Vital railroad developments are being created by California's mammoth $2.5 billion Central California Water Project, of which the Oroville Dam project is a segment. The Western Pacific line change, required by the Oroville Dam project, involves the latest techniques in high-level bridge and tunnel designs, soils and foundation developments, track laying, and other construction. The Oroville Dam, now under construction northeast of Sacramento, will divert waters of the fabulous Feather River to Southern California. The earthen-fill dam, measuring 3600 ft wide at its base, will rest on, and cover, a massive concrete core anchoring the dam to the river bottom.

Though railroaders are used to major engineering projects, few face projects the magnitude of Western Pacific's Oroville line change. Even so, this $40 million project, representing the cost of relocating the railroad, is but a small segment of the over-all Oroville project. It has involved the relocation of Western Pacific's main line between Oroville (MP 205.47) and Intake, California (MP 232.43), replacing the road's original main line which will be inundated by the reservoir behind the dam. The dam is scheduled for completion on November 15, 1967. The relocation cost will be borne by the State of California.

Oroville Dam itself will consist of 77 million cubic yards (154 million tons) of earth or 1.4 million railroad carloads of cobble and impervious clay materials. Its 750-ft height will make it the highest earth-filled dam ever constructed. It will create an immense lake storing up to 3.65 million acre feet of water, will control the Feather River flood waters, and will provide water for irrigation and industrial use in many parts of the state, especially along the San Joaquin Valley and as far south as San Diego, California. Its waters will generate vast amounts of hydro-electric power.

To construct the dam, the contractors built their own railroad. The earthmoving chore, it is said, based on the weight of material and the distance moved, will be three-and-a-half times that of famed Gatun Dam in Panama. Three operating trains utilizing four sets of cars, 42 cars in each set, operate 21 hours per day, five days each week on the Oro Dam Constructors' railroad.

By the construction of the earthmoving railroad and by the use of special excavators, Oro Dam Constructors are said to be doing the job at $10 million under the state's estimated cost. And, the contractors are ahead of schedule. Onan Construction Company, Inc. of Tennessee is the sponsor for the joint venture group along with seven other prominent contracting concerns which form the Oro Dam Constructors. The dam contract for $121.0 million makes it the largest non-defense construction contract ever awarded competitively in the United States.

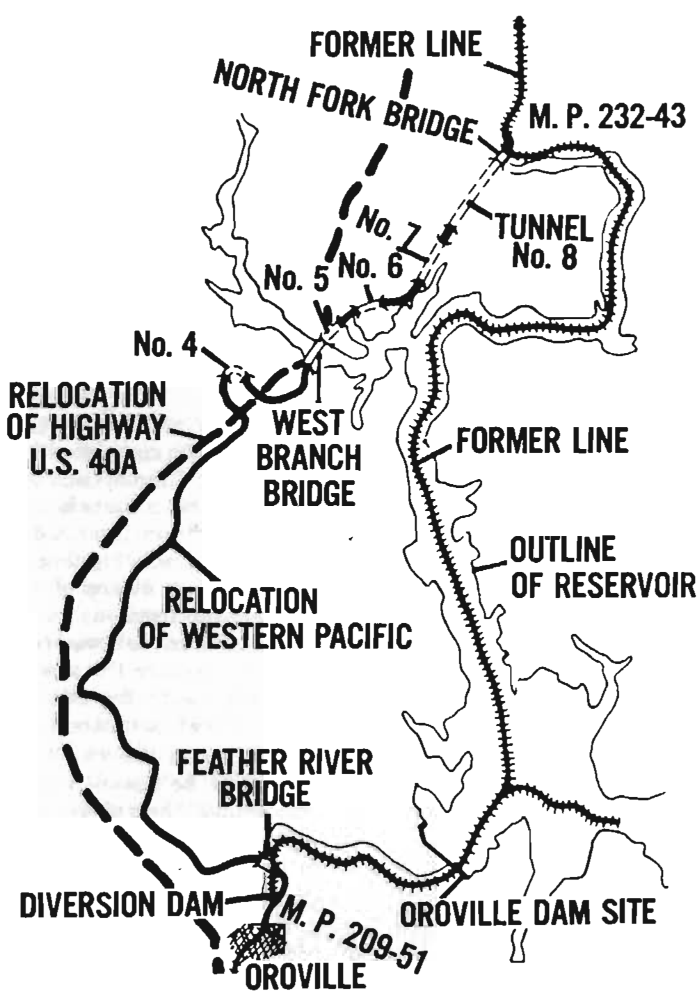
The work involving the Western Pacific was quite extensive. Some 27 miles of old line were replaced by 23 miles of new main track, four miles less than the old. Four major bridges were built —one being a notable 943-foot concrete arch structure; another a single arch 66-foot; a 1079-ft deck plate girder structure on single circular piers; and a joint highway through truss railroad bridge 1879 ft in length. Five concrete-lined tunnels and considerable earthmoving were required to hold the railroad's maximum gradient at one percent compensated.

