there have been many improvements made on the present Highway 108, but there are still steep grades over the summit, which can be a trial to many motorists.

The route starts in the San Joaquin Valley and winds through the foothills into the rugged Sierra Nevada, ending in Mono County. Most of Route 108 is situated in Tuolumne County.

Highway 70 crossing the Feather River while a Western Pacific freight twists its way below.



THE FEATHER RIVER HIGHWAY

On Friday, August 13, 1937, a gala banquet and ball in Oroville commenced a celebration of major importance for the Feather River country. After 70 years of planning and nine years of labor, a highway had finally been pushed through the Feather River Canyon, from Oroville on the eastern edge of the California Central Valley, to Keddie, seven miles north of Quincy, deep in the Northern Sierra. The festivities continued for three days in Quincy, Portola, and other Feather River communities. This highway, which was completed at a cost in excess of seven million dollars, or about $100,000 per mile, finally gave the residents of the canyon a year-round highway out to the Upper Sacramento Valley. Previous to completion the only access to the canyon was on horseback or by the Western Pacific Railroad. The highway is designated State Route 70, but is more commonly called the Feather River Highway.

The route is significant from a civil engineering standpoint due to the extremely difficult surveying and construction problems which were encountered. The Western Pacific Railroad was built through the canyon in 1909, and naturally took the best sites. It leaps back and forth across the Feather, seeking the path of least resistance. The highway, following along by almost 30 years, was forced to use a less desirable route. The canyon is too narrow in many places for both the highway and the railroad, so whenever the railroad crosses from one side of the canyon to the other, the highway usually does just the opposite. Both the railroad and the highway use tunnels blasted out of the solid granite to maintain a relatively low grade up the canyon. The three highway tunnels are grouped together about three miles north of Cresta Powerhouse. Many other items of engineering interest are visible on a drive through the Feather River Canyon, including several types of bridges, both rail and highway, and the series of PG&E powerhouses and dams.

DEPT. OF TRANSPORTATION LABORATORY

The Department of Transportation Laboratory, which now occupies a large building complex at 5900 Folsom Boulevard in Sacramento, California, was started in 1912 in a small wooden building on the old State Fairgrounds.

The original purpose was to supply materials testing for the State Highway contracts, but the need for improved procedures and controls led to the development of a research program which has resulted in significant contributions to highway design and construction. New test procedures, standards and specifications that have received national attention number more than one hundred. Space does not permit detailing of these many contributions but a few of the more important ones were:

1. Development in 1930 of the California Bearing Ratio test for soils. This test procedure is now used by many state and federal agencies to determine the pavement thickness required to support traffic.
2. Development in 1930-1935 of the Hveem Stabilometer for evaluating the stability of asphalt paving mixtures, and in 1941-1948 application of this test to soils after correlation with data from the Brighton Test Track built by the California Division of Highways in 1940. These test procedures are now used by the California Department of Transportation and many highway departments worldwide for design and control of asphalt pavements.
3. Design and use of Horizontal Drains as a means to stabilize landslide areas.
4. Development of quality control of welding on highway steel structures.
5. Development of techniques for measuring corrosion potentials of soils that affect highway drainage structures. Also development of effective cathodic protection for reinforcing steel.
6. Development in 1960 of new asphalt specifications as a result of a long experimental program that became the basis of the Uniform Pacific Coast Asphalt Specifications adopted by User Agencies in 1974.
7. Development of reflective traffic buttons or markers on highway pavements.
8. Development of dynamic testing methods for determining the effectiveness of median barriers to effectively separate opposing lines of traffic.
9. Development of computer controlled traffic signals.

EARTHMOVING EQUIPMENT

LETOURNEAU SCRAPER

Approximately 50 miles south of Sacramento, lies the once quiet farming community of Stockton. It was here that the famous line of LeTourneau earthmoving machinery got its start. Through the resourcefulness of one man, Robert LeTourneau, the burden of moving great quantities of earth has been greatly eased.

LeTourneau began his earthmoving career working for a local farmer. Employed as a tractor repairman he was one day commissioned to help level a piece of the farmer's land. The operation required two men: one to drive the tractor, and one to manipulate the scraper blade which was controlled by compressed air. It was a ramshackle combination at best, and a slow and tedious process.

Realizing the ineffectiveness of the combination, LeTourneau in his spare time redesigned the scraper by substituting electrical power for compressed air. This reduced the required manpower by 50 percent, since his scraper could be operated by just one man. Realizing the potentials of the land-leveling business, LeTourneau quit his job as repairman, sold his modified scraper to the much interested farmer, and set out on his own.

LeTourneau's business as a land leveler was a fairly lucrative affair, however he eventually decided to become a full-time manufacturer of earthmoving equipment. So, in the spring of 1922, R. G. LeTourneau produced his first scraper, a full-drag type, similar to the pattern of the day.

