



#4165 passing near Mt. Shasta in Northern California, 1943.

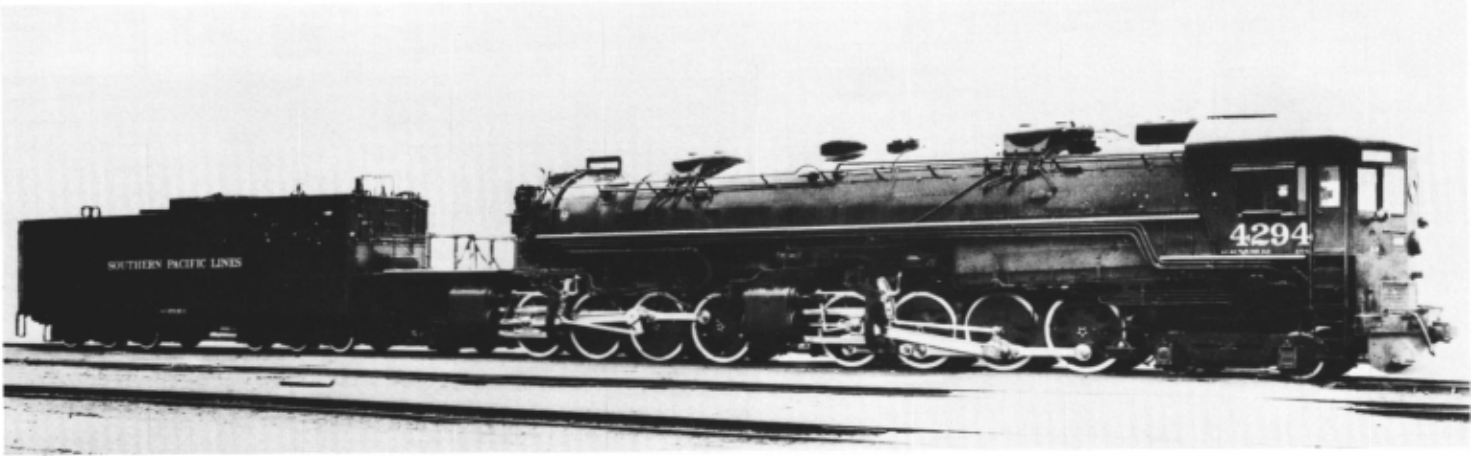
4294 Cab-In-Front Articulated Locomotive



A National Historic Mechanical
Engineering Landmark

The American Society of Mechanical
Engineers • May 7, 1981

California State Railroad Museum
Sacramento, California



Southern Pacific #4294 as photographed in 1944.

Southern Pacific #4294, a 4-8-8-2 cab-in-front articulated locomotive, is the sole surviving steam locomotive of its type. This engine is the culmination of a series of steam locomotive designs and developments that grew out of the ever expanding need for power, speed and tractive effort.

The 4-8-8-2

Some people called the 4-8-8-2s “back-up” locomotives; others called them “cab-in-front.” However, their correct designation was “Articulated-Consolidation” or “A-C” for short. They were numbered from 4100 to 4294.

Southern Pacific was the only major railroad in this country to use steam locomotives with the cab in front. This design concept allowed the engineer and fireman to see further down the track and contributed to greater safety around curves, and through tunnels and snowsheds in the mountains. It also eliminated smoke and heat entering the cab of the engine.

The 4-8-8-2 locomotives were really two engines combined into one. They had one boiler which served two sets of cylinders driving independent groups of wheels. “Consolidation” was the name given the older type of freight locomotive having eight driving wheels.

The 4-8-8-2 locomotives were long, heavy, and the largest, most powerful

locomotives on the Southern Pacific during their time. They were fast—capable of attaining speeds of 70 miles per hour. These locomotives were used to haul heavy freight and passenger trains over the steep grades in the Sierra and Cascade Mountains. On the Overland Route they pulled the *Overland Limited*, *San Francisco Challenger* and *Pacific Limited* up the Sierra.

The Southern Pacific's Roseville—Sparks Sierra Crossing, built initially as a single track railroad in 1869, reached full capacity in 1908. At that time serious consideration had to be given to increasing that capacity.