WP Makes a Mountain Line Change

by Edward T. Myers

MODERN RAILROADS, NOVEMBER 1964

MAP OF NEW AND OLD LINES

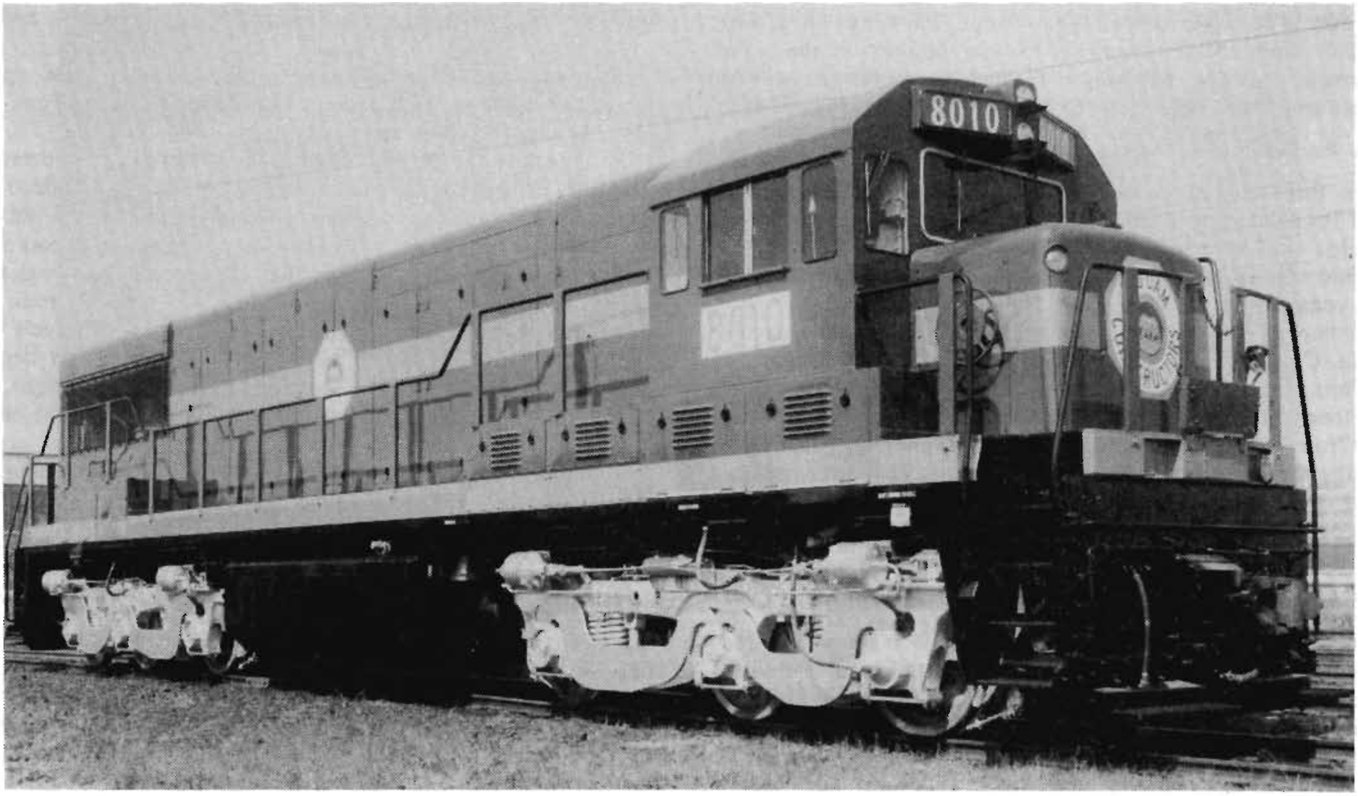


On October 22, 1962, Western Pacific started operating trains over its new line. Final work on the new alignment was essentially completed January 29, 1963. Immediately thereafter, Western Pacific's old alignment was parted at the dam site at which time dam construction officially got underway.

Oroville Railroad — A Heavy-Duty Line

This heavy-duty railroad was built by the contractor and extends for some twelve miles from the most remote borrow area to the dam. Segments of this haul line are double track. Gauntlet track is used in between the double track segments for purely economic reasons. Thus, the three crossings of the Feather River are by gauntlet. The only tunnel was formerly on the old Western Pacific line. Gauntlet operation was utilized only to avoid the expense of daylighting or of by-passing this tunnel with a second track. Also, in making the upper crossing of the Feather River near Thermalito, a single-track crossing was made. This bridge had originally been planned for double track, but the cost of the bridge, problems of curvature, and other engineering considerations caused the contractor to stay with single track.

Track on the contractor's railroad is 136-lb CF&I section rail, welded in 78-ft lengths for ease of construction. Operating speeds are relatively easy, with a maximum of 30 mph applicable for loaded trains and 40 mph for empty return moves. Loads, however, are relatively heavy, each car carrying 110-ton payloads. Each train consists of 40 loaded cars pulled by two General Electric U25C's, 2500-hp diesels with two empty cars on the rear. The two rear cars are essential for efficient operation of the hydraulic