Carolina Conductor

Volume 7 Number 7 — Monthly Newsletter of the Carolina Railroad Heritage Association, Inc. — © July 2020

Preserving the Past
Active in the Present
Planning for the Future

Web Site: hubcityrrmuseum.org
Facebook: Carolina Railroad Heritage Association & Hub City RR Museum

Meeting Site:
Woodmen of the World Bldg.
721 East Poinsett Street
Greer, SC 29651-6404
Third Friday of the Month at 7:00 pm

Hub City Railroad Museum and SOU Rwy Caboose #X3115:
Spartanburg Amtrak Station
298 Magnolia Street
Spartanburg, SC 29301-2330
Wednesday 10-2 and Saturday 10-2

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Articles can be submitted anytime.

Steam Turbine Locomotives

A steam turbine locomotive is a steam locomotive which transmits steam power to the wheels via a steam turbine. Numerous attempts at this type of locomotive were made, mostly without success. In the 1930s this type of locomotive was a way both to revitalize steam power and challenge the diesel locomotives then being introduced.

Advantages

High efficiency at high speed. Far fewer moving parts, hence potentially greater reliability.

Conventional piston steam locomotives give a varying, sinusoidal torque, making wheel slip much more likely when starting.

The side rods and valve gear of conventional steam locomotives create horizontal forces that cannot be fully balanced without substantially increasing the vertical forces on the track, known as hammer blow.

Disadvantages

High efficiency is ordinarily obtained *only* at high speed (though some Swedish and UK locomotives were designed and built to operate with an efficiency equal to or better than that of piston engines under customary operating conditions).

Peak efficiency can be reached only if the turbine exhausts into a near vacuum, generated by a surface condenser. These devices are heavy and cumbersome.

Turbines can rotate in only one direction. A reverse turbine must also be fitted for a direct-drive steam turbine locomotive to be able to move backwards.

Drive Methods

There are two ways to drive the wheels: either directly via gears or using generator-driven traction motors.

Direct Drive

Baldwin Locomotive Works

In the waning years of steam, the Baldwin Locomotive Works undertook several attempts at alternative technologies to diesel power. In 1944, Baldwin built the sole example of the S2 class, c/n 70900, for the Pennsylvania Railroad, delivering it in September 1944.

It was the largest direct-drive steam turbine locomotive in the world and had a 6-8-6 wheel arrangement. It was originally designed as a 4-8-4, but due to shortages of lightweight materials during World War II, the S2 required additional leading and trailing wheels.

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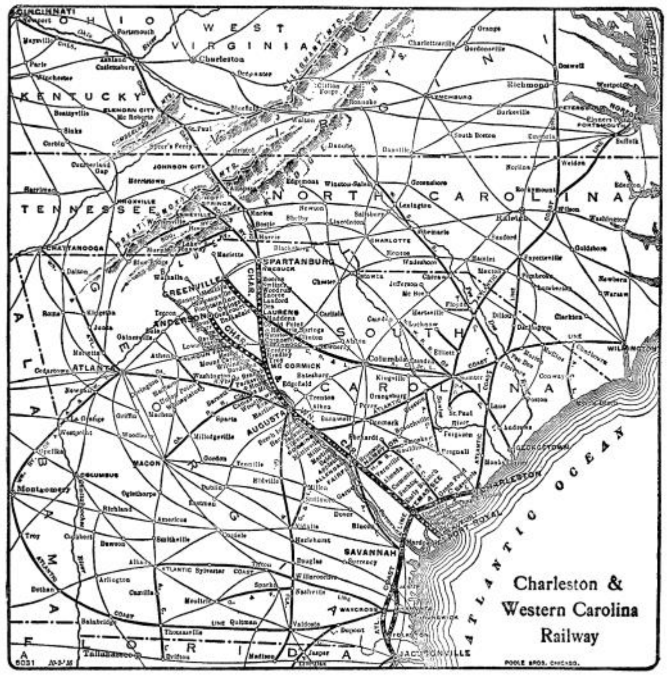
President's Message

