RAILWAY AGE
October 4, 1941

ALCO, Union Pacific Wasatch Class "Big Boy" Technical Profile

Union Pacific Gets Heaviest Articulated Locomotives

Single-expansion 4-8-8-4 type distinguished by unusually complete controlled flexibility—Particular attention paid to lubrication

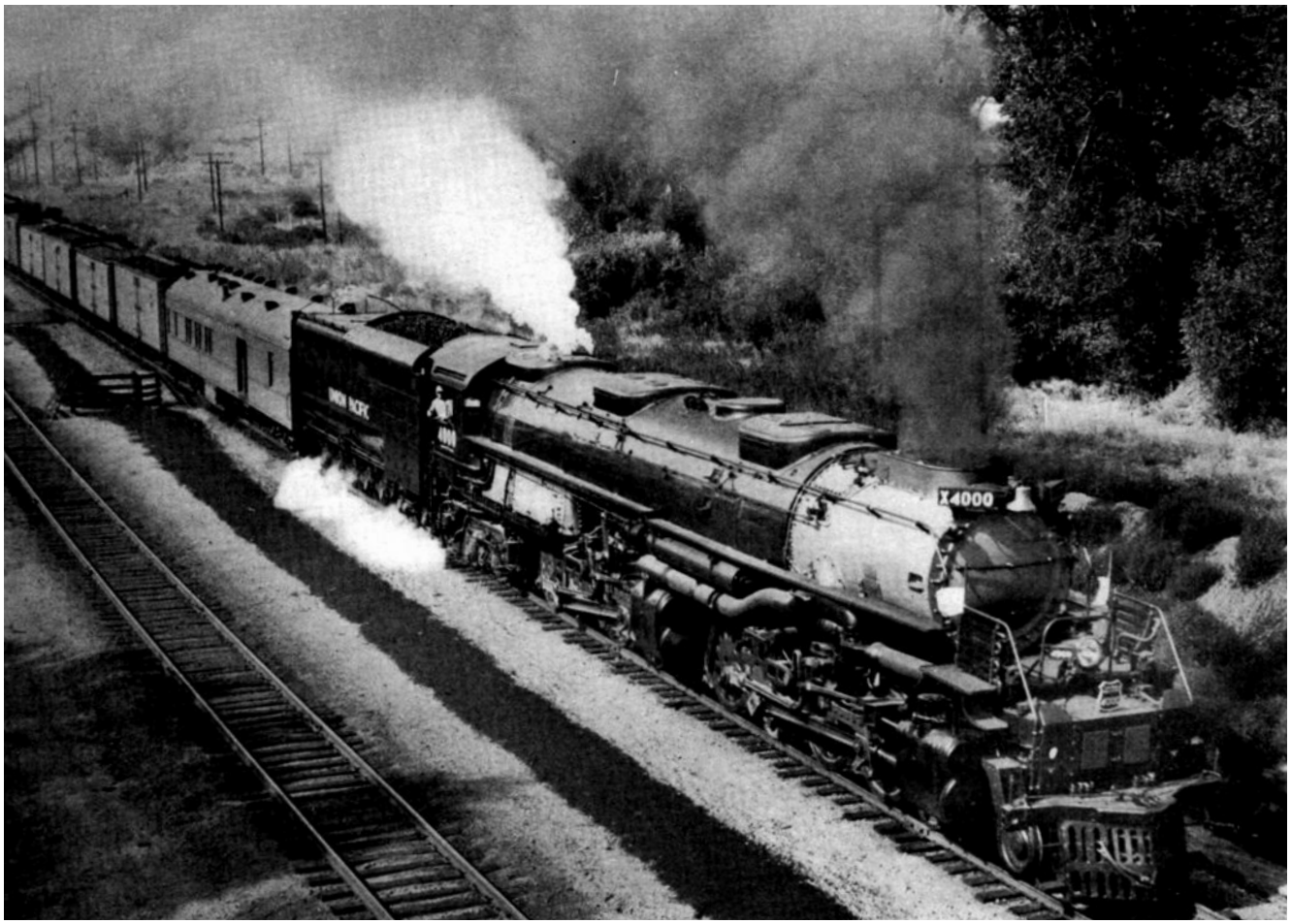
AN order of 20 single-expansion, articulated locomotives of the 4-8-8-4 type is being delivered to the Union Pacific by the American Locomotive Company. These locomotives are the largest in size and heaviest in point of total engine and tender weight of any simple articulated eight-coupled locomotives which have been built. The length over couplers is 132 ft. 9⅞ in.; the weight of engine and tender, 1,197,800 lb., and tractive force, 135,375 lb. The locomotives are also notable for many refinements affecting their performance.

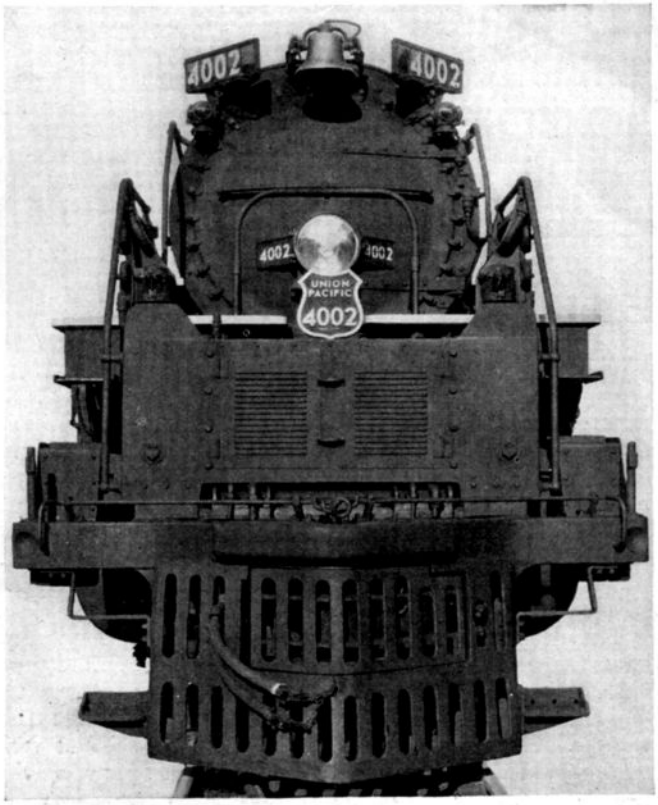
The basic design was developed by engineers of the Research and Mechanical Standards Department of the Union Pacific, under the direction of Otto Jabelmann, vice-president, to originate a locomotive capable of hauling maximum tonnage and maintaining schedules without helper service over the Wahsatch Mountains on a ruling grade of 1.14 per cent between Ogden, Utah, and Green River, Wyo. Results of exhaustive road tests and experience gained in operation of other single-expansion articulated locomotives were furnished to the American Locomotive Company which collaborated with the Union Pacific engineers in designing the locomotive.