pusher, a part of the automatic car dumper near the dam site. Cars, as well as locomotives, are new. All this sounds rather amazing for a railroad which is temporary and will be removed once its job has been performed; here rail haul proved to be the only practical mode for moving materials with high efficiency.



GE U25C Built for the Oro Dam Constructors, we missed getting one for Portola......

The 42-car trains depart from the loading point at one of the three borrow pit automatic loading stations on an average of every 20 to 30 minutes, five days per week, 21 hours every day. The additional two days, Saturday and Sunday, are used for maintenance of railroad motive power and cars. Each train handles 4400 tons of cobble or selected clay.

The contractor's railroad uses about three miles of the old Western Pacific line. This haul railroad was built to standard gage and AREA standards. Because property owners in the Thermalito area would not provide, at a most liberal offer, right-of-way to properly locate this railroad, Constructors' engineers found themselves forced to locate the major portion of the haul line in most disadvantageous locations. As a result, the railroad was placed along the low bank of the Feather River. This increased the number of river crossings. For example, three new bridges across the Feather River were required, with the possibility of a fourth. Furthermore, protection against overflow at times of high water was a must in dealing with the Feather River.

The railroad maintains three loading areas; one, for impervious clay and two for selected cobble fill. Loading is automatic, with ten cars being loaded simultaneously in three minutes from overhead hoppers. The entire 40 cars are loaded in 12 minutes. The road locomotives pull their own train through the loader.