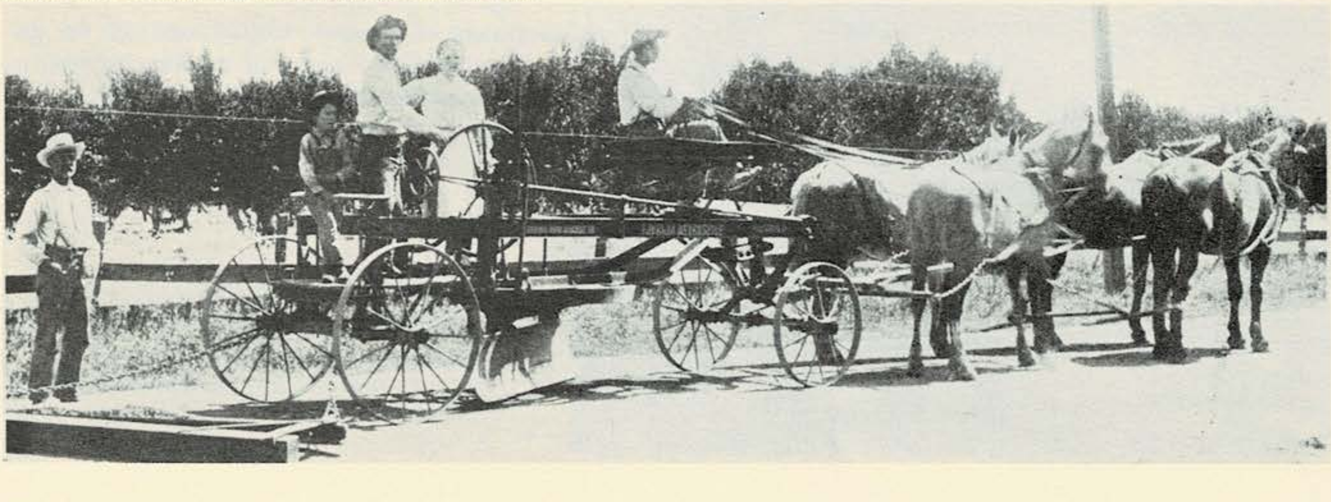
However, his second machine, the "Gondola," produced in the summer of 1922, was a radical advance in design and capacity. The Gondola was welded throughout, and therefore lighter in weight than other earthmoving tools. Capacity was about six cubic yards, doubling the capacity of conventional scrapers. Another LeTourneau innovation was the use of electrical motors for loading and unloading.

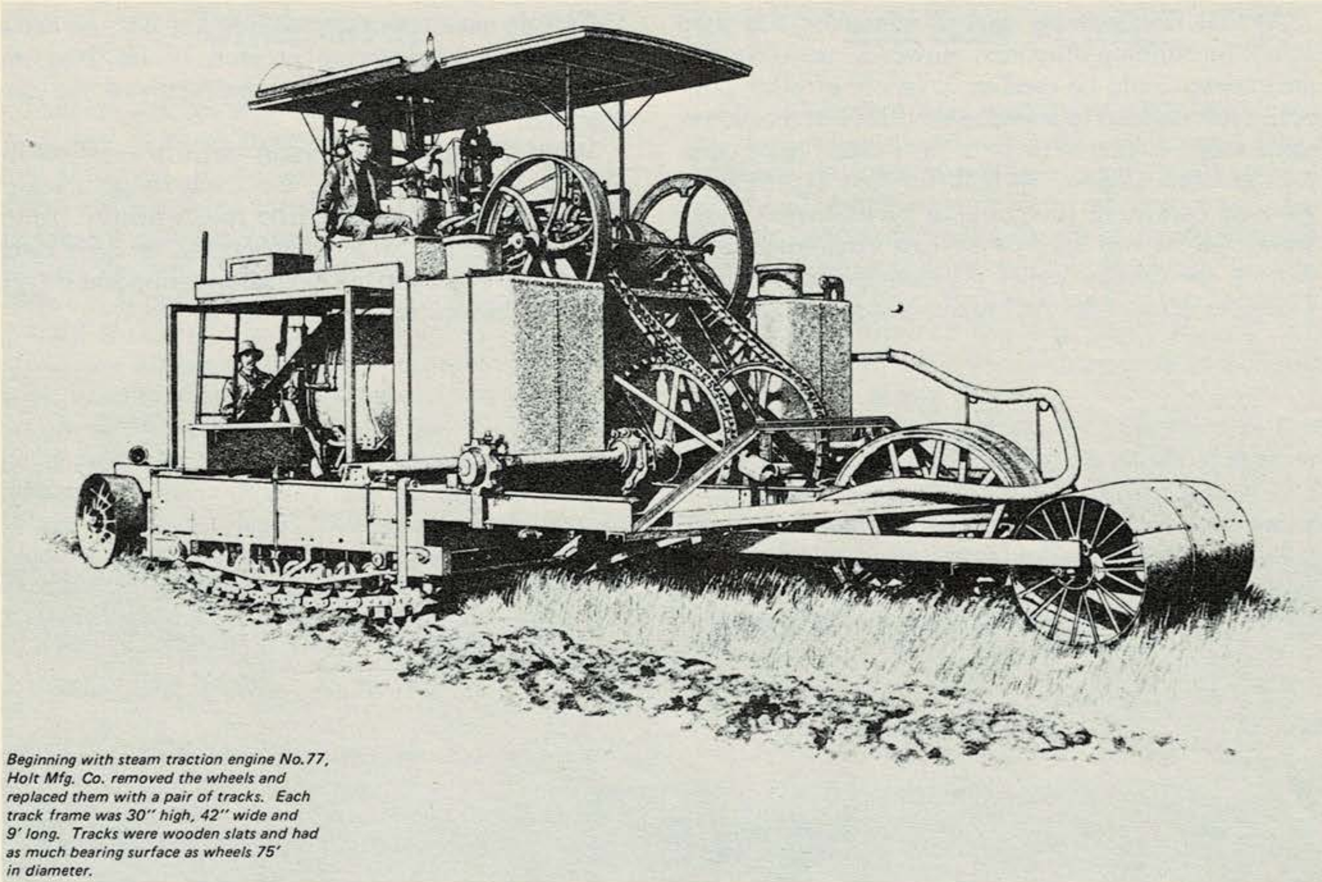
Early in 1923 machine No. 3 came along, and was another tremendous step forward in the carrying capacity over contemporary machines. The "Mountain Mover" was 12 feet wide, had two 4-foot buckets telescoping inside each other, and could pick up 15 or 16 cubic yards of earth with each load.