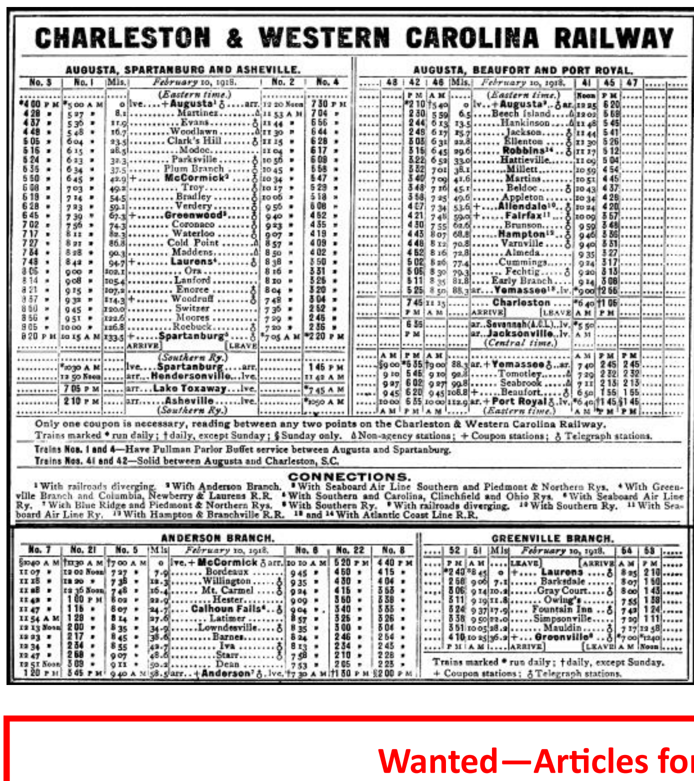
If you have not responded to the member survey regarding our meeting night, please do so by the end of the month.

The annual photo contest was cancelled due to a lack of participation. Only two entries were received.

C&WC Depot Greenville, SC



Charleston & Western Carolina Railway



CHARLESTON & WESTERN CAROLINA RAILWAY

AUGUSTA, SPARTANBURG AND ASHEVILLE. — February 10, 1918. (Eastern time.)

AUGUSTA, BEAUFORT AND PORT ROYAL. — February 10, 1918. (Eastern time.)

Only one coupon is necessary, reading between any two points on the Charleston & Western Carolina Railway.
Trains marked * run daily; † daily, except Sunday; § Sunday only. Δ Non-agency stations; + Coupon stations; ♁ Telegraph stations.

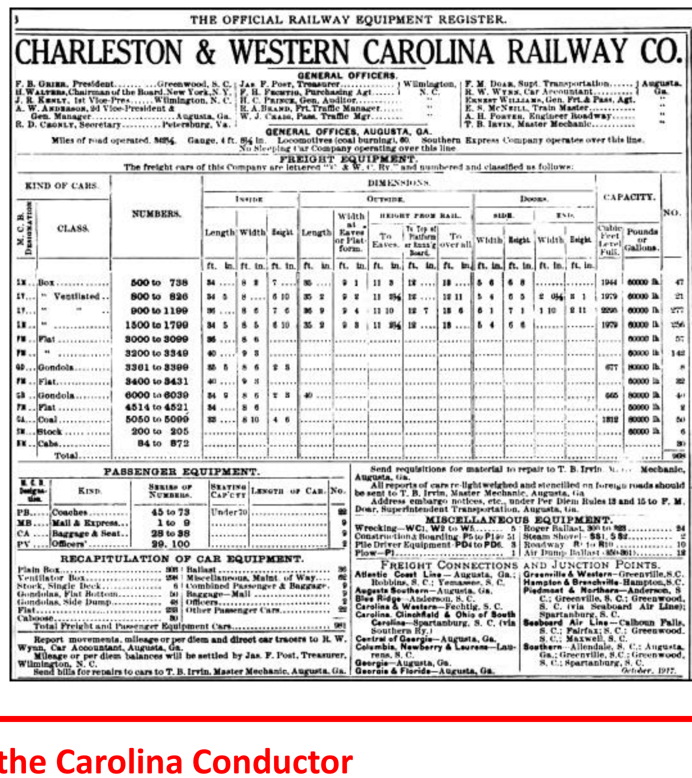
Trains Nos. 1 and 4—Have Pullman Parlor Buffet service between Augusta and Spartanburg.
Trains Nos. 41 and 42—Solid between Augusta and Charleston, S.C.