The new locomotives can operate on any part of the railroad and were designed for speeds up to 80 m. p. h. and to produce maximum power output continuously at 70 m. p. h.

The design of running gear permits great flexibility when moving around curves and at the same time provides for relatively high rigidity when operating on tangent track. The spring-rigging suspension of the locomotive also permits adjustment of the wheels to vertical curves with relatively little distortion of the weight distribution.

The arrangement of the running gear for tracking on curves embodies what is designated by the builder as the "lever principle." This term is applied to a system of





With the Coupler Retracted, the Pilot Surface is Smooth and Unobstructed

lateral-motion control and spring-rigging suspension, the function of which is to fit all wheels of the locomotives to the rails on curves with maximum freedom from binding and to adjust the wheels to vertical curves encountered with changes of grade with a minimum of disturbance to the distribution of the weight of the locomotive.

The use of the term "lever principle" arises from the employment of a definitely selected pivot point in the locomotive wheel base about which the mass of the locomotive rotates with respect to the track as the locomotive passes around curves. On an eight-coupled driving-wheel base this is the rear pair of driving wheels in which no provision is made for lateral movement of the axle with respect to the locomotive bed. The guiding wheels on the front engine unit (the front pair of truck wheels and the front pair of driving wheels) have provision for ample lateral movement against controlled resistance. The initial resistance of these wheels is about 17 per cent, increasing gradually as the movement progresses. The second and third pairs of driving wheels adjust themselves freely against a somewhat lower initial resistance and through a somewhat less range of lateral movement than that effective on the guiding wheels. Wheels back of the pivot pair control the movement of the rear end of the locomotive against an initial lateral resistance somewhat lower than that of the guiding wheels. All wheels are fitted to track gage with a setting of 53⅜ in. between the backs of the tires.

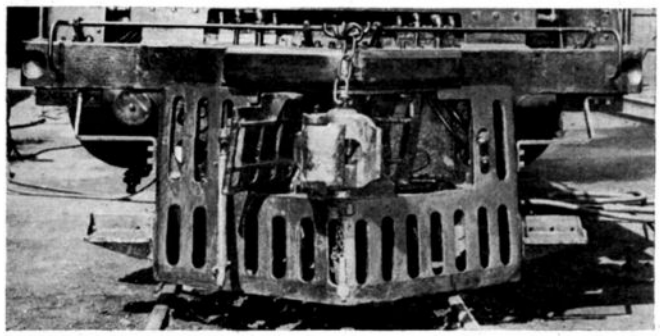
The effect of this arrangement is to produce a rigidly guided locomotive when on tangent track which adjusts itself freely on curves with a guiding force cushioned in its application. Locomotives on which this arrangement has been used are said to move around curves smoothly with complete absence of the succession of violent guiding oscillations characteristic of many existing steam locomotives.

In counterbalancing advantage has been taken of the absence of the tendency to nose, brought about by the lateral rigidity of the wheel base on tangent track, to keep down the overbalance. This has been fixed conservatively at 28 per cent of the reciprocating weights.

In order to relieve the tendency of locomotives with long wheel bases to overload the driving springs when passing over concave vertical curves at summits and to under load them with corresponding overloading of the truck springs at the ends of the wheel base when passing over a convex curve an unusual degree of flexibility has been provided in the spring rigging by the employment of coil springs at all points of anchorage of the spring rigging to the engine bed and to the trailer truck. Each of these cushion springs comprises two 8-in. double coils in tandem; they permit the elongation or shortening of what are customarily hangers of fixed length, and permit vertical adjustments throughout the entire wheel base to conform to the track with a minimum of distortion of the adhesion weight on the driving wheels. With this arrangement the main springs of the system are designed with an overload factor of only 5 per cent.

Unusual attention has been given to insuring freedom of adjustment of the entire spring-rigging suspension system. Wherever possible, the spring hangers are of the loop type. Alemite lubrication is applied to the circular curved surfaces between the hanger loop and the spring gib. Cross-equalizer hangers have ball ends which hang in removable seats in oil-waste-packed pockets in the equalizer.

The locomotive as a whole has a three-point suspension. All driving wheels of the front engine are equalized on each side and the two sides are cross-equalized at the front end to the suspension of the rear end of the main equalizer beam, the front end of which bears in the Bissel type center pin of the engine truck. Each side of the rear engine is equalized as a unit from front to back, including both trailer wheels.



The Coupler in Operating Position

Foundation and Running Gear

The two engine beds of the locomotive are connected by a vertical articulation hinge with the pocket and pin at the front end of the rear engine bed and the tongue at the rear end of the front engine bed, which is similar to the arrangement developed by the Union Pacific for their 4-6-6-4 type single-expansion locomotive. The two engine units are so arranged that when the boiler load is applied to the waist-sheet support on the front engine bed a load of about seven tons is delivered to the top of the tongue from the rear engine bed. The two engine units are thus completely rigid in a vertical plane and all adjustment to vertical curvature is through the spring-rigging suspension.

A combination of coil and elliptic springs characterize the Alco four-wheel engine truck. These operate in parallel. The inclined-plane-and-geared-roller centering device has an initial resistance to lateral movement of 18 per cent, increasing to 33 per cent. The center plate is sealed to exclude dust and is force-feed lubricated. Oil is also fed to the racks and roller teeth of the centering device. The wheels are 36 in. in diameter and have SKF inside journal bearings which are tied together with a one-piece top-half integral box, making this a non-self-aligning bearing.