The 2.3 percent maximum grade in the 87 miles from Roseville to Summit made slow going for both passenger and freight trains. As many as six 2-8-0 or 4-8-0 type locomotives were needed to move a train at 10 mph over the district. These trains had to stop frequently for fuel and water. Upon reaching the summit, the helper locomotives were removed from the train and returned light (without cars attached) to Roseville. This increased the number of individual movements and filled the district to capacity.

A partial solution was to double track the line. Another was to find more powerful locomotives and eliminate the number of helpers needed.

Improving on the design of Anatole Mallet of France, the Baldwin Locomotive Works had improved steam generation and distribution in articulated compound locomotives. Samuel Vauclain of Baldwin developed the compound principle to single coupled locomotives and adapted many of his improvements to the articulated design.

Facts About the #4294 Locomotive

Length of engine and tender: 125 feet, 6 inches.

Weight of engine and tender loaded: 1,046,900 pounds.

Horse power: 6,000. Tractive power: 124,300 pounds.

Size of 4 cylinders: diameter 24 inches; stroke 32 inches.

Boiler pressure: 250 pounds. Diameter of drivers: 63 inches.

Baldwin suggested using 2-8-8-2 compound articulated locomotive weighing 394, 150 pounds on 57-inch driving wheels to help meet the Southern Pacific's need. Two 26-inch H.P. (high pressure) cylinders would receive steam directly from the throttle and exhaust into two L.P. (low pressure) 40-inch with 30-inch stroke. Boiler pressure was 200 pounds and the locomotives would exert 94,880 pounds tractive effort.

Physical conditions of the original construction of the railroad restricted the dimensional freedom of the design. This was to plague the designers of the subsequent articulated locomotives through the end of steam.

Two locomotives, delivered in 1909 (Numbers 4000 and 4001), were classed MC 1. Four sisters were delivered to

Union Pacific properties in Oregon and Idaho.

Functionally the new locomotives lived up to, and in many cases exceeded, expectations. They handled 1,200 tons at 10 mph with substantial savings in fuel and water.

Problems arose, however, from extended operation in tunnels and the nearly 30 miles of snowsheds. Exhaust temperatures, which approached 750 degrees, combined with combustion gases to make the cabs all but uninhabitable. To aid breathing under these conditions, aspirators were installed in the cabs to draw air from the air brake system. While furnishing a form of air to assist breathing, this did nothing to relieve the intense heat. Engine crews began to resist assignment to trains

powered by the two mallets.

Many legends and secondhand stories abound regarding the solution of the problem. Several tests were made backing the locomotives with the tender running first. This proved to be unsatisfactory, so the daring decision was made to turn the locomotive around and run with the cab in front. The tender was trailed from the L.P. engine.

Fifteen locomotives of the new design were ordered from Baldwin for delivery late in 1909. They followed the basic specifications of the original locomotives, but were slightly heavier. They solved the habitability problem with the additional benefit of an unobstructed view of the track. Some problems were experienced in the delivery of fuel to the firebox. Southern Pacific was a pioneer in the use

Locomotive Shop at Sparks, Nevada in 1944.





of oil for fuel and did not have to solve burner problems having used the flat burners since the conversion to oil for the entire locomotive fleet in 1907. To help solve the problem, a pump was placed in the fuel line to the burner. Later it was found by pressurizing the oil compartment to 5 pounds psi in the tender, the pump could be eliminated. The success of the 15 MC 2 class locomotives prompted orders to be placed for 12 more in 1912 which were classed MC 4. Additionally, 12 locomotives of the 2-6-6-2 wheel arrangement were ordered for use on passenger trains. Like the MC 1 and 2 classes, they also were equipped with separable boilers, walshaert valve gear, and 25-inch and 38-inch cylinders with 28-inch stroke. The weight was 320,000 pounds on 63-inch drivers. Boiler pressure was 200 pounds and they developed 65,920 pounds of tractive effort. Equipped with whale back tenders of Southern Pacific design, they had greater fuel and water capacity than the square tenders on the MCs.