CONNECTIONS.
[1] With railroads diverging. [2] With Anderson Branch. [3] With Seaboard Air Line Southern and Piedmont & Northern Rys. [4] With Greenville Branch and Columbia, Newberry & Laurens R.R. [5] With Southern and Carolina, Clinchfield and Ohio Rys. [6] With Seaboard Air Line Ry. [7] With Blue Ridge and Piedmont & Northern Rys. [8] With Southern Ry. [9] With railroads diverging. [10] With Southern Ry. [11] With Seaboard Air Line Ry. [12] With Hampton & Branchville R.R. [13] and [14] With Atlantic Coast Line R.R.

ANDERSON BRANCH. — February 10, 1918.

GREENVILLE BRANCH. — February 10, 1918.

Trains marked * run daily; † daily, except Sunday. + Coupon stations; ♁ Telegraph stations.



THE OFFICIAL RAILWAY EQUIPMENT REGISTER.

CHARLESTON & WESTERN CAROLINA RAILWAY CO.

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FREIGHT EQUIPMENT.
The freight cars of this Company are lettered "C. & W. C. Ry." and numbered and classified as follows:

PASSENGER EQUIPMENT.

RECAPITULATION OF CAR EQUIPMENT.

MISCELLANEOUS EQUIPMENT.

FREIGHT CONNECTIONS AND JUNCTION POINTS.

Wanted—Articles for the Carolina Conductor

Submit an article of 200 words or more with some photos and captions and see them in print. Every one of us has some unique railroad experience that would make interesting reading for our membership. Your editor always needs more contributions of local railway history and news.

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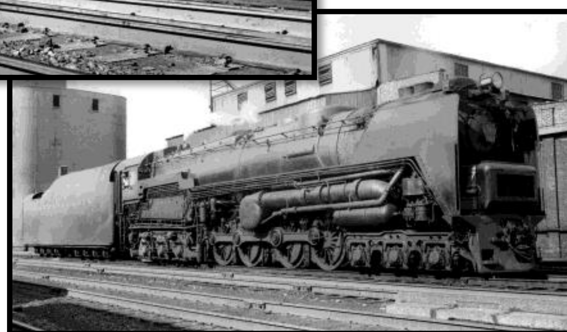

The PRR #6200 6-8-6 direct drive steam turbine locomotive was a one-of-a-kind and even sprouted "elephant ears" at one point.

Numbered 6200 on the PRR roster, the S2 had a maximum power output of 6,900 HP and was capable of speeds over 100 mph. With the tender, the unit was approximately 123 feet long. The steam turbine was a modified marine unit. While the gearing system was simpler than a generator, it had a fatal flaw: the turbine was inefficient at slow speeds. Below about 40 mph the turbine used enormous amounts of steam and fuel. At high speeds, however, the S2 could propel heavy trains almost effortlessly and efficiently. The smooth turbine drive put far less stress on the track than a normal piston-driven locomotive. However, poor efficiency at slow speeds doomed this turbine, and with diesel-electrics being introduced, no more S2s were built. The locomotive was retired in 1949 and scrapped in May 1952.

Electric Transmission
Union Pacific Railroad

General Electric built two steam turbine-electric locomotives with a 2+C-C+2 wheel arrangement for the Union Pacific Railroad in 1938. These locomotives essentially operated as mobile steam power plants and were correspondingly complex. They were the only condensing steam locomotives ever used in the United States. A Babcock & Wilcox boiler provided steam, which drove a pair of steam turbines which powered a generator, providing power to the electric traction motors that drove the wheels, as well as providing head-end power for the rest of the train. Boiler control was largely automatic, and the two locomotives could be connected into a *multiple unit*, both controlled from a single cab.

Photo of the Union Pacific GE steam turbine locomotives, April 1939. Photo at right shows the loco with an unusual dark paint scheme.

The boiler was oil-fired, and the fuel was "Bunker C" heavy fuel oil, the same fuel used in large vessels, and the fuel which was later used in Union Pacific's gas turbine-electric locomotives. Union Pacific accepted the locomotives in 1939, but returned them later that year, citing unsatisfactory results. The GE turbines were used during a motive power shortage on the Great Northern Railway in 1943 and appear to have performed quite well. However, by the end of 1943, the wheels of both locomotives were worn to the point of needing replacement, and one of the locomotive's boilers developed a defect. The locomotives were returned to GE and dismantled.