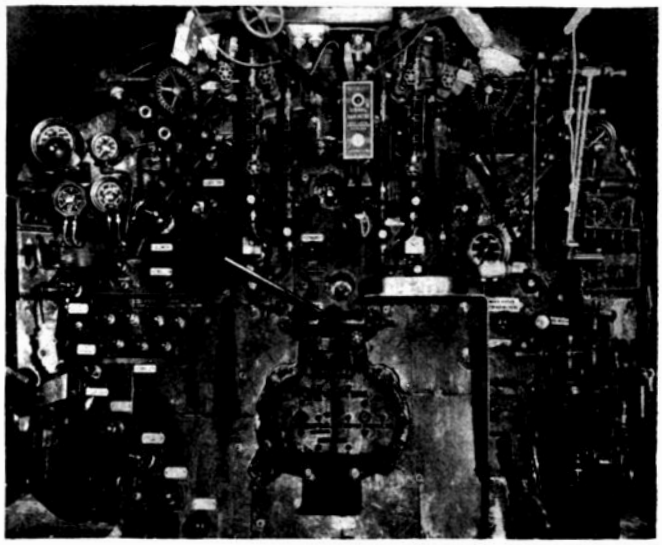
The General Steel Castings four-wheel trailing truck has 42-in. wheels with SKF twin-bearing outside journal boxes. It has a centering device with a 10 per cent initial resistance, increasing to 15 per cent and thence remaining constant.

The driving wheels, which are 68 in. in diameter over the tires, are of the Boxpok type. The axle journals have Timken roller bearings. The driving boxes and all other roller-bearing boxes on the locomotive are fitted with heat indicators. Driving boxes are equipped with Franklin compensator and snubber wedge assemblies. Alco lateral-motion devices are applied on the three leading driving axles of each engine unit.

The side rods are of the articulated type, eliminating knuckle-pin connections, similar to those developed by the Union Pacific for their first order of 4-8-4 type freight and passenger locomotives. Vertical grease pockets are located in the bodies of the rods adjoining the crankpins, except for the ends of the rods on the intermediate crank pin. This bearing is lubricated from the hollow bore of the crank pin. The driving axles, the main and side rods, crank pins and piston rods are heat-treated low-carbon-nickel steel.

The pistons were furnished by the Locomotive Finished Material Company. They are of light alloy-steel rolled section with three T-section combination bronze and cast-iron piston packing rings. The crossheads are manganese-Vanadium alloy-steel castings and operate in multi-bearing guides. The guides are carbon-steel forgings, secured at both ends by heavy clamps so that in adjusting themselves to the lateral expansion of the cylinders the bolts are not subjected to shearing stresses.

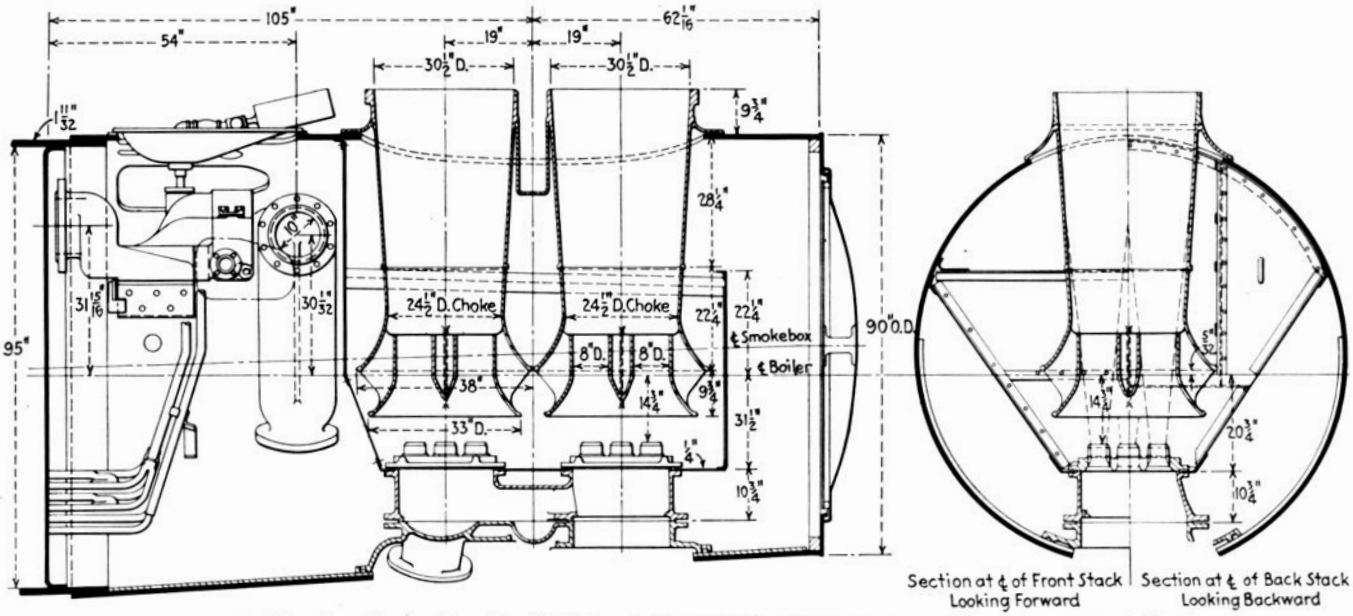
The weight of reciprocating parts on each side of the locomotive is 2,106 lb. on the front engine and 1,912 lb. on the rear engine. The weight of the main rod is apportioned between reciprocating and revolving weights by the center-of-percussion method. All revolving weights are balanced in each wheel and overbalance for 28 per cent of the reciprocating weights is divided equally among all wheels. The main driving wheels are cross-balanced. To avoid the use of separate patterns the primary counterbalance is symmetrical about the diameter through the crank pin and in the wheel center are cast separate secondary counterbalance pockets at either end of the primary counterbalance for the cross-balance correction. One of these is used and closed with a steel plate, welded on. The other is left open. The maximum dynamic augment at diametral speed is 7,590 lb.