Tracking problems and excessive overhang in the front of the locomotives brought about their conversion to 4-6-6-2 wheel arrangement by placement of a four wheel truck under the fire box and redesigning the front frame structure. Their performance eliminated the use of helpers on the average passenger train and expedited schedules.

Twenty more 2-8-8-2s were ordered in 1912. Classed MC 6 they were similar to the original locomotives and brought the total units in service at Roseville to 46. The two original conventional locomotives had been sent to Southern California for use on Beaumont Hill.

Southern Pacific's first cab-in-front (top) shows the original compound articulated engine after cylinder conversion to single expansion H.P. #4034 (above) was one of the first Mallet consolidated (double expansion) cab-in-front engines. #4272 (below) shows the latest configuration.





#4170, being used as a mid-train helper near Colfax, California, was one of the first series built for H.P. only.

By 1917 competitive pressures dictated faster freight schedules that could not be met with the slow moving compound articulated locomotives. Eleven 2-10-2 type single expansion locomotives were ordered from American Locomotive Company and placed in service in Roseville. So successful were these locomotives that 159 more units were ordered through 1924 and in 1925 the 4-10-2 type was added. The rigid wheel base of these units increased rail wear and general track maintenance costs.

A reappraisal of articulated locomotives was made. In 1922 Baldwin Locomotive Works delivered a series of simple H.P. 2-8-8-2 conventional cab locomotives to the Chesapeake and Ohio Railroad which proved that increased speeds and tractive effort could be obtained with articulated locomotives.

Southern Pacific's Motive Power Department studied the possibility of converting the Mallets to simple locomotives with the additional benefit of their flexibility and short fixed wheelbase. (Simple locomotives had high pressure cylinders only.)

Locomotive 4041 was taken into the shops at Sacramento in 1927 for the conversion. The L.P. cylinders were replaced with 22-inch cylinders and the original H.P. 26-inch cylinders were bushed to 22 inches. The boiler pressure was increased to 210 pounds; tractive effort to 90,940 pounds. Tests showed the 4041 could handle the same tonnage as the 4-10-2s at 15 mph—an increase

of 50 percent. Plans were then made to convert all the Mallets to simple. This then led to the ultimate design of the 4-8-8-2 types.

State-of-the-art techniques and appliances were incorporated in the design of the new locomotives. Assembled cast steel frames, cast steel cylinder blocks, front end throttles, E type superheaters, BL feedwater heaters, Nathan forced feed lubricators and many other devices proved in use on the 2-10-2, 4-10-2 and 4-8-2 types designed, built and placed in service during the 1920s. Lateral motion boxes were applied to the fourth and fifth axles, flange lubricators, water tire coolers and clips were applied for use during periods of heavy braking.

The redesigned boiler was to become the standard for the subsequent 195 locomotives in eight classes. The first two classes, AC 4 and AC 5 (numbered 4100-4109, 4110-4125), carried 235 pounds boiler pressure. Beginning with the AC 6 class, the boiler pressure was raised to 250 pounds and allowed the tractive effort to be raised to 124,300 pounds from 116,900 pounds.

