

# N&W 611. CLASS J. STEAM LOCOMOTIVE

## NATIONAL HISTORIC MECHANICAL ENGINEERING LANDMARK

MAY 1984



THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS



## INTRODUCTION

The 611 is the sole survivor of fourteen class“J” steam locomotives designed by Norfolk and Western Railway mechanical engineers in 1940. These locomotives were built in the N&W Roanoke, Virginia shops between 1941 and 1950. For 18 years the“Js” pulled the *Powhatan Arrow*,

*Pocahontas* and *Cavalier* through Roanoke on their daily 680-mile runs between Norfolk, Virginia and Cincinnati, Ohio. They also ran on the N&W portion of the joint N&W and Southern Railway routes, pulling the *Pelican*, the *Birmingham Special* and the *Tennessean* that operated between Washington, D.C. and southern cities.

Several of the“Js” ran almost 3 million miles each before retirement. Their superb performance and reliability allowed them to operate 15,000 miles per month, even on the relatively short, mountainous N&W routes. This success delayed the day when progress, in the form of the diesel electric locomotive, inevitably would prevail.

The 611 was placed in service on May 29, 1950 at a final cost of \$251,544. Six years later, on January 23, 1956, while traveling westward with the *Pocahontas*, the 611 derailed on a wide curve near Cedar, West Virginia and almost fell into the Tug river. As a result of the extensive repairs made necessary by the accident, the 611 was in good condition when the“Js” were retired in January 1959. A request by the Roanoke Chapter of the National Railway Historical Society to operate a passenger excursion later that year led the N&W to pull the 611 out of a group of“Js” destined for the scrap yards at Portsmouth, Ohio. After completing the excursion

between Bluefield, West Virginia and Roanoke in October, 1959, the 611 was donated to the City of Roanoke’s Transportation Museum, the present owner. In 1981, N&W towed the 611 from the museum to the Southern Railway’s Norris Yard steam shop at Birmingham, Alabama to be rebuilt. Restored to mint condition, the 611 steamed into Roanoke in August, 1982 with N&W Chairman Robert Claytor at the throttle. The rebuilding of the“J” was a gift from the N&W to the City of Roanoke in honor of the City’s 100th birthday.

To the delight of railfans nationwide, the 611 now pulls special excursion trains, recalling grand memories of our nation’s era of steam rail passenger service. The 611 has taken her enthusiastic entourage to such distant cities as Birmingham, Atlanta, Chicago, Columbus, and St. Louis, with practically every weekend booked from spring through fall.

The 611 is an operating example of the highest achievements in steam locomotive engineering and as an ASME National Historic Mechanical Engineering Landmark commemorates the efforts of engineers and craftsmen in a colorful and vital period in our transportation history.

On the cover: The 611 picks up speed leaving Reidsville, North Carolina, on August 22, 1982, with N&W chairman Robert Claytor at the controls. This was the final leg of the three day return trip to Roanoke after reconstruction.  
*Photo by Jim King.*

Back cover: Train No. 25 in the Shenandoah Valley near Roanoke in 1958. No. 25 was the “Powhatan Arrow,” an all coach luxury train that operated in each direction daily between Norfolk, Va. and Cincinnati, Ohio.  
*Photo from N-S files.*





## DESIGN

The “J” is the most advanced and most powerful 4-8-4 passenger locomotive ever built in terms of actual drawbar horsepower at speeds up to 50 MPH. Built during an age when other lines were abandoning steam for diesels, many design features incorporated by the N&W

represent the pinnacle of steam locomotive technology.

The J<sup>1</sup> was designed for a maximum tractive effort of 80,000 pounds, as shown in the general data in Fig. 1 and the plot in Fig. 2. As can be seen from Fig. 2, maximum drawbar horsepowers near 5100 were expected at speeds from about 40 mph to 80 mph. This performance was realized, as can be seen from the data in Table 1; under controlled tests an average drawbar horsepower of 5,028 was realized at a speed of 41.03 mph. This performance has not been surpassed, even by modern single unit diesel locomotives. Under test conditions, the “J” propelled a 15-car, 1015-ton passenger train at 110 mph on level tangent track. Performance in regular service was equally impressive, with speeds on straight sections of track reported to approach 100 mph.

The “J” was mounted on a rigid steel frame cast by General Steel Castings Corporation. This huge one-piece casting included not only the complete locomotive frame, but the two cylinders, the mounting brackets for certain auxiliaries, and an extended support for the cab. Air compressors were mounted on the pilot beam area in front of the boiler. Hollow sections cast integral with the frame were designed to serve as reservoirs for compressed air used to operate the air brakes and signaling devices.