The Back Head Presents an Orderly Arrangement of Valves, Gauges, and Controls

Steam Pipes and Steam Distribution

The live- and exhaust-steam pipes applied to these locomotives are larger than those heretofore applied to any other single-expansion articulated locomotives. Test data developed by the Research and Mechanical Stand-



In the Front End Are Two Stacks, Two Four-Jet Exhaust Nozzles and a Patented Labyrinth Front-End Draft Appliance

Requiem for a Heavyweight

The only operating example in the world of the largest steam locomotive ever built thundered her way, in May 2019, from Union Pacific's Steam Shop in Cheyenne, Wyo., to Ogden, Utah, to take part in ceremonies marking the 150th anniversary of the Golden Spike, which completed the nation's first transcontinental railroad.

She's "Big Boy" 4014, built in 1941 by the American Locomotive Co. to UP specifications for hauling heavy trains over the Wasatch Mountains between Ogden and Green River, Wyo., on a 1.14% ruling grade.

Beginning in the late 1930s, a UP design team led by Mechanical Department Research & Mechanical Standards Vice President Otto Jabelmann, working with ALCO, re-evaluated the railroad's 4-6-6-4 Challenger locomotives. They enlarged the Challenger's firebox to 235 x 96 inches (157 square feet), increased boiler pressure to 300 psi, added four driving wheels and reduced driving wheel diameter from 69 to 68 inches. The resulting single-expansion, articulated, 975.75-ton (with tender, in working order) 4-8-8-4 featured an axle loading of 67,800 pounds, and a maximum starting tractive effort of 135,375 pounds with a 4.0 factor of adhesion.

ALCO manufactured 25 Big Boys for UP, 20 in 1941 and five in 1944. They saw service until their fires were dropped for the last time in 1961. Eight survived; UP re-acquired 4014 in 2013 from the RailGiants Museum in Pomona, Calif., and meticulously restored her to operating condition.

The nine-page *Railway Age* article of Oct. 4, 1941, pp. 519-526, 528, reproduced here, describes the Big Boy in detail, listing all component suppliers, some of which are still in business.

We salute Union Pacific, its Steam Team, and all suppliers, past and present, who returned 4014 to glory. — *William C. Vantuono, Editor-in-Chief, July 2019*

ards Department of the Union Pacific conclusively demonstrated that, to utilize full boiler capacity and develop maximum power output, past practices could not be followed. The arrangement of the steam pipes applied to these locomotives represents a further development of the system of flexible connections to the leading pair of cylinders which has been employed on a number of articulated locomotives previously turned out by this builder. By this system steam from the branch pipes is divided and delivered directly to each pair of cylinders. By the use of a short rotating steam-pipe connection at the cylinder, to the outer end of which the longer flexible connection to the branch-pipe is attached by a flexible joint, these pipes adjust themselves to the lateral movement of the front engine on curves without the use of slip joints. The three flexible connections in each pipe are full ball joints, permitting complete freedom of adjustment. While the use of ball joints at these locations is not new, those installed on the Union Pacific locomotives have been materially simplified in design.

Because of the universal movement permitted by the ball joints, a pair of outrigger studs has been applied to the ball-joint casing at each cylinder. There is normally a small clearance between the ends of the studs and the face plate over which they move as the joint rotates. Should this joint and the pipe arm attached tend to roll out of alignment when there is no pressure in the pipes these studs prevent the pipe from tipping out of alignment.

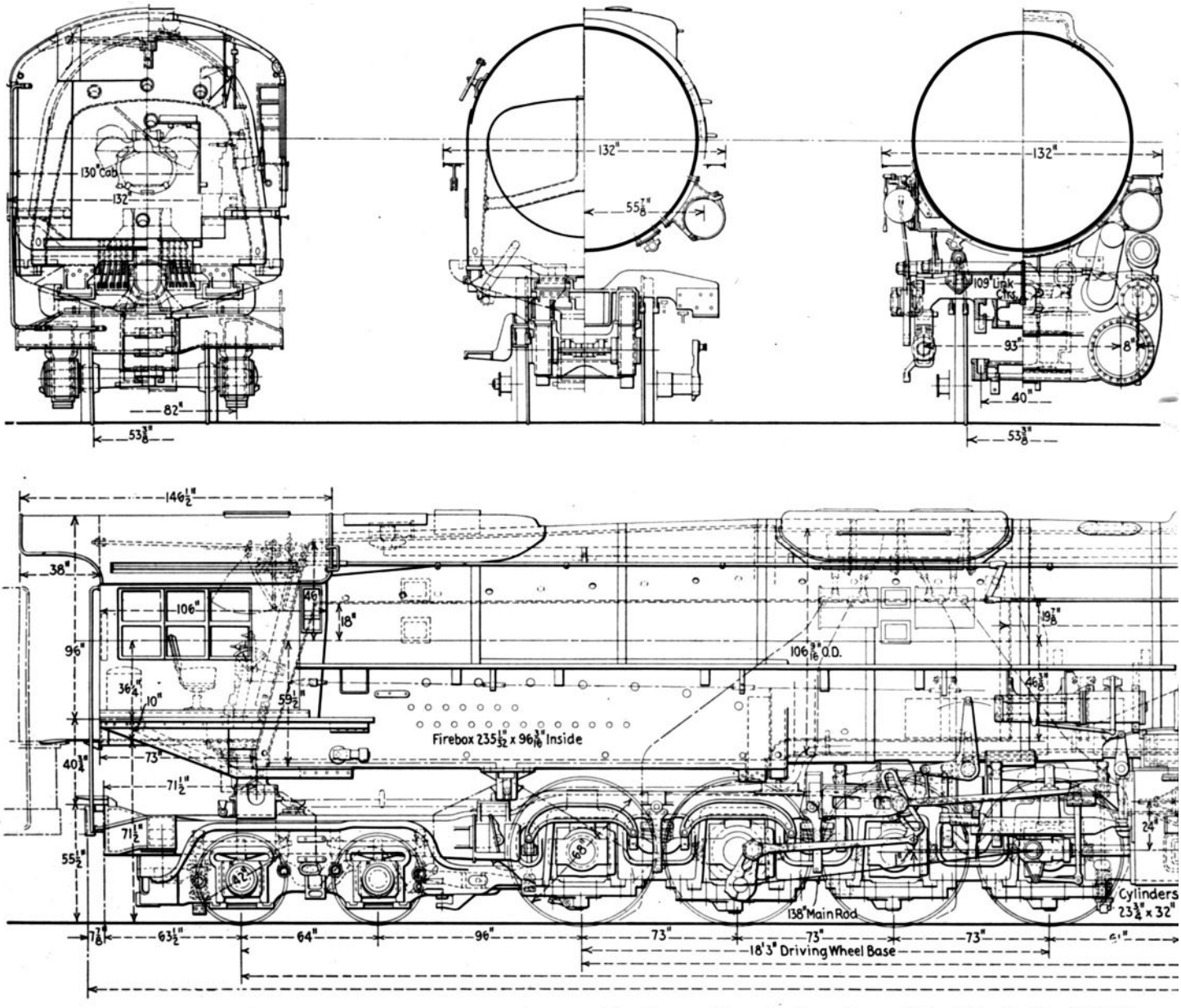
The main steam pipes to both pairs of cylinders are insulated with Unarco Insubestos pipe covering.