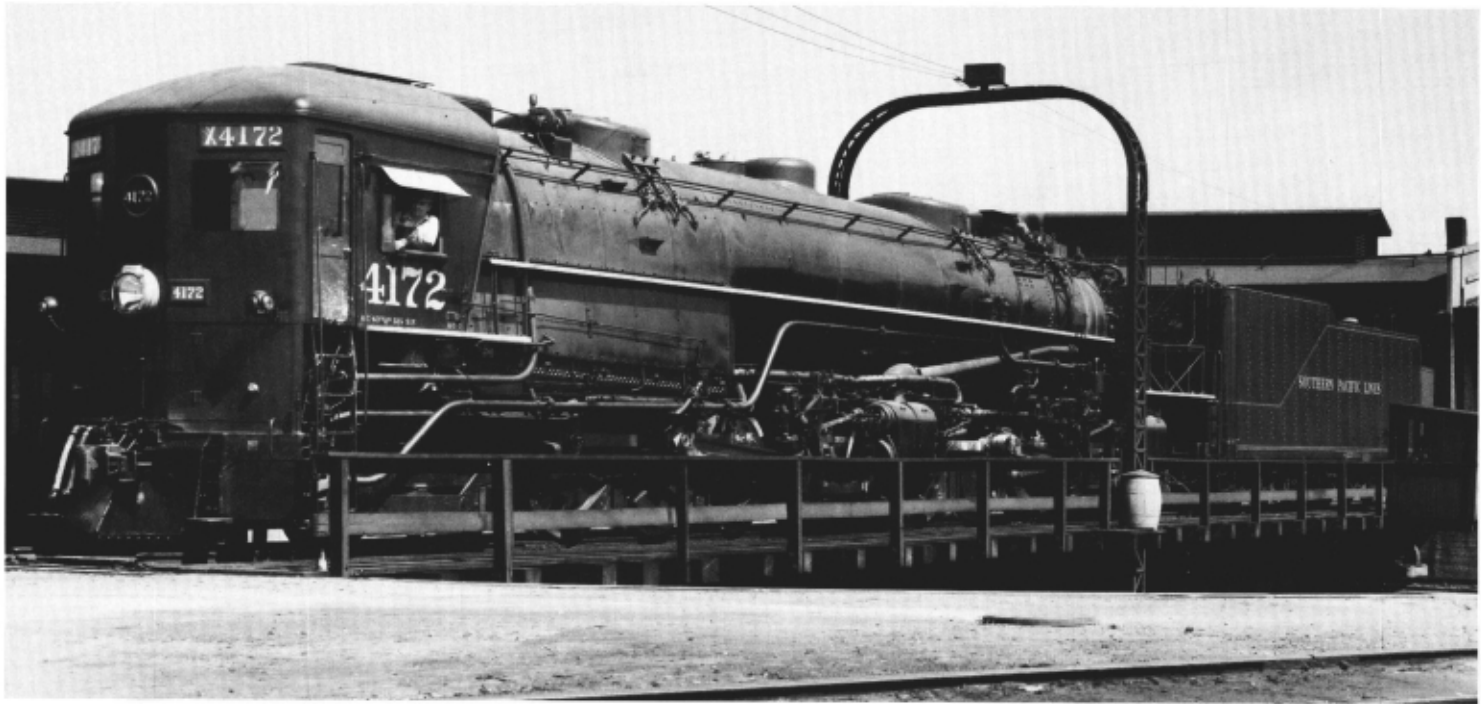
With the AC 6 class in service by 1931, the 10 coupled locomotives were reassigned to other parts of the system. Although the new locomotives were larger and heavier, their flexibility reduced track wear and the ACs were to reign supreme in the Sierra until displaced by diesels in the 1950s.

Beginning with the AC 7 class in 1937, integral cast steel frames were used. The

cylinders and end beams were cast in one piece with the frame, thus reducing frame maintenance costs. The use of Box-Pok disc driver allowed cross balancing and made the top speed of the locomotives around 65 mph. Earlier some of the AC 4 and 5 classes were assigned to dual service between Los Angeles and Bakersfield. The greater speed allowed the locomotives to be used in both passenger and freight service throughout the lines west of El Paso, although the heaviest concentration was always at Roseville.

Visually, the remaining classes were the same with a few minor differences. The wedge-shaped cab gave a semi-streamlined look as opposed to the flat faces of the previous classes. Continued improvement of appliances were made to all classes as they became available including continued improvement in oil burner design. All of these locomotives were equipped with friction bearings and lubricated by the patented spring pad lubricators. Large rectangular tenders were fitted to these locomotives having a capacity of 6,100 gallons of oil and 22,000 gallons of water. The AC 12s (# 4294) weighed 658,000 pounds in working order. The tenders weighed 198,000 pounds (388,900 pounds fully loaded).

The last year of operation for these giants was 1956. The last cab-in-front to operate was the # 4274 during the weekend of November 30, and December 1. A farewell excursion over



#4172 on the turntable at Roseville, 1937.