All of the early LeTourneau scrapers were characterized by these principles: welding throughout, thereby decreasing the overall weight; the use of electric motors to control loading and unloading; large carrying capacity; and the ability to spread the unloaded earth to the precise depth required in smooth even layers, varying from 1 to 20 or 22 inches. This last characteristic was a particular advantage over the conventional scrapers of the day, especially in the construction of highways.

The LeTourneau scraper, although getting its start in the Stockton area, has been used extensively on a wide variety of civil engineering jobs throughout the world. These machines allowed man to move earth faster and more economically than any other earthmover, thereby greatly influencing the civil engineering field.

Early road scraper being used on a Yolo County road.





Beginning with steam traction engine No.77, Holt Mfg. Co. removed the wheels and replaced them with a pair of tracks. Each track frame was 30'' high, 42'' wide and 9' long. Tracks were wooden slats and had as much bearing surface as wheels 75' in diameter.

First crawler tractor built by the Holt Manufacturing Company.

CATERPILLAR TRACTOR

The Caterpillar tractor today is also used on all kinds of civil engineering construction projects. The inventor, Benjamin Holt, considered his discovery to be the solution only for a troublesome local problem, and never dreamed that his idea would be multiplied hundreds of thousands of times.

Since man's settling of the area, the rich, but soft and spongy peat soil at the head of the San Joaquin River near Stockton, had always plagued farming and construction efforts. Thousands of acres of this rich Delta soil had to lie unproductive because the large steam traction engines were too heavy and cumbersome, and sank easily into the soft earth.

At first the problem was attacked by applying more and larger wheels to increase the bearing surface. The resulting machines were expensive and unwieldy, with the final attempt at such a tractor having a thirty-six foot wheel spread! But it also was too heavy and cumbersome and rapidly sank into the soil.