The expansion joint at the rear end of the long steam pipe to the rear cylinders is balanced against the effect of internal pressure.

The cylinders, together with the back cylinder heads, are integral parts of the bed castings. Both cylinders and valve chambers have Hunt-Spiller gun-iron bushings.

The steam distribution is effected by 12-in. piston valves and is controlled by Walschaert valve gear. The valves are Hunt-Spiller lightweight design with Duplex bronze and cast-iron lip-type packing rings.

All pins in the Walschaert valve gear, except the eccentric crank pin are fitted with McGill needle bearings. An SKF self-aligning roller bearing is applied on the eccentric crank pin. The union links, combination lever, radius bars, radius-bar lifters, and valve stems are



Elevation and Cross-Sections of one of the Union Pacific 4-8-8-4 Type

heat-treated low-carbon nickel steel. The links, link blocks, and valve-motion pins are casehardened.

The reverse gear is an Alco special Type H with a 12-in. by 24-in. cylinder. Compensating springs are applied to the reverse shafts on both engines.

Lubrication

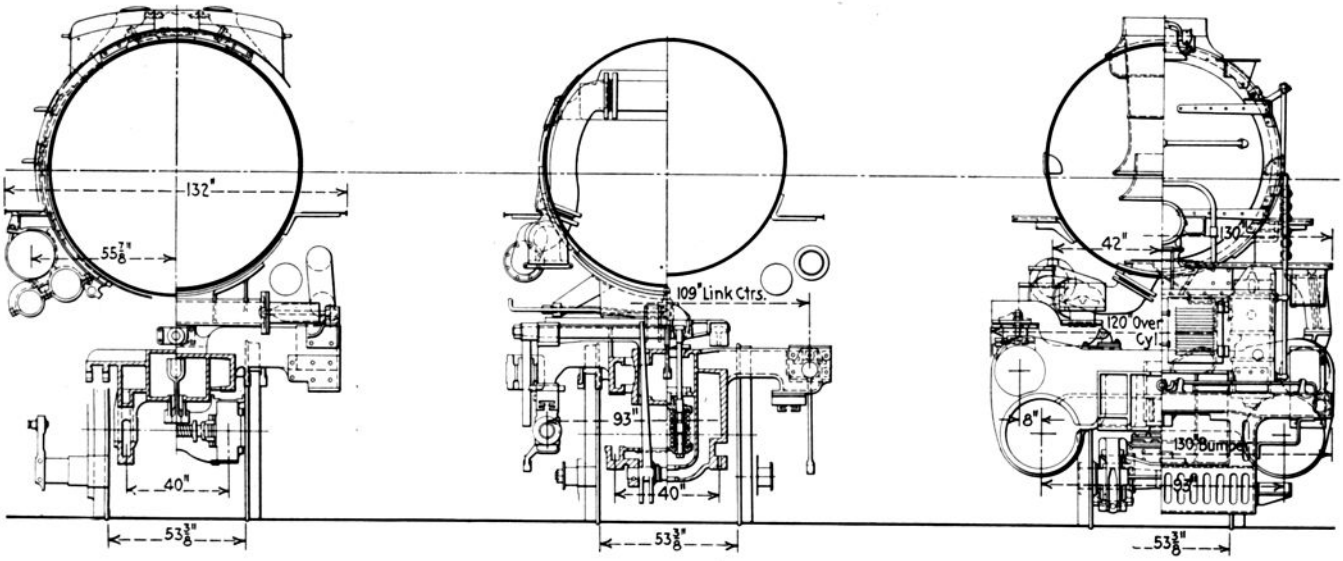
Mechanical application of oil lubrication to these locomotives is effected by four Nathan DV7 36-pint mechanical lubricators with a total of 49 feeds leading through Detroit two- and four-way dividers and terminal checks to 123 oil outlets, exclusive of the air compressors and tender. The points lubricated include the valves, cylinders, cylinder cocks, piston-rod packing, steam-pipe and exhaust-pipe ball and slip joints, the driving boxes and driving-box wedges, guides, engine-truck and trailer-truck center plates, trailer-truck journal boxes, engine-truck lateral-motion device, throttle, reverse gear, articulation hinge pin, stoker, and radial buffer. Two of these lubricators supply cylinder oil to the bearings subjected to steam temperatures; the other two furnish lubrication for the chassis bearings.