C&O Railway

In 1947–1948 Baldwin built three unusual coal-fired steam turbine-electric locomotives for passenger trains on the Chesapeake and Ohio Railway (C&O). Their designation was M1, but because of their ex-

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The C&O M1s numbers 500-502 were called "Sacred Cows" due to their poor performance.

pense and poor performance they acquired the nickname "Sacred Cow". The 6,000 horsepower units, which had Westinghouse electrical systems, had a 2-C1+2-C1-B wheel arrangement. They were 106 feet long. The cab was in the center with a coal bunker ahead of it and a backwards-mounted conventional boiler behind it (the tender only carried water).

These locomotives were intended for a route from Washington, D.C. to Cincinnati, Ohio but could never travel the whole route without some sort of failure. Coal dust and water frequently got into the traction motors. While these problems could have been fixed given time, it was obvious that these locomotives would always be expensive to maintain and all three were scrapped in 1950.

Norfolk & Western Railway

In May 1954 Baldwin built a 4,500 horsepower steam turbine-electric locomotive for freight service on the Norfolk and Western Railway, nicknamed the *Jawn Henry* after the legend of John Henry, a rock driller who famously raced against a steam drill and won, only to die immediately after. Length including tender was 161 ft 1-1/2 inches, probably the record for a steam locomotive; engine-only length was 111 ft 7-1/2 inches, perhaps the record for any single unit.

The unit looked like the C&O turbines but differed mechanically; it was a C+C-C+C with a Babcock & Wilcox water-tube boiler with automatic controls. The boiler controls were sometimes problematic, and coal dust and water got into the motors. The *Jawn Henry* was retired from the N&W roster on January 4, 1958.

The N&W "Jawn Henry" was a 4500hp brute. It totaled over 111 feet long. Seen with #611 the extreme length is obvious.

Gas Turbine Locomotives

A gas turbine locomotive is a type of railway locomotive in which the prime mover is a gas turbine. Several types of gas turbine locomotives have been developed, differing mainly in the means by which mechanical power is conveyed to the driving wheels. A gas turbine train typically consists of two power cars (one at each end of the train), and one or more intermediate passenger cars.

A gas turbine offers some advantages over a piston engine. There are few moving parts, decreasing the need for lubrication and potentially reducing maintenance costs, and the power-to-weight ratio is much higher. A turbine of a given power output is also physically smaller than an equally powerful piston engine, so that a locomotive can be extremely powerful without needing to be inordinately large.

However, a gas turbine's power output and efficiency both drop dramatically with rotational speed, unlike a piston engine, which has a comparatively flat power curve. Additional problems with gas turbine-electric locomotives include the fact that they are very noisy and produce such extremely hot exhaust gasses that, if the locomotive were parked under an overpass paved with asphalt, it could melt the asphalt.

Unlike steam engines, internal combustion engines require a transmission to power the wheels. The engine must be allowed to continue running when the locomotive is stopped.

Early Developments

A gas turbine locomotive was patented in 1861 by Marc Antoine Francois Mennons (British patent no. 1633). The drawings in Mennons' patent show a locomotive of 0-4-2 wheel arrangement with a cylindrical casing resembling a boiler. At the front of the casing is the compressor, which Mennons calls a ventilator. This supplies air to a firebox and the hot gases from the firebox drive a turbine at the back of the casing.

The exhaust from the turbine then travels forwards through ducts to preheat the incoming air. The turbine drives the compressor through gearing and an external shaft. There is additional gearing to a jackshaft which drives the wheels through side rods. The fuel is solid (presumably coal, coke or wood) and there is a fuel bunker at the rear. There is no evidence that the locomotive was built but the design includes the essential features of gas turbine locomotives built in the 20th century, including compressor, combustion chamber, turbine and air pre-heater.

Work leading to the emergence of the gas turbine locomotive began in France and Sweden in the 1920s but the first locomotive did not appear until the 1940s. High fuel consumption was a major factor in the decline of conventional gas-turbine locomotives and the use of a piston engine as a gas generator would probably give better fuel economy than a turbine-type compressor, especially when running at less than full load.