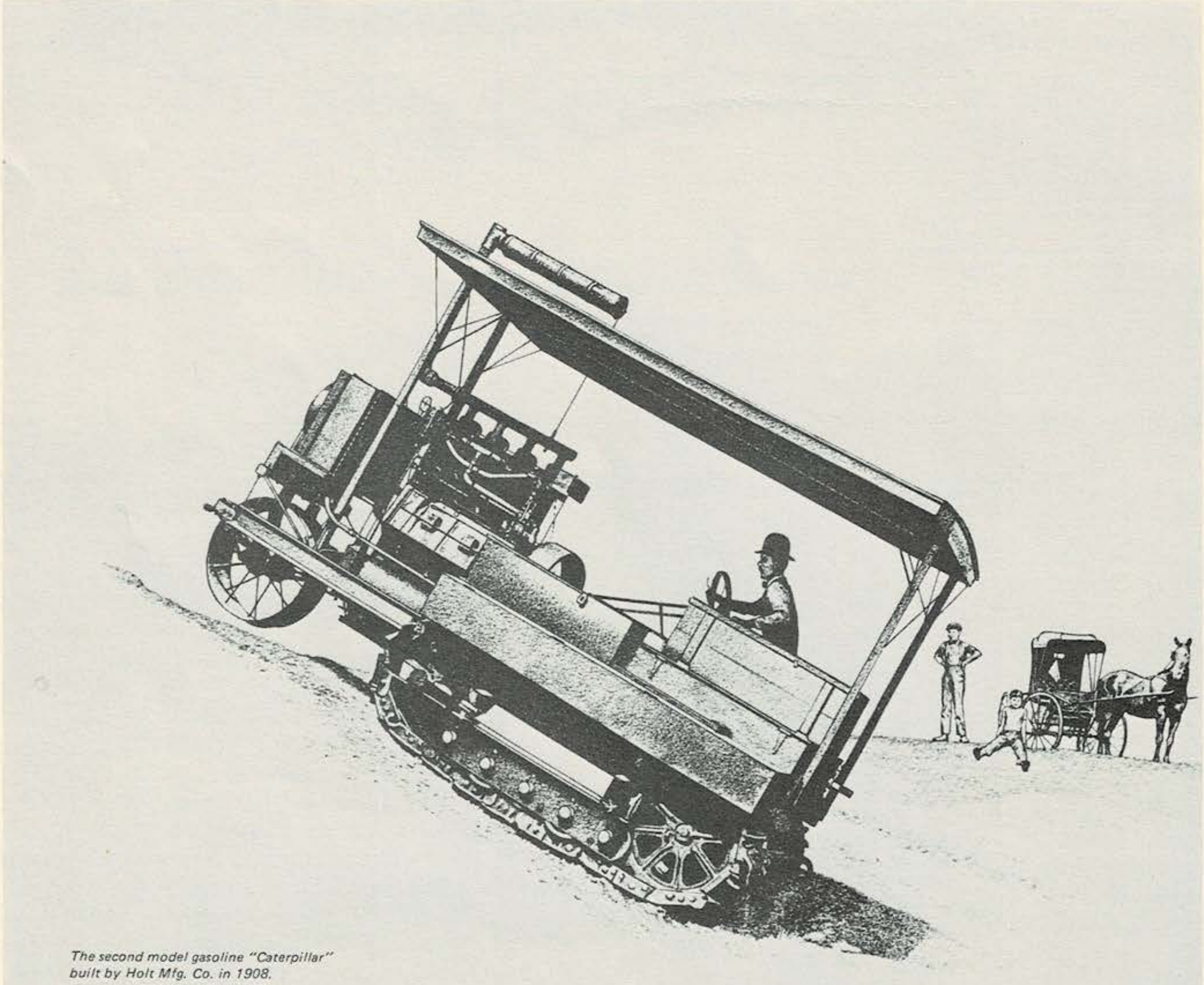
Around the turn of the 20th century, Benjamin Holt, a Stockton manufacturer of steam traction engines, realized that increasing the wheel size was not a suitable solution to the problem. The need was evident: more traction through greater ground contact area, yet with compactness and better maneuverability. These considerations led Holt to the idea of a ''treadmill'' type of machine, traveling by picking up and laying track on its own broad base. The concept of such a vehicle was hundreds of years old, and over a hundred patents already existed. However, it took Holt's genius to transform this idea into a workable and successfully operating machine.

Testing of the first crawler occurred on Holt's property, November 4, 1904. It was a success, and introduced to the world the first practical track-type tractor.

At first Holt's steam caterpillar crawler was used solely for farming purposes. However, realizing that the crawler could be used on a variety of other projects, Holt decided to abandon the heavy and cumbersome steam engine in favor of the lighter, more compact gasoline engine. He built his first experimental gasoline crawler in 1906, and in 1908 the new track-laying tractor was used on its first civil engineering project, the Owens Valley Aqueduct, which twisted 232 miles across both the Mojave Desert and Southern California mountains to reach Los Angeles. As one of the greatest engineering projects of its time, the aqueduct presented a real challenge to the new machine.

With its highly successful performance on the Owens Valley Aqueduct, the track-laying tractor's popularity spread rapidly. The rest is history. Along with other earth moving paraphernalia, an early caterpillar is on display in the Pioneer Museum and Haggin Galleries located in Victory Park in Stockton.

A 1908 Caterpillar, the forerunner of the World War I tanks.



The second model gasoline "Caterpillar" built by Holt Mfg. Co. in 1908.
Courtesy—Holt Bros.