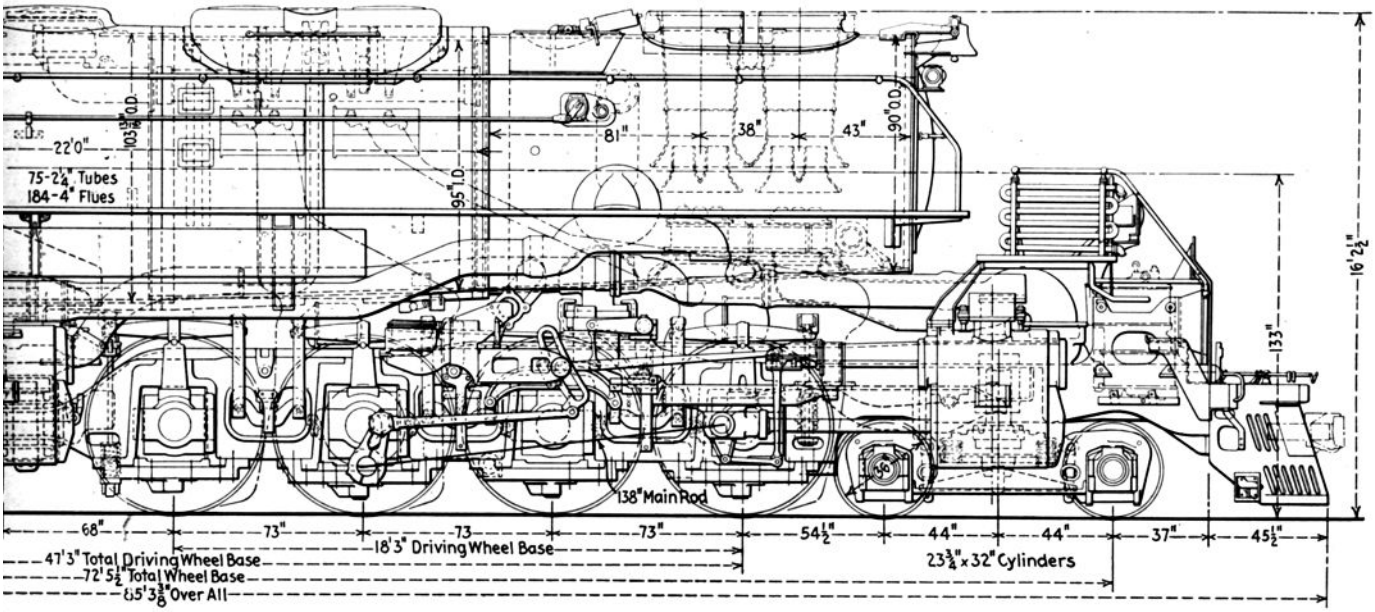
In addition to the oil lubrication, all spring-rigging joints, brake-rigging pins, and valve-motion bearings have Alemite fittings. In the few points at which pin connections are used in the spring rigging, the pins fit in Grafitex self-lubricating bushings.

The Boiler

The boiler has three barrel courses and, due to thickness, the sheets were cold rolled and then stress relieved before riveting the seams. The first course is conical with an inside diameter of 95 in. at the front end. The third course, which surrounds the combustion chamber, is $106\frac{9}{16}$ in. outside diameter. All longitudinal seams are of the saw-tooth type riveted and caulked inside and outside; also, all circumferential seams are caulked inside and outside. The firebox is $235\frac{1}{32}$ in. in length by $96\frac{3}{16}$ in. in width, and the combustion chamber is 112 in. long. The crown sheet is about 27 ft. in length and has a relatively small slope; the highest point at the front tube sheet is only $1\frac{7}{8}$ in. higher than the lowest point at the door sheet.

Practically the entire boiler structure is built of Bethloc





Single-Expansion Articulated Locomotives for Fast Freight Service

steel. This includes the barrel sheets and the firebox wrapper sheets, as well as the entire inside firebox. The front barrel sheet is $1^{11}/_{32}$ in. thick, and the two larger courses $1^{3}/_{8}$ in. each. The smokebox is of three-piece welded construction, to which is attached the boiler bearing, thus relieving the boiler barrel of any shock load which may be transmitted from the front engine unit.

All seams in the firebox, including the attachment of the back tube sheet to the combustion chamber, are welded. At the mud ring the caulking edges of the inside sheets are welded around all four corners, and the outside sheets around the front corners. At the back, the caulking edge of the outside sheet is welded around the corners and entirely across the mud ring. Seal welding is also applied to the outside caulking edges of the wrapper-sheet and back-head seams, to the side- and roof-sheet seams, and to a large part of the front wrapper-sheet seams. The ends of the longitudinal barrel seams are also seal welded.

The Flannery flexible staybolts have the MK type caps. There is a complete installation of flexibles around the combustion chamber and over the crown sheet. There are flexible bolts also along the top of the side sheets, across the top rear corner of the side sheets, and around the rear corners of the firebox. Flexible bolts are also applied at all locations on the back head under the cab deck. The rear firebox corners have radii of 24 in. inside and 25 in. outside at the mud ring, tapering upward to the customary short radii near the top of the side wrapper sheet.

The firebox is supported on the engine bed by four sliding-shoe furnace bearers. Each is enclosed by an oil-tight sheet-steel casing and is immersed in an oil bath.

In the firebox are seven Security circulators and through each side are 20 secondary air tubes.

The boilers have the Electro-Chemical Engineering Company foam-collapsing trough and automatic blow-down system. The Wilson blow-off cocks in the firebox side near the back head are pneumatically operated and are piped into the centrifugal separator which forms a part of the automatic blow-down system. An additional blow-off cock is provided in the belly of the boiler at the front end of the first course, with the nozzle directed toward the firebox for use in blowing down and filling the boiler. Blow-off cocks which are hand-operated from the ground are placed in the sides of the firebox near the throat sheet.

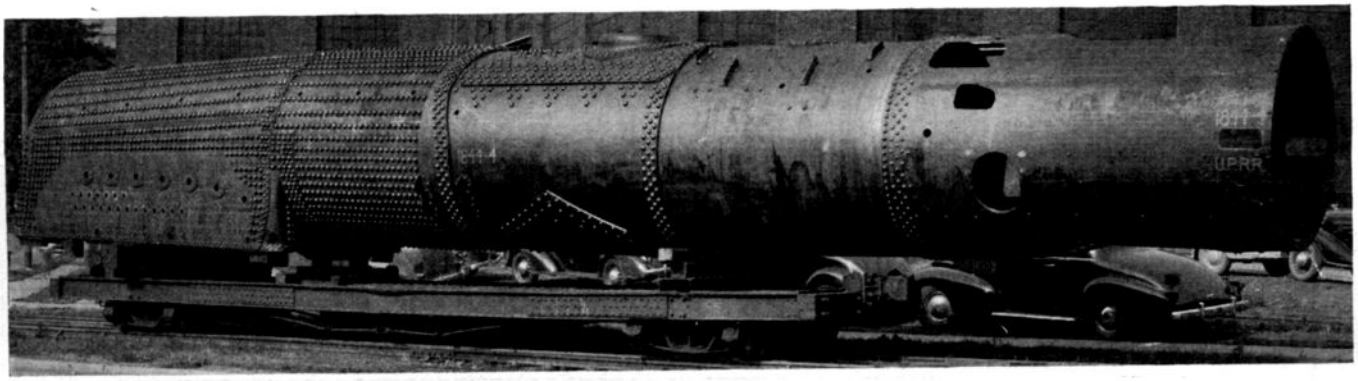
The Firebar grates have 15 per cent air openings. The stoker is the Standard Type MB with the stoker engine installed in the tender. The boiler feed equipment includes a Nathan live-steam injector on the right side and an Elesco exhaust-steam injector with remote control and centrifugal pump on the left side.