The “J” was designed with comparatively small 70-inch drivers, allowing the riveted boiler to be

unusually large in diameter without exceeding the clearance and height limits of eastern railways. The “J” had the longest combustion chamber of any 4-8-4 and the largest firebox on a 4-8-4 burning eastern bituminous coal.

A unique side-rod-and-driver counter-balancing design, in conjunction with stiffened centering of the leading and trailing trucks, permitted speeds in excess of 100 mph with drivers only 70 inches in diameter, performance unequaled by other steam locomotives. According to vibration calculations, the balancing theoretically would have allowed speeds of up to 140 mph without the rail damage that could have occurred with conventional designs. The piston, piston rod, crosshead, side-and-main-rod assembly are of Timken Roller Bearing Company light-weight design. The N&W engineers incorporated needle, roller, and tapered-roller bearings throughout the locomotive to reduce friction and wear. Mechanical pressurized lubrication systems could operate 1300 miles between refills, feeding oil to 220 points. Grease fittings were located to allow fast relubrication of 72 points. Eleven of the J<sup>1</sup>s operated a total of over 5 million miles with only two roller-bearing failures.

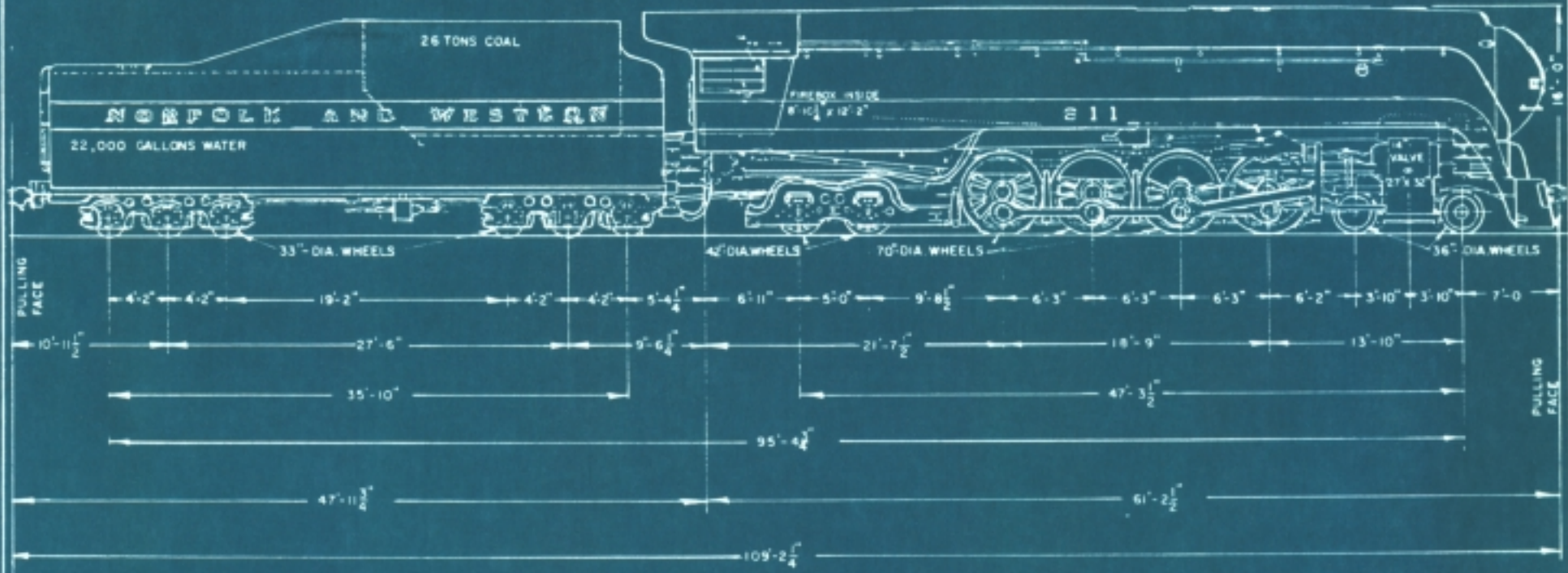
A side elevation view of the engine is shown in Fig. 1.



REVISION DATES					NW MECHANICAL DEPARTMENT ROANOKE, VA.		RR	SERIES	CLASS
6-17-83							NW	611	"J"
3-23-84							NW	220165	TENDER

# 4-B-4 PASSENGER LOCOMOTIVE CLASS J

MAXIMUM HEIGHT 16 FT.  
MAXIMUM WIDTH 11 FT.