As of October 6, 1964, an approximate 62 million cu yd of material has yet to be moved. Although at this time, only 19 percent of the fill material had been moved, the contractor was and still is running considerably ahead of schedule. This good fortune results from an abundance of "know-how" by the project manager in his utilization of ultra-modern earthmoving techniques, which extend from the most unique excavation methods to the contractor's selection of a railroad as a material haul medium coupled with special dumping methods. Over $20 million was spent on modern earthmoving equipment before full-scale dam building operations got fully underway.

Modern Excavating Equipment Fills Trains

At the head of the railroad is an ultra-modern layout of excavation equipment, all operated by the contractor. A large 30-ft diameter Wellman-Lauchhammer bucket wheel is the prime excavator for the select cobble fill. It is supplemented by two 12-yd draglines, both being major excavating components. The big wheel has a working radius of 61 ft and a cutting height of 32 ft, and loads onto a belt conveyor which carries the fill material back to the loading hoppers above the railroad track. Despite its large size, the excavator rig has tremendous maneuverability. When a move is necessary, dozers shove the track on which the conveyor operates into a new position. A TV camera keeps the operator informed on the two-unit mobile conveyor's operation. Since the wheel excavator cannot quite keep up with the capacity of the trains for moving the fill, a dragline operation of two 12-yd draglines with 55-cu yd haulers supplements the big wheel. A second belt conveyor is located uphill from the dump.

The impervious clay fill is excavated by means of either a dragline or 55-yd Caterpillar scrapers pushed by D-8-H dozers. The clay is loaded into the train haul cars from overhead cylindrical tanks. Internal and external vibrators are necessary to help dislodge the impervious clay material, especially when any moisture is encountered.

Each of the 40 loaded railroad cars carries 110 tons or about 55 cu yd of fill material. This cobble material is loaded from under a high overhead storage pile through means of automatic overhead doors which load ten cars at one operation.

At the near dam site, or north end of the railroad, a Wellman-Lauchhammer revolving car dumper dumps two cars at a time in one minute. The cars have rotating couplers permitting the dumping operation to take place without uncoupling cars.

Trains are operated by an engineer and an oiler-helper. The engineer takes his locomotive through the dumper and automatically uncouples from his train. The loaded cars are pushed through the dumper automatically by a special car pusher. The engineer then proceeds to pick up a 42-car train of waiting empties to return to the loading area. Each locomotive has automatic couplers and air connections activated by solenoids. When the engineer backs into a cut of cars, he controls the coupling manually from his cab; after which action an automatic device makes immediate connection of the locomotive to the train. Thus, a minimum amount of time is lost at the unloader in uncoupling from the loaded trains and in coupling to empty trains. From the

WP MAKES A MOUNTAIN LINE CHANGE CONTINUED

east side of the river where the dumper is located, the fill material is distributed by a 2380-foot conveyor belt which spans the Feather River on its own bridge, depositing material at a storage pile located over a conveyor tunnel. This layout will move 77 million cubic yards from the left bank at the car dumper to the right bank storage area for distribution through a second set of belt conveyors and 55-cu yd wagons to dam construction area.

Western Pacific Moves Across the River

Before the contractor's railroad could go into operation, the Western Pacific had to move to the opposite side of the Feather River. First work was to prepare a new roadway for the Western Pacific and two diversion tunnels for the Feather River beneath the dam construction area.

Relocation of the railroad extends for 23 miles from Oroville to Intake, California. As measured on the old line, this was 27 miles. Thus, Western Pacific's route has been shortened by approximately four miles. Maximum curvature on the new line was reduced from 10 deg to 4 deg 30 min. Grades on the new line were held to the same maximums as on the old line: one percent compensated. Unfortunately, the new line has a considerable disadvantage over the old. The old had an easy 0.4 percent grade approaching "the hill," the point of maximum grade. Here, the engineer had a 14-mile run for the hill. Now virtually the whole line is on an ascending grade eastbound.