The exhaust-steam injector is the recently developed type TP. It is started and stopped by a simple starting valve. The amount of water delivered to the boiler is regulated by an indexing handle in the cab which is the only manual control and does not need to be moved when the injector is shut off. The operation is entirely automatic once the starting valve is opened. The centrifugal booster pump is added to the type TP injector so that the choice of location on the locomotive is not limited by the non-lifting characteristic of the injector itself, and on these locomotives the exhaust-steam injector is located on the left side of the smokebox.

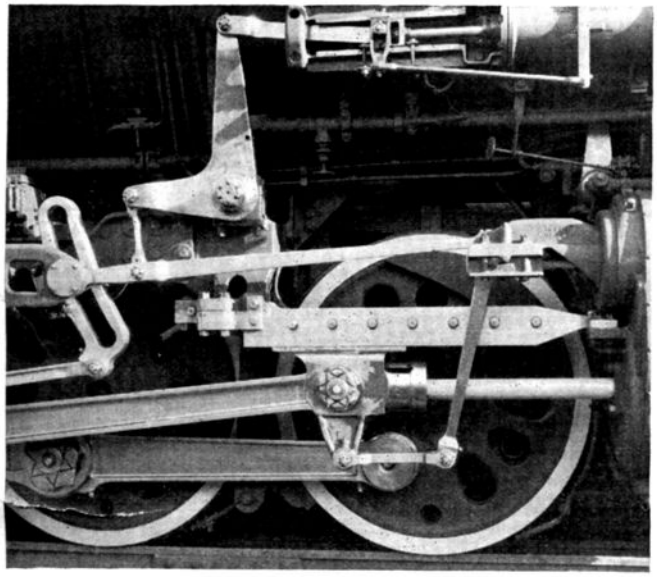
The Type E superheater has 93 units. These units, which are inserted in 4-in. flues, are $1^{3}/_{8}$ in. in diameter. The multiple throttle includes an auxiliary throttle, supplied with saturated steam from the dome, for drifting and handling the locomotives by hostlers at terminals. The throttle has a double quadrant and latch to permit

General Dimensions and Weights of the Union Pacific 4-8-8-4 Type Locomotives

Railroad	Union Pacific
Builder	American Loco. Co.
Type of locomotive	4-8-8-4
Road numbers	4000-4019
Date built	1941
Service	Fast frt.
Rated tractive force, engine, lb.	135,375
Weights in working order, lb.:	
On drivers	540,000
On front truck	97,000
On trailing truck	125,000
Total engine	762,000
Tender	435,800
Wheel bases, ft.-in.:	
Driving, total	47-3
Front and rear engine, each	18-3
Engine, total	72-5½
Engine and tender, total	117-7
Driving wheels, diameter outside tires, in.	68
Cylinders, number, diameter and stroke, in.	4-23¾x32
Valve gear, type	Walschaert
Valves, piston type, size, in.	12
Maximum travel, in.	7
Boiler:	
Steam pressure, lb.	300
Diameter, first ring, inside, in.	95
Firebox length, in.	235 1/32
Firebox width, in.	96 3/16
Combustion chamber length, in.	112
Security circulators, number	7
Tubes, number and diameter, in.	75-2¼
Flues, number and diameter, in.	184-4
Length over tube sheets, ft.-in.	22-0
Fuel	Soft coal
Grate area, sq. ft.	150
Heating surfaces, sq. ft.:	
Firebox and comb. chamber	593
Security circulators	111
Firebox, total	704
Tubes and flues	5,185
Evaporative, total	5,889
Superheater	2,466
Comb. evap. and superheater	8,355
Tender:	
Type	Water bottom
Water capacity, gal.	250,000
Fuel capacity, tons	28
Trucks (one)	4-wheel



The Boiler of One of the Union Pacific Locomotives



Running-Gear Details of a Rear Engine Unit

half-notch adjustment. It provides additional head room in the cab.

The front-end arrangement consists of two complete stacks and exhaust nozzles on a common base, one for each of the two engine units. Each exhaust tip has four jets. Each stack extension includes a four-jet combining tube at the bottom which resembles somewhat the formerly much-used petticoat pipe in its relation to the stack extension proper. These jet-combining tubes comprise in effect four draft tubes, one for each exhaust jet, and the setting is such that the jet fills the tube near the top. As the exhaust jets pass into the upper part of the stack extension, further injector action is effected in the annular passage between the top of the draft tubes and the stack-extension bell.

The labyrinth front-end draft appliance is a patented device developed on the Union Pacific. Instead of the customary arrangement of table plate, the exhaust nozzles and smoke stacks are enclosed at the sides by longitudinal sheets which slope from the arch of the smokebox to the top of the exhaust stands. Thus, the gas passages to the front of the smokebox range from 96 to 112 per cent of the net gas area through the tubes and flues.

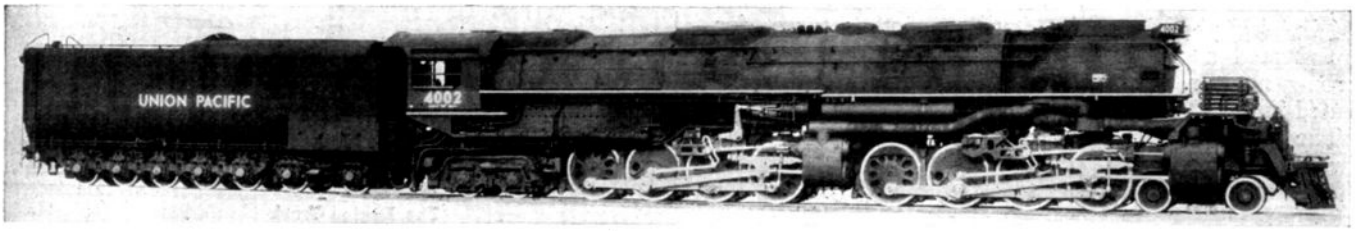
The front of the space about the stacks and nozzles is partially closed by a vertical plate, the top of which is 22¼ in. above the center line of the boiler. The gases pass through the space between this plate and the smokebox door and over its top through the area between it and the top of the smoke arch through the labyrinth draft appliance. The areas of these passages are in excess of the net gas area through the tubes and flues.