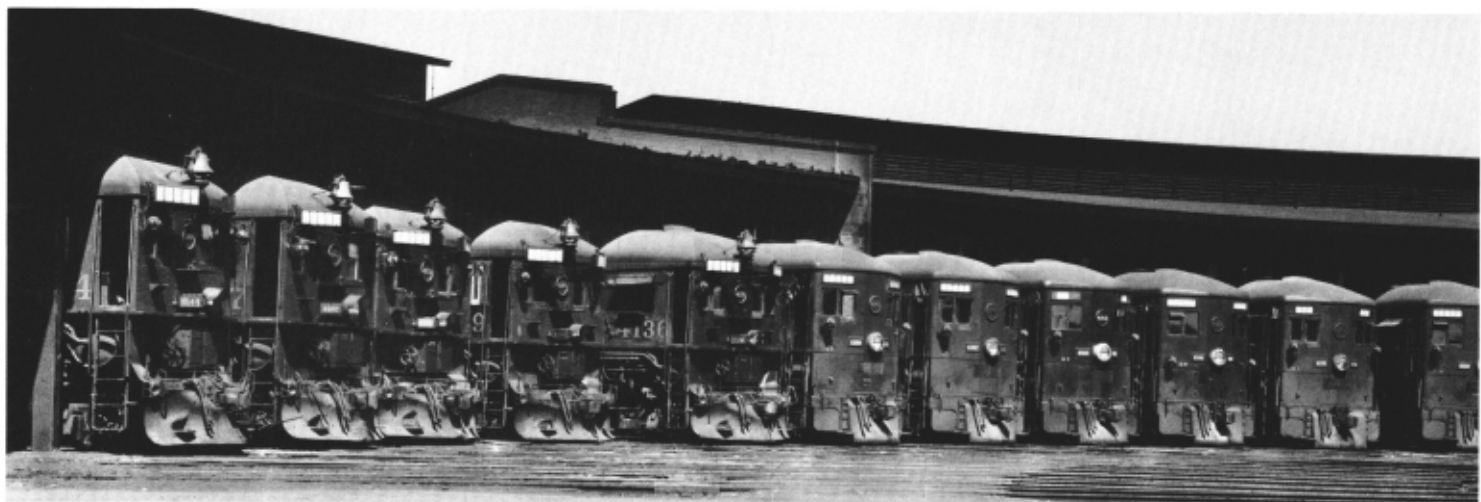
the Sierra was sponsored by a rail enthusiast group.

The #4294 had been removed from service prior to this time. Fred A. Stindt of the Pacific Coast Chapter, Railway & Locomotive Historical Society solicited support from Southern Pacific and civic groups to save the last of these unique machines.

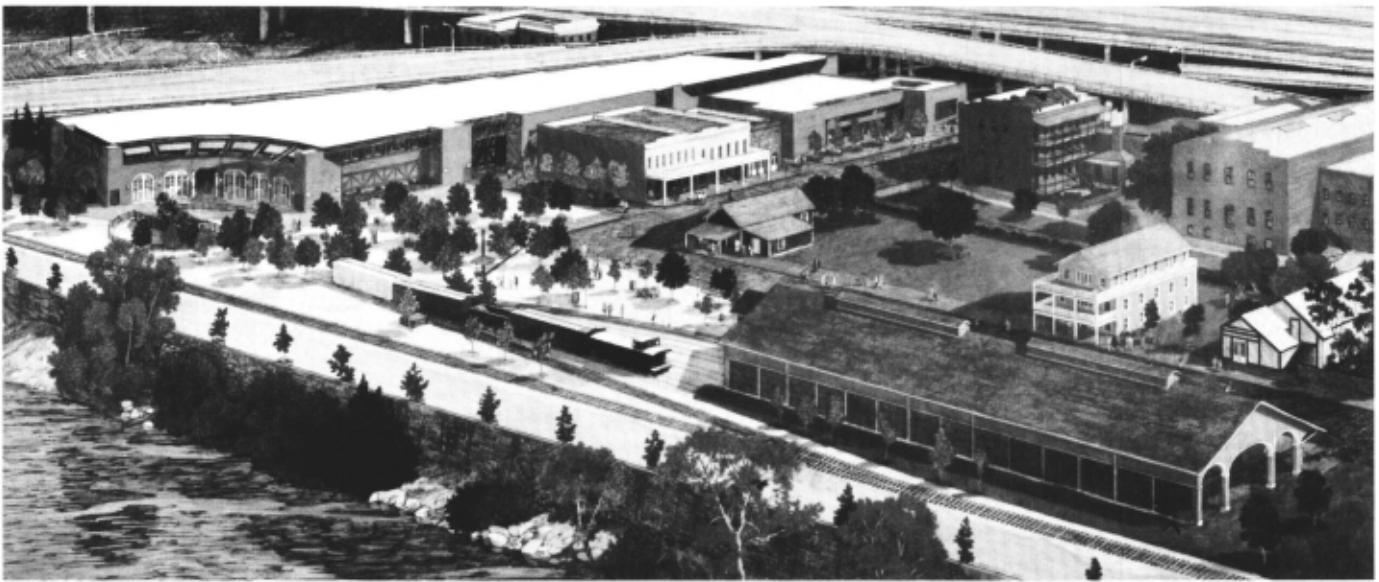
On October 19, 1958, #4294 was presented to the City of Sacramento and