BUILDINGS

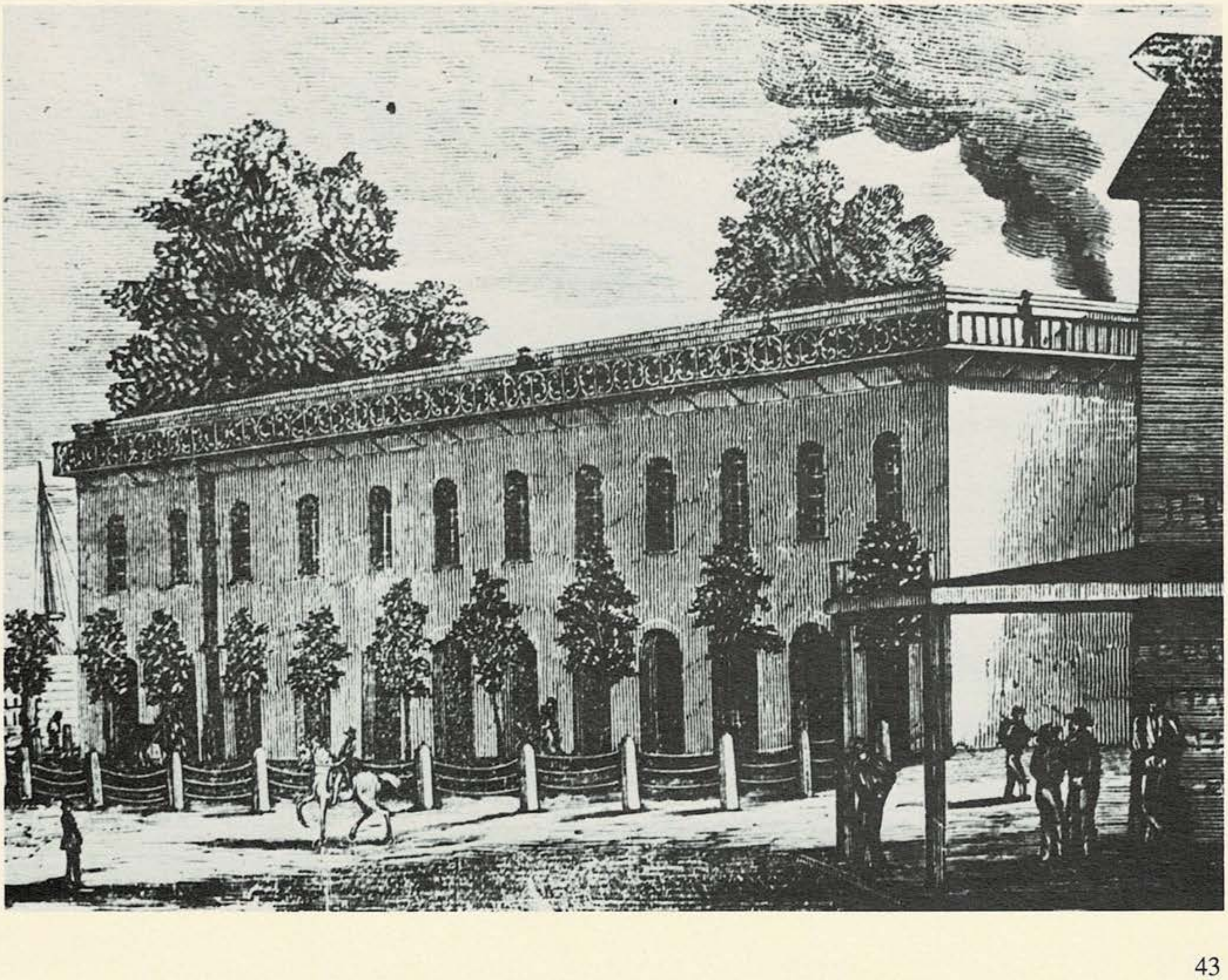
FIRST WATER WORKS ON THE PACIFIC COAST

The earliest methods of water distribution within Sacramento were extremely primitive, and the great fire of November 1852, which nearly destroyed the entire city, forcibly called attention to the need for an adequate water supply system. On February 13, 1853, the voters approved a direct tax for the establishment of a water supply system. Work commenced in October, 1853, and was completed in April, 1854, thus giving Sacramento the first municipal water supply on the Pacific Coast.

The Water Works consisted of a brick building, with pumping machinery installed in back near the Sacramento River. Water was pumped from the middle of the river into a 200,000 gallon reservoir located on top of the building, forty feet above the existing street level. Distribution of the water was by natural gravity feed. This system served the city adequately (except for pump failures) until about mid-1859, when the increasing number of customers and the expanding distribution system lowered the water pressure to an undesirable fire protection level.

The Water Works Building is to be reconstructed on its original site as a part of the Old Sacramento restoration project, and will house the Sacramento City-County Museum.

First City Hall and Waterworks building.