GENERAL DATA			HEATING SURFACE		SPECIALTIES	
BUILT BY - ROANOKE SHOPS			FLUES	4,693 SQ. FT.	SUPERHEATER	TYPE E
YEAR BUILT - 1950			FIREBOX	518 SQ. FT.	FEED WATER HEATER	WORTHINGTON TYPE 6 SA
WEIGHTS:			ARCH TUBES	60 SQ. FT.	VALVE GEAR	BAKER
ON DRIVERS	288,000 LBS.	MAXIMUM CURVATURE - (14'-9" GAUGE)	SUPERHEATER	2,177 SQ. FT.	STOKER	STANDARD TYPE HT
ON ENGINE TRUCK	101,600 LBS.	MAXIMUM TURNOUT - NO. 8	TOTAL	7,448 SQ. FT.	ROLLER BEARINGS	
ON TRAILING TRUCK	104,400 LBS.	(STANDARD OR SELF-GUARDED FROGS)			DRIVING WHEELS	TIMKEN
ENGINE TOTAL	494,000 LBS.		FLUES	NO. 63 2 7/8" DIA. LG. 19'-2 1/2"	ENGINE TRUCK	TIMKEN
ENGINE AND TENDER	889,260 LBS.	HEIGHT OF CENTER OF GRAVITY	FLUES	NO. 227 1 1/2" DIA. LG. 18'-2 1/2"	TRAILING TRUCK	TIMKEN
LIGHT WEIGHT TENDER	141,940 LBS.	ENGINE 84"	ARCH TUBES	NO. 5 1 1/2" DIA.	TENDER TRUCK	SKF
TENDER	395,210 LBS.	TENDER EMPTY 60 1/2" FULL 84"	SUPERHEATER UNITS	1 1/4" DIA.	RODS	TIMKEN
BOILER PRESSURE	300 LBS.				VALVE GEAR	MCGILL MULTIROD
TRACTIVE EFFORT	60,000 LBS.					
GRATE AREA	107.7 SQ. FT.	AIR BRAKE EQUIPMENT - 26L				
FACTOR OF ADHESION	3.6	AIR LINE PIPING DIAGRAM - 10-C-129				

SHEET NO.

Figure 2: Calculated draw bar pull and horsepower curves for Class J locomotive.