placed on display next to Southern Pacific's first locomotive, "C. P. Huntington." Freeway construction forced the removal of # 4294 to storage at Southern Pacific shop facilities at Sacramento. The locomotive was later given to the State of California by the City for restoration and display in the California State Railroad Museum where it again joins the "C. P. Huntington" in an impressive display of the development of the steam locomotive in the West.

The foregoing historic development was made possible through the effort of many dedicated mechanical engineers who designed, calculated and documented the myriad details that are involved in the construction and manufacture of small and large machinery. The American Society of Mechanical Engineers is proud to acknowledge this silent partnership in the success of these behemoths of the rails.



Cab-in-fronts at the roundhouse in Roseville, 1937.



The California State Railroad Museum occupies a block-long site along the Sacramento River in Old Sacramento. #4294 is displayed in the Museum of Railroad History (upper left). The Central Pacific passenger station is shown at the lower right.

The California State Railroad Museum: The #4294's New Home

The new Museum of Railroad History is the largest and most complex phase of the California State Railroad Museum. Located in Old Sacramento State Historic Park, it was built under the direction of the California Department of Parks and Recreation.

The Museum is the largest of its kind in the world. It houses 22 pieces of historic railroad rolling stock, hundreds of authentic artifacts of railroad history and folklore, and many thrilling exhibits and displays.

The first phase of the Museum, opened four years ago, was the reconstruction of the Central Pacific passenger station on a block-long site along the Sacramento River.

Second phase was the completion of the Big Four Building—formerly the Huntington-Hopkins Hardware Store and the Stanford Brothers Dry Goods

Store. The building houses the Museum's administrative offices, flexible exhibit space and one of the most extensive reference libraries of railroadiana in existence. The building also contains the Big Four conference room and the office of the Central Pacific Railroad where the idea of the transcontinental railroad was proposed.

Largest phase, just completed, is the three-story Museum of Railroad History, built on a five acre site that houses restored locomotives and cars, and 40 interpretive exhibits dealing with railroads and their impact upon the nation

John H. White, Jr., chairman of the Department of Industries at the Smithsonian Institution, has described the Museum's railroad equipment as "one of the great collections in the United States."

ACKNOWLEDGEMENTS

The Rail Transportation Division of The American Society of Mechanical Engineers gratefully acknowledges the efforts of all who cooperated on the landmark designation of the #4294 Cab-in-Front locomotive. A special thank you is extended to the California State Railroad Museum, Southern Pacific Transportation Company, and the Pacific Coast Chapter of the Railroad & Locomotive Historical Society for their assistance.

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The #4294 Cab-In-Front Locomotive is the 59th National Landmark designated by the Society. For a complete listing of Landmarks, please contact the Public Information Department, ASME, 345 E. 47th St., New York, NY 10017 212/644-7740.

This brochure was produced with the assistance of Mr. Brian Thompson, author-historian and vice chairman, Pacific Coast Chapter of the Railway & Locomotive Historical Society.