STATE CAPITOL

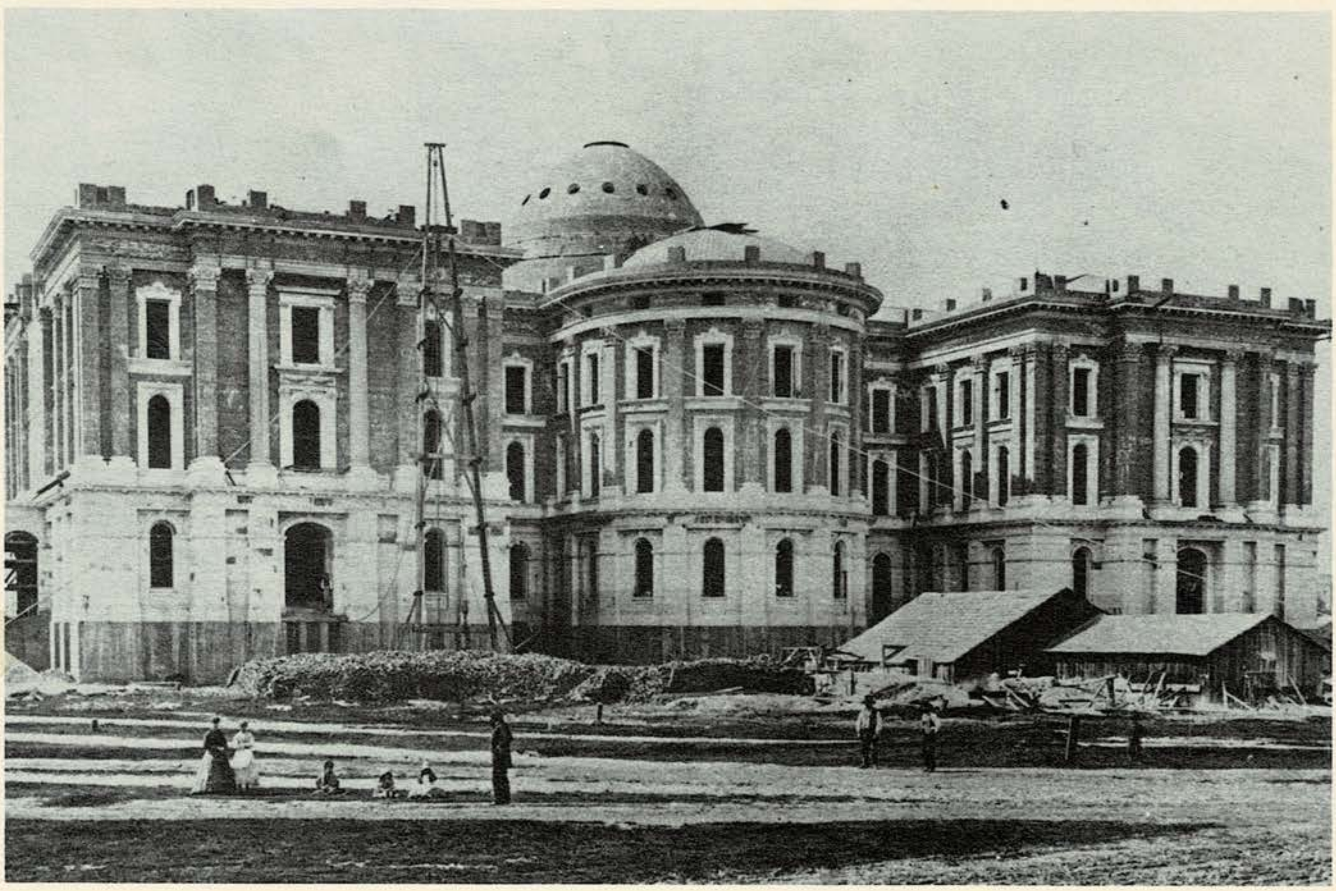
In March of 1860, a bill approved by both houses of the legislature was laid on Governor Downey's desk. This bill permitted the City of Sacramento to acquire approximately four blocks of land and present it to the state as the future site of the new capitol. The legislature also appropriated $500,000 as a construction fund, and appointed a commissioner to superintend the erection of a capitol building. The commissioner received seven plans in response to advertisements, chose those submitted by M.F. Butler, and appointed Reuben Clark as superintending architect. Detailed drawings and working plans were prepared by Clark as the work progressed.

On September 24, 1860, ground was broken for the foundations. The cornerstone, quarried at Folsom, was laid in the presence of a crowd which the Sacramento Union estimated to be in excess of 3000 persons. The cornerstone formed part of a foundation which was patterned after the 250 year old Spanish fortress in Panama, probably the strongest type of construction known. This type of construction was needed because of the enormous size of the proposed structure. The foundation extended far below the basement floor. Those foundations supporting the outer walls and the rotunda were 18 feet wide at the base; those under the inner walls were 9 feet wide. On a footing of concrete, brick was laid in diminishing courses so that the foundations curved inward as they rose to meet the walls.

Clearly the capitol was strongly built. Records of its construction, however, are incomplete. The architects, who superintended the builders worked from general plans, solving the ever present problems as they occurred. Many minor records still exist, but the original architect's drawings, even the original plans, have vanished.

By 1869 the capitol was very close to completion. As the Sacramento Union said, "The skeleton work of the interior already gives evidence of its magnificent

California's capitol under construction.



State Capitol decorated for The Festival of Lights, the 1895 celebration of electrical power generation at Folsom.

proportions and the promised elegance of its architectural finish, particularly the legislative halls and the state library." On November 26, 1868, the offices of the Governor and Secretary of State were opened. The building was occupied by State Departments on December 6, and the legislature held its first session in its new chambers.

From 1870 through 1874 finishing touches were put on the new capitol. The work was completed by Gordon P. Cummings, who succeeded Reuben Clark in 1865, after Clark fell ill. The three porticoes were completed during 1872. Their columns represented the outcome of architect Cummings' losing battle with the Board of Capitol Commissioners. Although he assured them that it was customary to have such large columns cast in three sections, the board did not believe that sectional columns were sufficiently dignified for the capitol of California. Consequently they were cast in San Francisco as iron monoliths, each weighing about 11 tons. When the fourth was sent up on a river boat, it was accompanied by the man who had contracted to transport it to the capitol grounds. He brought his 10 horse team with him, and a crowd followed to watch him maneuver the long column through the downtown streets. The Union recorded that the only casualty was a skinned hip for one horse. The dome and third floor were also completed during this period. The interior was embellished according to the decorative ideas in vogue, popularly known as the "General Grant." The grounds of the original site, which extended up to Twelfth Street, were graded and planted with grass and trees. In 1874 the capitol was then declared completed.