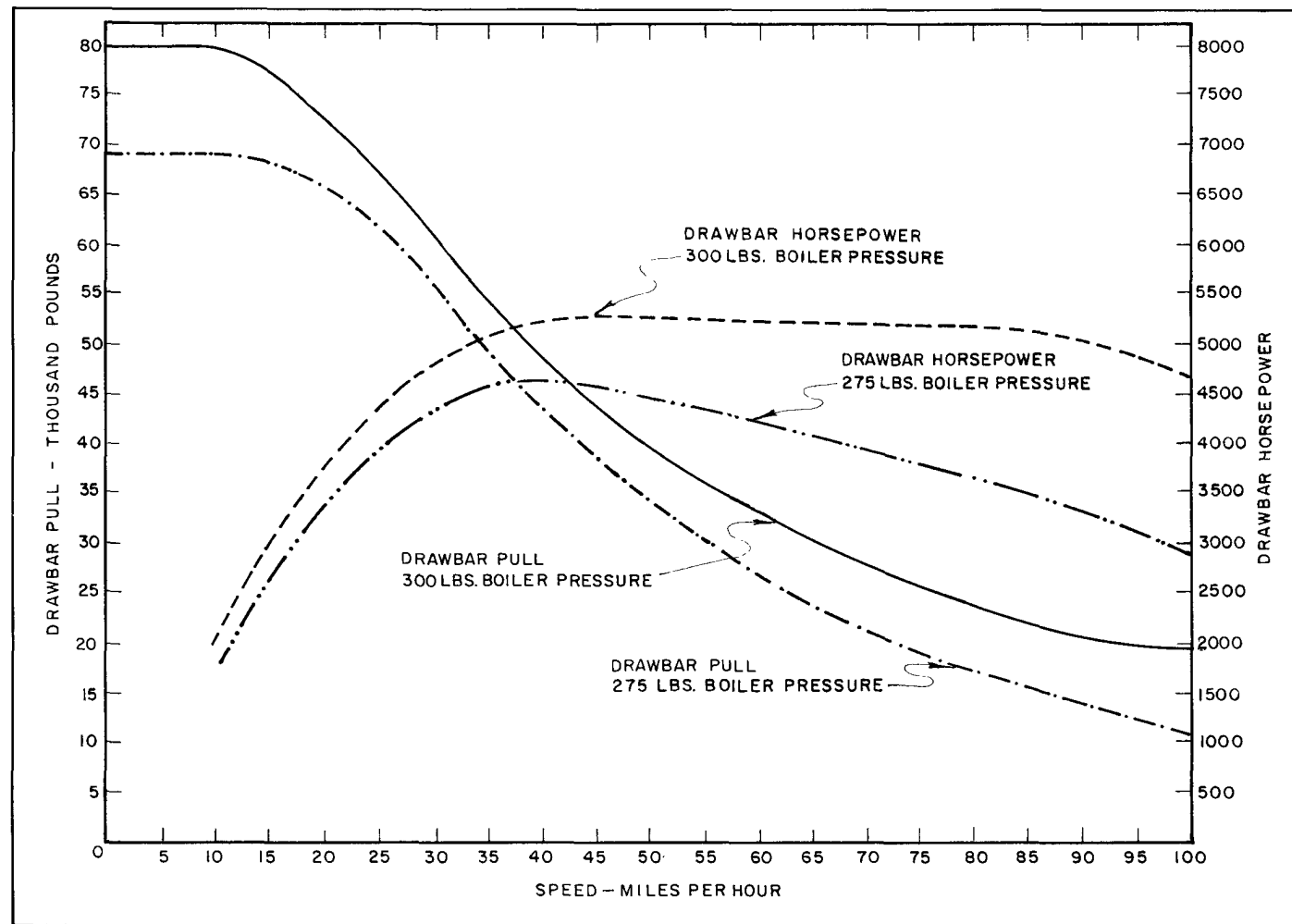
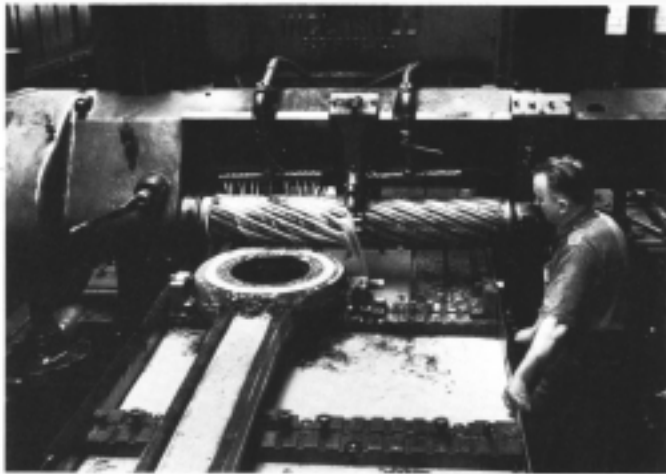


Figure 3: Selected data from test runs developing maximum horsepower of Class J locomotive. April 18, 1946.

Run No.	Speed MPH	Cut Off %	Train (Tons)	Water Evaporated Lbs./Hr.	Dry Coal Fired Lbs./Hr	Firing Rate Lbs./Hr.	Pressure (lbs.)			Steam Chest Temp. °F.	Average Draw Bar Horse Power
							Boiler	Steam Chest	Ex. Passage		
					275 lbs. Boiler Pressure						
23	39.15	66	1,065	104,946	15,145	141	270	238	19.9	665	4,795
25	39.07	66	1,065	103,860	15,646	145	274	243	20.6	701	4,784
					300 lbs. Boiler Pressure						
24	39.14	61	1,065	103,365	14,828	138	287	253	19.0	676	4,806
26	41.03	60	1,065	99,942	13,068	121	295	268	20.2	697	5,028

Figure 1: Side elevation and general data for Class J locomotive.



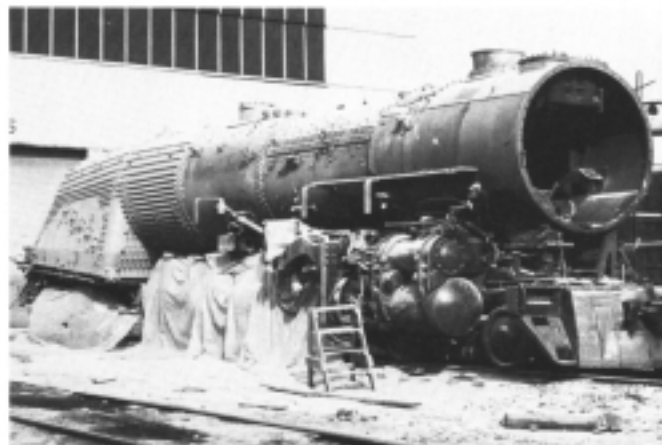
Made July 18, 1941, showing main rod being machined in the N&W East End Shop. This massive section of steel transmits the main thrust of the pistons in the cylinders, to the driving wheels. The I-beam section strength was carefully computed by N&W designers, as was the "eye" at the end of the rod, which is shown during machining process. Roller bearings will be inserted into the "eye", prior to application on the locomotive. The main rod is in a milling machine, with a huge tool utilized for this milling operation. Photo from N-S files. Caption by A. M. Bixby, Sr.