One option is a two-shaft machine, with separate turbines to drive the compressor and the output shaft. Another is to use a separate gas generator, which may be of either rotary or piston type.

Early General Electric Gas Turbine built for the Union Pacific.

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Gas Turbine-Mechanical

Gas turbine-mechanical locomotives use a mechanical transmission to deliver the power output of gas turbines to the wheels. Owing to the difference in their speeds, this is technically challenging and so a mechanical transmission did not appear until ten years after the first electric transmissions.

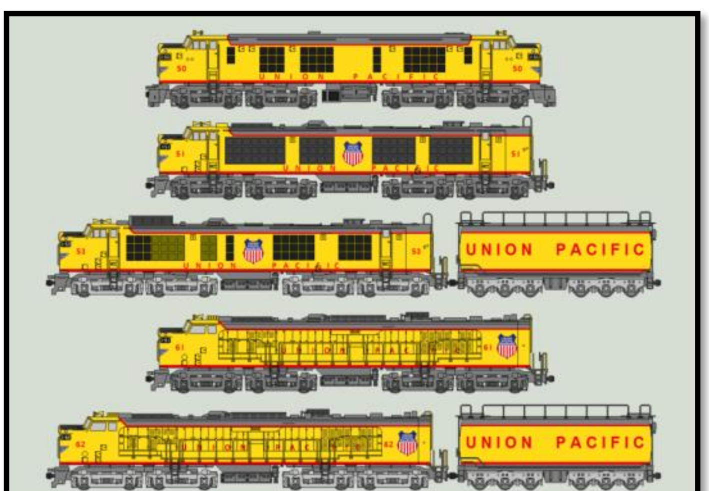
A gas turbine-electric locomotive (GTEL) is a locomotive that uses a gas turbine to drive an electric generator or alternator. The electric current thus produced is used to power traction motors. This type of locomotive was first experimented with during the Second World War but reached its peak in the 1950s to 1960s. Few locomotives use this system today.

A GTEL uses a turbo-electric drivetrain in which a turboshaft engine drives an electrical generator or alternator via a system of gears. The electrical power is distributed to power the traction motors that drive the locomotive. In overall terms the system is very similar to a conventional diesel-electric, with the large diesel engine replaced with a smaller gas turbine of similar power.

Union Pacific operated the largest fleet of such locomotives of any railroad in the world and was the only railroad to use them for hauling freight. Most other GTELs have been built for small passenger trains, and only a few have seen any real success in that role. With a rise in fuel costs, gas turbine locomotives became uneconomical to operate, and many were taken out of service. Additionally, Union Pacific's locomotives required more maintenance than originally anticipated, due to fouling of the turbine blades by the Bunker C oil used as fuel.

ALCO-GE built a prototype oil-fired gas turbine-electric locomotive in 1948, with a B-B-B-B wheel arrangement. After demonstration runs it was acquired by Union Pacific, who were seeking a more powerful alternative to diesel for transcontinental trains.

From January 1952 to August 1953, UP received units 51-60, like the prototype but with a cab at only one end to increase fuel capacity. Each cost US$540,000.



Different models of the turbine locomotives of the UP.

UP ran a fleet of 55 turbine-powered freight locomotives starting in the early 1950s, all produced by Alco-GE. The first- and second-generation versions shared the same wheel arrangement as the prototype; the third-generation version were C-C types. All were widely used on long-haul routes, and were cost-effective despite their poor fuel economy, due to their use of "leftover" fuels from the petroleum industry. At their height the railroad estimated that they powered about 10% of Union Pacific's freight trains, a much wider use than any other example of this class. As other uses were found for these heavier petroleum byproducts, notably for plastics, the cost of the Bunker C fuel increased until the units became too expensive to operate and they were retired from service by 1969.