Since the capitol's completion in 1874 there have been several improvements, as well as major remodelings in 1906-08, in 1928, and in 1939. In all, the total expenditure on the building and grounds has exceeded $3,000,000. In 1973, following concern over the safety of the building in the event of a major earthquake, the Sacramento Section of ASCE passed a resolution urging that the State take whatever steps necessary to preserve the present building. During the present restoration, much of the interior is being rebuilt to more nearly resemble the original beauty.

THE SACRAMENTO SHOPS AND SOUTHERN PACIFIC DEPOT

Certainly the success of the historic Central Pacific and current Southern Pacific railroads depended considerably on the immense complex known as the Sacramento Shops. These shops, some as large as 90 feet by 495 feet, were erected during the period 1865-1930, and many still stand today. All types of railroad cars, including over 200 locomotives, were manufactured from the wheels up in these once bustling shops.

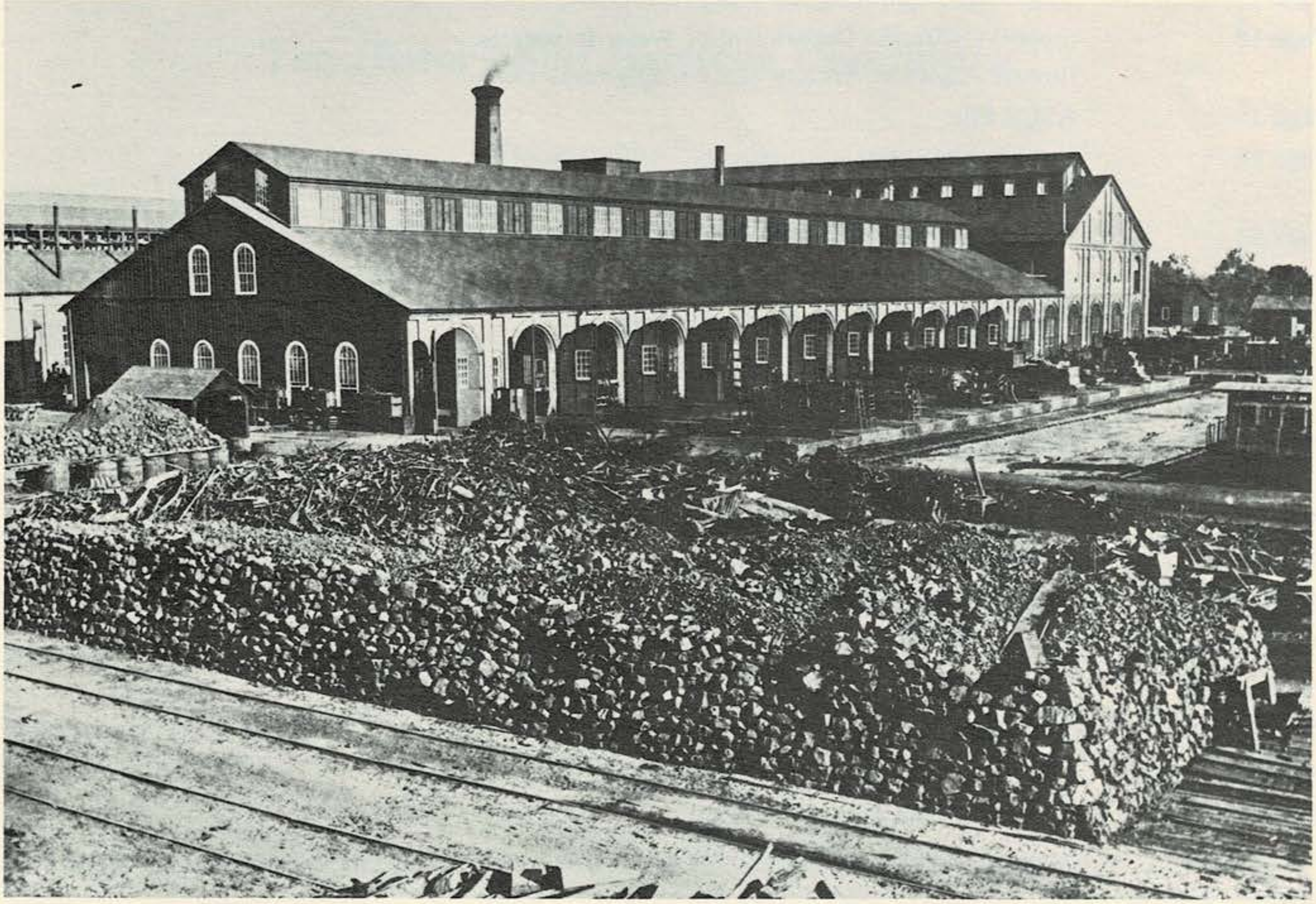
China Slough, site of the present Southern Pacific Depot and Shops.