Made July 18, 1941, showing fabrication of firebox and boiler shell. The assembly is turned upside down in the photograph to enable easy access to the outside of the firebox by the boilermakers, who are shown in the picture applying flexible staybolt caps around the throat sheet, utilized as a connection between the firebox and second boiler barrel. *Photo from N-S files.* Caption by A. M. Bixby, Sr.



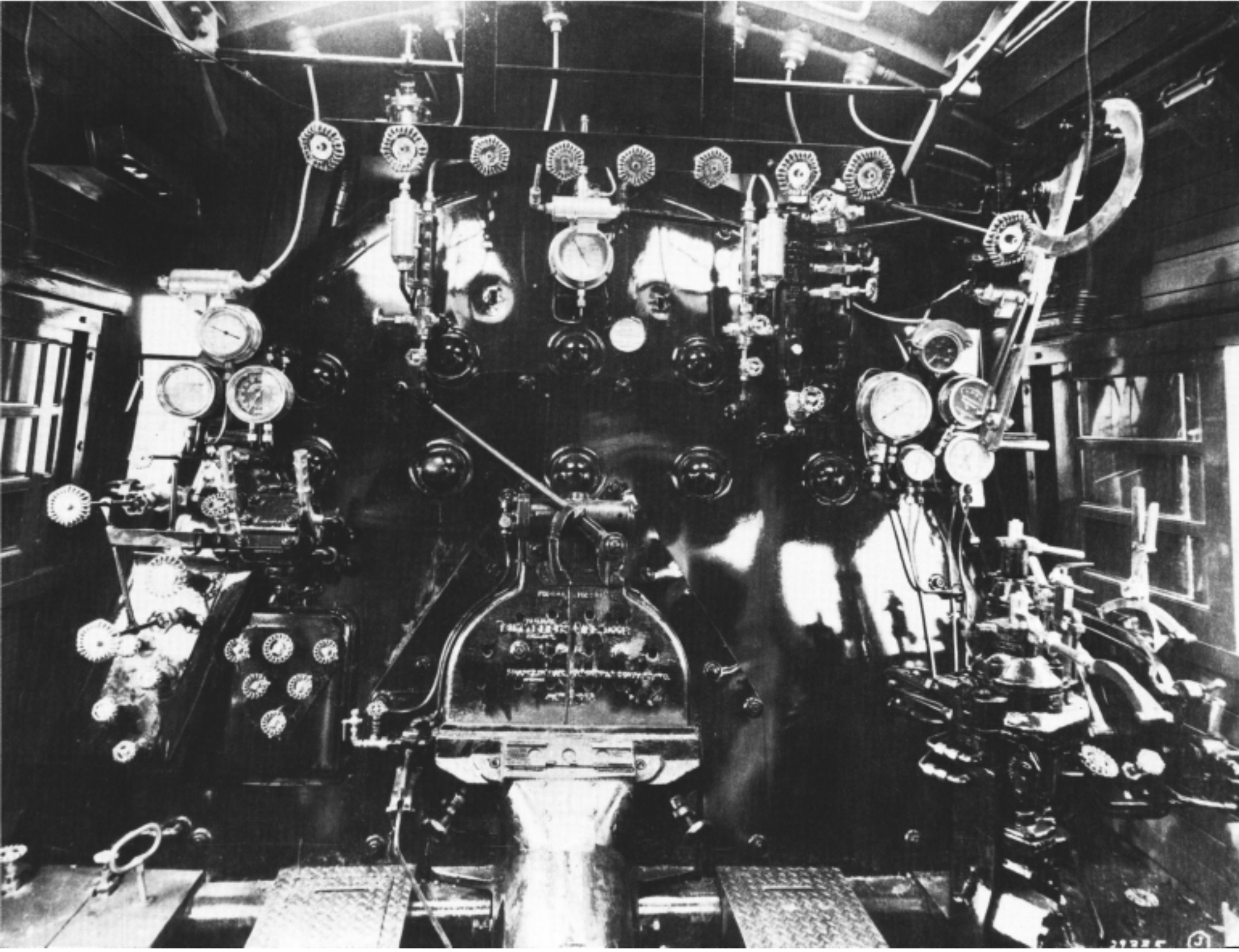
Made July 14, 1941 at N&W East End Shops in Roanoke, Va., showing cast steel steam locomotive "Bed". This huge one piece casting includes the entire locomotive frame, the two cylinders, various brackets for mounting of auxiliaries and a large support for mounting of cab. Note the 8½" cross compound air compressor mounted at left front of pilot beam, with workman connecting piping to carry air throughout the locomotive and train behind. The cylinder saddle appears just behind the air compressor, where the front end of the boiler or smokebox will seat. The cast steel "locomotive bed" was a great improvement in steam locomotive construction. Another bed frame appears at top left of photograph, showing cylinders prior to application of heads. *Photo from N-S files.* Caption by A. M. Bixby Sr.