In April 1950, Baldwin and Westinghouse completed an experimental 4,000 hp turbine locomotive, #4000, known as the *Blue Goose*, also using the B-B-B-B wheel arrangement. The locomotive used two 2,000 hp turbine engines, was equipped for passenger train heating with a steam generator that utilized the waste exhaust heat of the right-hand turbine and was geared for 100 miles per hour. While it was demon-

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strated successfully in both freight and passenger service on the PRR, MKT, and CNW, no production orders followed, and it was scrapped

Westinghouse-Baldwin **No. 4000 was an experimental 4,000-hp B-B-B-B demonstrator locomotive built in 1950.**

The United Aircraft Corp. built one of the first gas turbine powered trains to enter service for passenger service.

in 1953.

In the 1960s United Aircraft built the Turbo passenger train, which was tested by the Pennsylvania Railroad and later used by Amtrak and Via Rail. The Via remained in service into the 1980s and had an excellent maintenance record during this period but was eventually replaced by the LRC in 1982. Amtrak purchased two different types of turbine-powered trainsets, which were both called Turboliners. The sets of the first type were similar in appearance to SNCF's T 2000 Turbotrain, though compliance with FRA safety regulations made them heavier and slower than the French trains. None of the first type Turboliners remain in service. Amtrak also added several similarly named Rohr Turboliners (RTL) to its roster. There were plans to rebuild these as RTL IIIs, but this program was cancelled. The units owned by New York State were sold for scrap and the three remaining RTL trainsets are stored at Bear and at North Brunswick, New Jersey.

In 1966, the Long Island Rail Road tested an experimental gas turbine railcar powered by two Garrett turbine engines. This car was based on a Budd Pioneer III design, with transmissions like Budd's 1950s-era RDCs. The car was later modified to add the ability to run on electric third rail as well.

In 1977, the LIRR tested eight more gas turbine-electric/electric dual mode railcars, in an experiment sponsored by the USDOT. Four of these cars had GE-designed powertrains, while the other four had powertrains designed by Garrett (four more cars had been ordered with GM/Allison powertrains, but were canceled). These cars were like LIRR's M1 EMU cars in appearance, with the addition of step wells for loading from low level platforms. The cars suffered from poor fuel economy and mechanical problems and were withdrawn from service after a short period of time. The four GE-powered cars were converted to M1 EMUs and the Garrett cars were scrapped.

In 1997 the Federal Railroad Administration solicited proposals to develop high speed locomotives for routes outside the Northeast Corri-

The RTG (from the French *Rame à Turbine à Gaz*, or gas turbine train) model was an Americanized version of the French ANF T 2000 RTG Turbotrain.

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dor where electrification was not economical. Bombardier Ltd, at the Plattsburg, N.Y. plant where the Acela was produced, developed a prototype which combined a Pratt & Whitney Canada PW100 gas turbine and a diesel engine with a single gearbox powering four traction motors identical to those in Acela. The diesel provided head end power and low speed traction, with the turbine not being started until after leaving stations. The prototype was completed in June 2000, and safety testing was done at the FRA's Pueblo, CO test track beginning in the summer of 2001. A maximum speed of 156 miles per hour was reached. The prototype was then taken on a tour of potential sites for high speed service, but no service has yet begun.

Amtrak model RTL turbo liner manufactured by Rohr Industries.

Coal-Firing

In the 1940s and 1950s research was conducted and aimed at building gas turbine locomotives that could run on pulverized coal. The main problem was to avoid erosion of the turbine blades by particles of ash. Only one working example is known to have been produced and it was written off as a failure following testing.

In 1946, a Northrop-Hendy partnership launched an attempt to adapt the Northrop Turbodyne aircraft engine for locomotive use, with coal dust rather than kerosene as a fuel. In December 1946, Union Pacific donated their retired M-10002 streamliner locomotive to the project. However, the project was abandoned by the end of 1947 and there is no clear evidence that the locomotive provided for the experiment ever actually moved under gas turbine power or even had it installed. Details of the research were passed to Britain's London, Midland and Scottish Railway. Following a rise in fuel prices that was making their oil-fired GTELS uneconomic, UP experimentally revived the coal-fired gas turbine idea in the early 1960s, producing one prototype coal GTEL in October 1962. The problems with blade fouling and erosion were severe. The project was declared a failure after 20 months, during which time the locomotive ran less than 10,000 miles.

After Union Pacific expressed interest, GE built a prototype, GE 101, completed in November 1948. After tests in the Northeast during June 1949, it was re-lettered for UP #80.