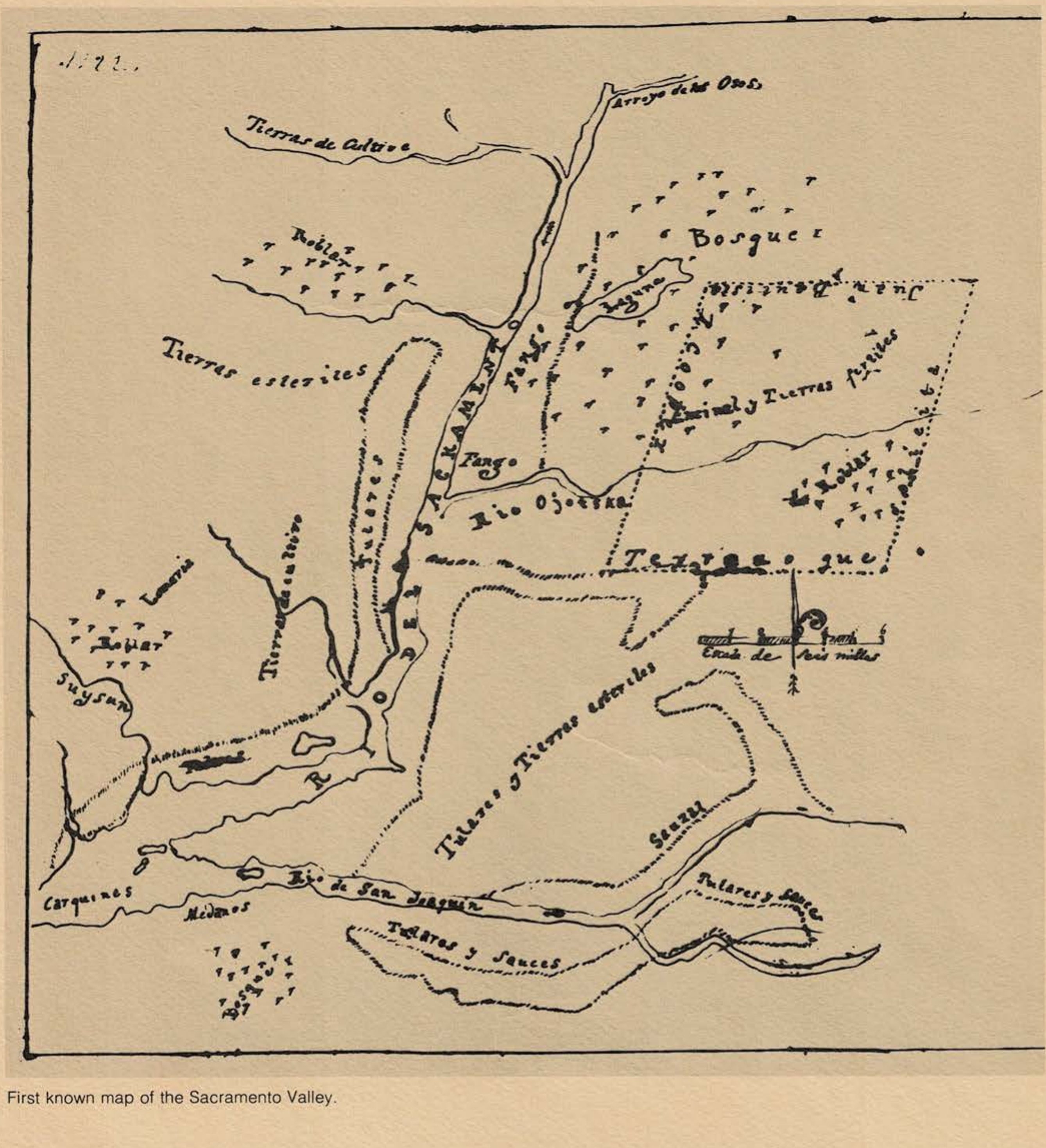
From an engineering standpoint, these buildings are significant in that they now rest on what was once a body of water known as Lake Sutter (or China Slough). The foundations were especially critical because of the enormous weights they were destined to support. A solution to the problem in some cases consisted of driving numerous 12 inch square cedar piles to gravel beds, and then placing huge stones of granite on them to form the necessary bearing surface. Other buildings had no piles, but rather their foundations consisted of 12 inch square redwood timbers laid both lengthwise and crosswise. On these timbers, piers of brickwork 17′3″ by 8′10″ at the bottom tapering to 8′2″ by 3′6″ at the top, were used to support the walls.

The most recent Southern Pacific Depot Building, completed in 1927, is further significant in that here one of the first extensive soil investigations, including on-site compaction testing, was conducted prior to construction. These tests were so thorough that results from them were used over 30 years later in the design of Interstate 5.

Pile bearing tests in 1925, for the Southern Pacific Depot.

The Sacramento Shops have long played a major role in the success of the Central Pacific and Southern Pacific.





First known map of the Sacramento Valley.