The 611 being sandblasted during reconstruction in the southern railway's Birmingham shops in 1982. *N-S File photo.*

View inside cab showing the "J" controls and instruments. The stoker conveyor at lower center brought coal from tender to firebox, introducing it to firebed inside the Franklin "Butterfly" type fire door. The throttle appears at top right, with reverse lever directly below, in front of engineer's seat. At left are brake valves, the smaller valve controlling locomotive brakes, larger controlling brakes for entire train. *Photo from N-S Files,* caption by A. M. Bixby, Sr.









The following people are credited with the design and construction of the class "J":

#### NORFOLK AND WESTERN RAILWAY

##### Supervision

R. G. Henley*	General Mechanical Superintendent
H. C. Wyatt*	Assistant General Mechanical Superintendent
C. E. Pond	Assistant General Mechanical Superintendent

##### Design

H. W. Reynolds*	Mechanical Engineer
G. P. McGavock*	Locomotive Designer
C. H. Faris*	Locomotive Designer
V. C. Glaze	Chief Draftsman
M. W. Faville	Draftsman
F. C. Noel*	Tool Supervisor (Streamlining Designer)

##### Test

H. W. Coddington	Research and Test Engineer
I. N. Moseley*	General Boilermaker
R. M. Pilcher	Mechanical Inspector

\*Deceased

#### TIMKEN ROLLER BEARING COMPANY

T. V. Buckwalter	Design of Lightweight Pistons, Hollow Piston Rods, Aluminum Multi-Bearing Crossheads, Roller Bearing Main and Side Rods
O. J. Horger	

The restoration project in 1981-82 was supervised by Paul Housman, a retired N&W East End Shop foreman, who was retained for the project. Mark Faville, retired from the N&W Motive Power Department, provided copies of the original drawings for the rebuilding.

The 611 rounds curve at Elliston Springs, Va.  
Photo Fall 1982 by Jeff Weiler.

## COMMONWEALTH OF VIRGINIA PROCLAMATION



### *CERTIFICATE of RECOGNITION*

*By virtue of the authority vested by the Constitution  
in the Governor of the Commonwealth of Virginia,*

*there is hereby officially recognized:*  
ASME NORFOLK & WESTERN NO. 611, CLASS J

STEAM LOCOMOTIVE HISTORIC LANDMARK

The 4-8-4, No. 611, Class J design of steam-powered, coal-fired railroad passenger locomotive from 1941 to 1959 brought much improvement in travel on the Norfolk & Western System. The Class J, designed and built by citizens of the Commonwealth of Virginia in the Norfolk & Western Shops at Roanoke, Virginia, was the high point of steam-operated railroad motive power in the state and nation.

Accordingly, I, Charles S. Robb, join the distinguished gathering for its dedication in tribute to those who made and operated this outstanding product of transportation technology and to those who now call the historical importance of this example of engineering ingenuity to the attention of all Virginians.

*Charles S. Robb*  
Governor

## HISTORY OF NORFOLK AND WESTERN RAILWAY

The beginnings of the N&W date back to 1833, when 41 residents petitioned the Virginia General Assembly to incorporate a “Rail Road” from Petersburg to City Point, on the James River. The first train was operated on the nine mile City Point Rail Road on September 7, 1838.

The second railroad involved in what became the N&W system was the South Side Railroad which was merged with the City Point Road and opened in 1854 for 123 miles between Petersburg and Lynchburg. Then came the Virginia & Tennessee, opened from Lynchburg to Bristol in 1856. A continuous rail link between Norfolk and the state of Tennessee was completed in 1858 when the Norfolk & Petersburg Railroad connected those two Virginia cities. During the Civil War each line remained autonomous and each sustained repeated damage.