The new line departs from the former main line a few hundred yards north of Western Pacific's passenger station at Oroville. This station is some four miles downstream from the Oroville Dam site and has been the center of intense activity since a steady flow of supplies for both the railroad and the dam project began arriving. The old line which followed the Feather River will not only be completely inundated, but will lie directly beneath the dam. The new line departs from the Feather River canyon by turning west and first crossing Feather River. It then sweeps around Table Mountain which lies some miles to the west of the future reservoir.

The new Feather River bridge, the first bridge on the new line, crosses an afterbay in which the water will be up to 110 ft deep. The main plate-girder span is 125 ft long. Total length of the bridge is 1079 ft, all on a 3 deg 30 min curve. The spans are carried on attractive, single, circular, reinforced, concrete piers 12 ft in diameter at stream level and tapering to 10 ft at deck level. "T" heads support the steel girders which carry the ballast deck. Communication poles are mounted in steel sockets. Poles are 40 ft high, of which the lower 17 ft are 18 in. in diameter and the upper 23 ft are 12 in. in diameter. Where the permanent low-water channel of the Feather River was crossed, two massive concrete foundations were necessary on which to support the 12-ft base of the cylindrical piers.

As can be seen, bridges are an important segment of the new Oroville line change. Each of the Western Pacific's four principal bridges is different. Each is distinctive. All are designed for Cooper's E-72 rating; however, the railroad has since adopted E-80 as its new standard in order to meet the demands of heavier wheel loadings.

As the relocation swings around the mountains to the west of the canyon, it crosses the West Branch of the Feather River on a $10 million combination highway and railroad bridge. This is a two-level truss bridge with a ballast deck on the lower level for the railroad. Highway 40A, some sixty feet above, consists of six lanes. The 1879 ft bridge includes one 36-ft deck plate girder, a 360-ft, two 432-ft, and one 576-ft through-truss spans. Trusses are supported on concrete piers measuring some 20x58 ft at their bases. Their tops are some 400 ft above the present water level. The massive spread concrete footings were well-keyed into solid rock. The railroad on this structure can be converted to double track should this become desirable in the future. Immediately upon crossing this bridge, an eastbound train will plunge into Tunnel No. 5 which is 2922 ft long.

Most striking of Western Pacific's four major railroad bridges is the North Fork Bridge which marks the eastern entrance to the new line. This dramatic bridge leaps 943 ft across the North Fork of the Feather River by a series of striking concrete arches. The central arch, of 308 ft, is flanked by two other arches with spans of 194 and 247 ft respectively. In addition, the bridge includes ten ballast deck spans; seven being simple 22- and 28-ft spans.

This structure is described as a single-track, open spandrel reinforced concrete arch with a main span of 308 ft. Total length of the bridge, including approach spans, is 943 ft.

"It is believed to be the longest railroad reinforced concrete arch structure in the United States," explains Frank Woolford, chief engineer, Western Pacific. "Height from the base of the rail to the river bottom is 150 ft. To everyone's surprise, the cost of this bridge proved to be lower than that of more conventional types."

Needless to say, a line change in the mountainous terrain which surrounds the Feather River Canyon involves extremely heavy grading at many locations. Some cuts have maximum depths of 218 ft at the center line. Fills range up to 265 ft in height. Excavations totaled more than six million cu yd of material—most of it in rock. The contractor used Caterpillar bulldozers, scrapers, and other most effective and efficient earthmoving equipment, including Athey T Line·PW660 material haulers with Caterpillar 660 tractors pulling.

Line Change Involved Building Five New Tunnels

As a general policy over the past 15 years, Western Pacific has been daylighting, relocating around, or concrete-lining tunnels; however, five new tunnels, 18x24 ft inside, replacing similar numbered but much shorter length bores, were required in this project. Longest is Tunnel No. 8—8856 ft. Trains westbound over the North Fork Bridge plunge directly into Tunnel No. 8 on the west bank. This is followed quickly by Tunnel No. 7 which is 4406 ft long. The two tunnels are only 125 ft apart with a 66 ft concrete arch bridge between them. Tunnels No. 4, 5, and 6 are 2410, 2922, and 2583 ft in length respectively. Territory traversed is rugged with hillsides lined with fir trees. The ghost town of Cherokee, once a thriving mining community, is near Table Mountain, which the new line skirts. Cherokee Mine pit, on one side of flat-topped Table Mountain, was once rich in gold which was mined hydraulically.