After the war the Virginia & Tennessee, the South Side, and Norfolk & Petersburg were rebuilt and consolidated by William Mahone. Mahone named the corporation the Atlantic, Mississippi and Ohio. At this time, the offices and shops of the new line were located in

Lynchburg, Virginia. The Norfolk and Western Railroad was named in 1876 when Clarence Clark, a Philadelphia banker, purchased the financially troubled A M & O. The name Norfolk and Western was chosen to calm the fears of Norfolk citizens that Clark intended to divert east-west rail traffic to Philadelphia.

Since that time, the N&W has expanded into a national transportation system extending from Norfolk to Chicago, and Buffalo to Kansas City. The N&W was renowned for its huge steam locomotives, many of which were built in their Roanoke, Virginia shops. The N&W was the last major railroad to use steam locomotives regularly, discontinuing their operation in 1960.

The Norfolk and Western Railway, after consolidating with the Southern Railway in 1983, is now known as the Norfolk Southern Corporation. The N&W has endured and prospered throughout its history and stands currently as one of the nation's greatest railroads.

With Virginia's Peaks of Otter in the background, the 611 passes mile post 240 near Montvale, Virginia on August 22, 1982.  
*Photo by Harry Bundy.*





611

NORFOLK AND WESTERN

Established by the City of Roanoke, Virginia in 1963, the Roanoke Transportation Museum is the largest municipally-owned facility of this type in the United States. The Museum contains the largest collection of historical railroad artifacts east of the Mississippi River and south of

Baltimore, Maryland. Eight steam locomotives, and assorted railroad rolling stock are on display along with numerous antique automobiles, trucks, horse-drawn vehicles, extensive model railroad exhibits and transportation memorabilia. The Museum owns the 611 and will display the ASME Landmark plaque.

The Museum has been designated the official transportation museum of the Commonwealth of Virginia by the Virginia General Assembly. This popular museum has 50,000 visitors annually.

## ROANOKE TRANSPORTATION MUSEUM

**NATIONAL HISTORIC  
MECHANICAL ENGINEERING LANDMARK  
Norfolk & Western 611, Class J, Steam Locomotive  
ROANOKE, VIRGINIA**

**1950**

Developed for use in both the plains and mountains, this coal-fired passenger locomotive was among the most advanced in design, construction, and performance of any 4-8-4. Designed by N&W engineers and built by the craftsmen of the N&W Roanoke shops, the 611 was specially balanced to minimize rail damage at high speeds. No. 611, 12th of 14 constructed and the last survivor, was retired from service and donated to the Roanoke Transportation Museum in 1959.

**SPECIFICATIONS:**

Engine Weight: 494,000 Lb	Engine and Tender Wt: 889,260 Lb
Boiler Pressure: 300 PSI	Max. Drawbar Pull: 80,000 Lb
Drivers: 70 Inch Diameter	Horsepower: 5100 at 40 MPH
Cylinders: 27 x 32 Inches	Bearings: Roller

The American Society of Mechanical Engineers—1984

The 611 on display at the Roanoke Transportation Museum just prior to being removed for rebuilding. *Photo by Kenneth L. Miller on October 16, 1981.*









## ASME NATIONAL MECHANICAL ENGINEERING LANDMARK PROGRAM

The ASME Council reactivated the Society's History and Heritage program in 1971 with the formation of a national History and Heritage Committee. The overall objective of the Committee is to promote a general awareness of our technical heritage among both engineers and the general public. The Committee is charged with compiling data on works and artifacts with a mechanical engineering connection which are of historical significance to the profession, an ambitious goal achieved largely through volunteer efforts of Section and Division History and Heritage committees and interested ASME members.

The national Committee directs two activities toward these goals: (1) a listing of industrial operations and related mechanical engineering artifacts in local, regional, and national Historic Engineering Records, and (2) a National Historic Mechanical Engineering Landmark program.

In addition, the Society cooperates with the Smithsonian Institution in a joint project which provides

contributions of historical material to the National Museum of American History in Washington, D.C. The Institution's collections are under the direction of a curator, who also serves as Secretary of the ASME History and Heritage Committee.

The N&W J-611 Steam Locomotive is the 68th National Historic Mechanical Engineering Landmark. Other nearby Landmarks within the southeastern region of the country include the Shot Tower near Wytheville, Virginia, where lead shot was made between 1812 and 1839, and the *N.S. Savannah* in Charleston, South Carolina, the world's first nuclear-powered merchant ship.