In open stretches of track, Western Pacific laid 119-lb CF&I 78-ft rail. In the tunnels and on the bridges, continuous welded rail was laid in 1440-ft strings. Through Tunnels No. 7 and 8, and also across the North Fork arch bridge, these strings were joined in the field by welding, utilizing the Rapid Thermit process.

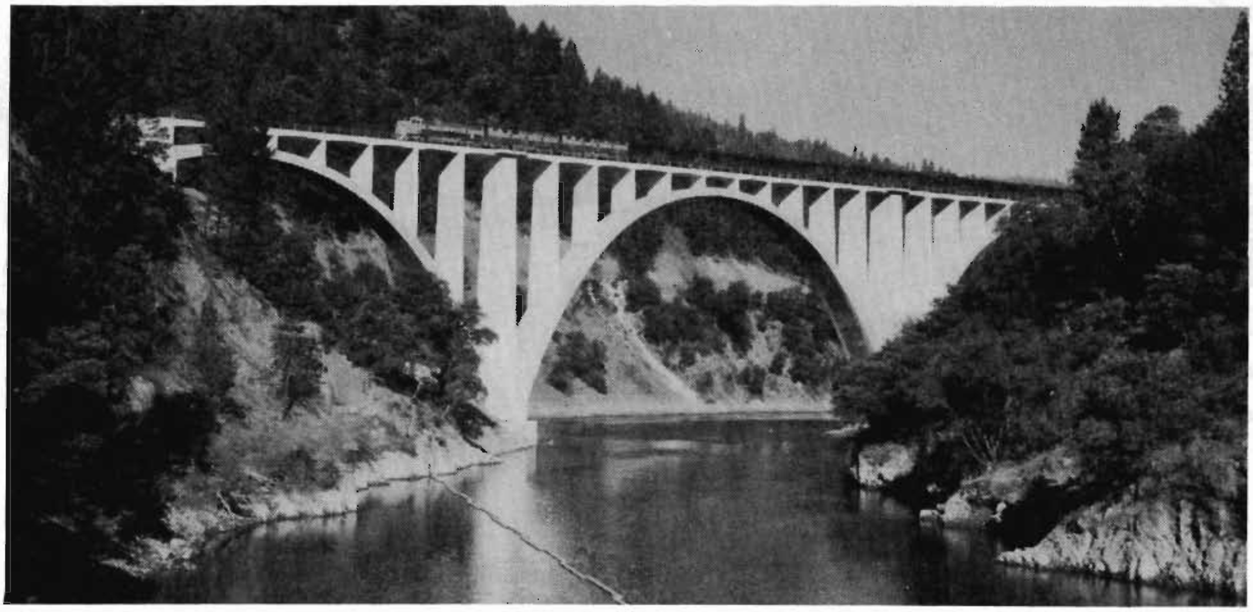
"This is one step to get away from joints and joint maintenance," explains Frank Woolford. "For operating safety, we tested every thermit weld by cobalt X-ray. This track now serves as a test of the durability of Rapid Thermit welds on a mountain railroad engaged in normal operations."

These thermit welds have been in service since late 1962, with no evidence of failure. This line handles some 15 million gross tons of heavy traffic each year.

In laying the continuous welded rail on bridges, Western Pacific used a two-stage technique, necessitated by the lack of a storage area for 1440-ft rails, the unavailability of the welding plant on demand, and the limited number of rail cars. Lightweight rail was laid in construction. This rail initially served to put railroad into operation and secondly, as a route of travel for the equipment which brought in and laid the welded rail. When the continuous welded rail was placed, the lighter and former running rails were jacked over to an inside position where they became the inside guard rail through tunnels and across bridges.