The 611 is being fired up during early morning hours at the Woodall Road Passenger Station at Lynchburg Va., for a run to Atlanta on October 26, 1983.  
*Photo by Jim King.*







# THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

The American Society of Mechanical Engineers (ASME), with over 100,000 members, is the third oldest engineering society in the United States. Engineers from all over the world belong to the Society, although the primary membership is found in the United States.

The ASME was founded in 1880. This was a dynamic time in the growth and definition of mechanical engineering as a separate technical entity. The first mechanical engineering curriculum had been established at Stevens Institute of Technology by Robert Henry Thurston in 1871; the potential of steam power had been demonstrated publicly at the Centennial International Exhibition in Philadelphia in 1876, where the Corliss double walking-beam engine was used to furnish power to the exhibition hall. This exhibition, as well as a smaller but equally significant exhibit at Cornell University, brought together several influential engineers who realized the need for a new technical society. After discussions with Professor Sweet of Cornell, Frank C. Smith, Superintendent of the Delaware Foundry and Machine Company, wrote to Jackson Bailey, founder of the *American Machinist* in 1877, suggesting a new society. In turn, Jackson Bailey wrote to Professor Sweet, urging him to call a conference to discuss the formation of a Society of Mechanical Engineers. On January 18, 1880 Professor Sweet sent a letter to fifty prominent mechanical engineers, stating, in part:

"It having been suggested by several prominent engineers that a national association of mechanical engineers would be desirable, and a meeting for the purpose of taking steps to organize such a society at the office of the American Machinist, 96 Fulton Street, New York, the sixteenth day of February, 1880 at 1 o'clock sharp, at which time the necessary steps for organizing such an association will be made."

Thirty-one engineers responded. The preliminary work of organization and incorporation was done under the able direction of Alexander Lyman Holley. The formal organization meeting was then held on April 7,

1880, at the Stevens Institute of Technology. R. H. Thurston was unanimously elected the first president of the newly formed ASME.

Technology has changed and expanded greatly since 1880, and so has the ASME. The interests of mechanical engineers are broad, and this is reflected in ASME. There are currently 32 technical divisions, each centered around some area of concern to mechanical engineers. These include; Gas Turbine, Diesel and Gas Engine Power, Rail Transportation, Automatic Control, Bioengineering, Heat Transfer, Lubrication, Management, Aerospace, Nuclear Engineering, and Solar Energy divisions. Technical areas within which mechanical engineers work are so diverse that there are very few industries which do not rely heavily on mechanical engineers.

ASME members have been interested in steam power since the earliest days of the Society. Explosions of steam boilers are very destructive, and were quite common when ASME was founded in 1880. Thus, one of the first concerted efforts undertaken by the Society was the establishment of boiler design and construction standards. This activity continues on an expanded scale today. The Codes and Standards developed by this society have been written into the laws of most states and many municipalities in order to provide protection to the public from improper design and construction. This protection is provided in many areas besides boilers and pressure vessels now.

As ASME enters its second century it remains dedicated to benefiting mankind through the responsible application of technology.

Ascending Blue Ridge  
grade east of Roanoke  
during fall 1982  
excursion.  
*Photo from N-S files.*

The Virginia Section of the American Society of Mechanical Engineers gratefully acknowledges the efforts of all who cooperated on the landmark designation and dedication of the Norfolk and Western J-611 Steam Locomotive.

## ACKNOWLEDGMENTS

### THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS NATIONAL OFFICERS AND STAFF:

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Robert A. Bennett, P.E., Secretary/Treasurer  
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Brian J. Lasley, Past Vice Chairman, ASME Student Section

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Advisors: Arthur M. Bixby, Sr., Curator, Roanoke Transportation Museum  
H. L. Scott, Jr., Vice President and Chief Mechanical Officer,  
Norfolk Southern Corporation.  
Joan H. Munford, Member Commonwealth of Virginia House of Delegates  
Typing: Sharon Hopkins, Lynne Sawyer  
Financial Assistance: Norfolk Southern Corporation  
Official Dedication Photographers: David W. Dayton, Marshall T. Smith  
Dedication Program: Ingersoll Rand Corporation

The "J" eases through  
the S-curve west of  
Montvale, Va. on  
April 30, 1983.  
*Photo by Jim King.*

*Overleaf: The 611 steams  
through Nottoway Vir-  
ginia on the way from  
Roanoke to Norfolk, Va.,  
Labor Day, September 4,  
1982. This was the first  
excursion after  
reconstruction.  
Photo by Jim King.*