The new line which removes the railroad from the lower reaches of the Feather River canyon begins at an elevation of 200 ft, near Oroville (timetable west end) and rises to nearly 1100 ft at Intake, named for the intake tower of the Las Plumas powerhouse.

Location work for the new line was made by Western Pacific engineers. California Department of Water Resources engineers drew up the working plans and handled the construction contracts for the subgrade and selected base materials, bridges, and tunnels. Western Pacific engineers designed the bridges, tunnels,



North Fork Bridge has a span of 308ft, length of 943ft.........

and profile of embankment and during construction, maintained inspectors on the entire project. After the state turned the completed subgrade over to the Western Pacific, the railroad's gangs took five months to complete the new railroad.

From long experience in the mountainous areas of the state, Western Pacific engineers knew pretty much what to expect in the way of slides after such alignment was completed. In several instances, state engineers had been overly confident and unwisely conservative, with the result that several severe slides occurred. The line is now becoming seasoned with the hope of all movements of Mother Earth passed. One slide, however, forced the moving of the tracks a maximum of 130 ft for nearly a quarter of a mile. Some 60,000 cu yd of material slipped into the subgrade area; a second slide at the same location brought an additional 25,000 cu yd of hillside down upon the new alignment. Western Pacific engineers then found it necessary to take over from the state's engineers to solve this earthmoving problem. The cost to clean up the slide, flatten the slope, and move the track ran to some $200,000.

Special Foundation Material Prevents Water Damage

Another serious problem developed in the two longest tunnels. A 10-in. concrete floor had been placed on selected granular material. By mistake, decomposed granite was substituted for crushed rock material in floor backfill. Hydraulic action of water appeared to float out the decomposed granite material in this foundation. Failures of the tunnel concrete inverts appeared in many locations. Before serious damage resulted, interrupting operation of trains, Western Pacific engineers recreated the foundation under train traffic by the use of high-pressure concrete grouting methods. Good results were obtained using a 1-to-1 neat cement mix with a one percent fluid additive of Bentonite, which served to lubricate the grout so it would penetrate all of the crevices which the foundation had leached away and as a cement mass joined the remaining aggregate together. Following the pressure grouting, engineers utilized a diamond drill to check the penetration of the grout and the restoration of the foundation.

Longest culvert in the project is a 126-in. diameter, 4406-ft Armco pipe placed some 300 ft west of Tunnel No. 7. This was assembled in place and coated with an asphaltic material.

Largest culvert is 174 in. in diameter and 152 ft long. Nine concrete boxes, 14x14-ft, were installed primarily for local roadways and underpasses; however, in several places, they serve as safety "valves" for storm sewers.

Only portion of the old line to remain in use is a connection between Oroville (or an assembly yard known as Zephyr) and the dam site. This will serve the power house after completion of the dam and after the contractor's removal of all haul roads south or west of Zephyr.

The Oroville line change is one of the largest of its kind in years and the first of any major size on the Western Pacific since the construction of the railroad in the early 1900's. Completion of the $40 million State of California financed project brought to a close some thirteen years of locating, surveying, planning, negotiating, and constructing. ■

WESTERN PACIFIC BALLAST CARS.......

10001-10200	Hart Convertible	Blt 1906	Rodger Ballast Co.
10001-10050	Open-top Ballast	Blt 1970	Darby Corp Jan 87 49 in service
10301-10400	Hart Selective	Blt 1927	AC&F
10401-10500	Hart Selective	Blt 1936	AC&F
10501-10600	Hart Selective	Blt 1937	AC&F
10601-10700	Selective Hopper	Blt 1953	Pullman, 10649 at Portola Jan 87 28 in service
10701-10800	Selective Hopper	Blt 1957	AC&F Jan 87 88 in service