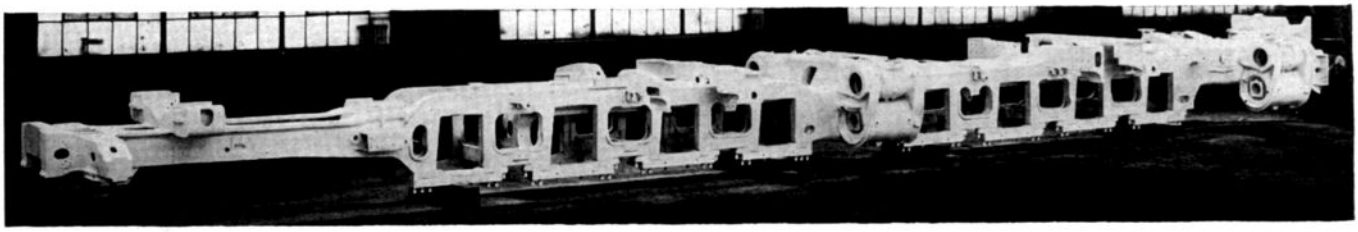
The cab is completely supported from the boiler. It is insulated with Fiberglas and lined with Masonite. It has Prime clear-vision windows with air defrosters at the front and windshield wings at the windows on each side. Both the engineman's and fireman's seats, furnished by Heywood-Wakefield, are adjustable both horizontally and vertically. There is a seat for the road foreman on the right side, and a seat for the brakeman on the left side.

These locomotives are equipped with two water columns each having two standard-length water glasses, and the right-hand water column is provided with three gauge cocks. The height of water above the highest point of the crown sheet on level tangent track is 10½ in. with the water level in the boiler at the bottom gauge cock. Each pair of water glasses is applied with a vertical difference of 5½ in. in the lowest water-glass indication. The upper water glass is for indicating the

Partial List of Materials and Equipment on the Union Pacific 4-8-8-4 Type Locomotives

Bases, driving-wheel centers, bumpers and pilots, trailing trucks	General Steel Castings Corp., Eddystone, Pa.
Engine and trailer-truck wheels	Bethlehem Steel Co., Bethlehem, Pa. Carnegie-Illinois Steel Corp., Pittsburgh, Pa.
Lateral-motion device; trailer and driving springs; tires	American Locomotive Co., Railway Steel Spring Div., New York.
Radial buffers; frame wedges; compensator and snubber	Franklin Railway Supply Co., Inc., New York.
Roller bearings	SKF Industries, Philadelphia, Pa. The Timken Roller Bearing Co., Canton, O.
Frame equalizer bushings; shaft arm bushings	Gatke Corp., Chicago.
Engine couplers	Buckeye Steel Castings Co., Columbus, Ohio.
Brakes	Westinghouse Air Brake Co., Wilmerding, Pa.
Brake shoes	American Brake Shoe & Foundry Co., New York.
Brake-pipe conduit	United States Rubber Co., New York.
Air pump intercooler	New York Air Brake Co., New York.
Boiler and firebox plates	Bethlehem Steel Co., Bethlehem, Pa.
Tubes	National Tube Co., Pittsburgh, Pa.
Tube turns	Tube-Turns, Incorporated, Louisville, Ky.
Brick arch; Security circulators	American Arch Co., Inc., New York.
Staybolt material	Jos. T. Ryerson & Son, Chicago. Ulster Iron Works, Dover, N. J.
Flexible stays; expansion stays	Flannery Bolt Co., Bridgeville, Pa.
Rivets	The Champion Rivet Co., Cleveland, Ohio.
Fusible plugs	Nathan Manufacturing Co., New York.
Lock washers	National Lock Washer Co., Newark, N. J.
Stop nuts	Elastic Stop Nut Corp., Union, N. J.
Door hinges	The Homer D. Bronson Co., Beacon Falls, Conn.
Steam pipes; exhaust pipes	National Tube Co., Pittsburgh, Pa.
Pipe clamps	Adirondack Foundries & Steel, Inc., Watervliet, N. Y.
Pipe supports	Symington-Gould Corp., Rochester, N. Y.
Copper pipe	Chase Brass & Copper Co., Waterbury, Conn. Phelps Dodge Copper Products Corporation, New York.
Asbestos tubing	Union Asbestos & Rubber Co., Chicago.
Cylinder and boiler lagging	Johns-Manville Sales Corp., New York.
Multiple throttle	American Throttle Co., New York.
Packing	The Garlock Packing Company, Palmyra, N. Y.
Superheater pipes; exhaust steam injectors	The Superheater Company, New York.
Steam line injectors	Nathan Manufacturing Co., New York.
Foam collapsing system	Electro Chemical Engineering Corp., Chicago.
Coal sprinklers	Wm. Sellers & Co., Inc., Philadelphia, Pa.
Ashpan sprinkler valve	The Lunkenheimer Company, Cincinnati, Ohio.
Washout plugs; circulator plugs	The Prime Manufacturing Co., Milwaukee, Wis.
Hose	Hewitt Rubber Corp., Buffalo, N. Y.
Blow-off cocks	Wilson Engineering Corp., Chicago.
Feed pipe strainer	T-Z Railway Equipment Co., Chicago.
Grates	Waugh Equipment Co., New York.
Firedoors	Franklin Railway Supply Co., Inc., New York.
Stokers	Standard Stoker Co., Inc., New York.
Stoker flexible joints	Barco Manufacturing Co., Chicago.
Cab insulation; ventilators	Gustin-Bacon Mfg. Co., Kansas City, Mo.
Cab roof; side walls	Masonite Corp., Chicago.
Clear vision windows	The Prime Manufacturing Co., Milwaukee, Wis.
Shatterproof glass	Pittsburgh Plate Glass Co., Pittsburgh, Pa.
Floor plates	Carnegie-Illinois Steel Corp., Pittsburgh, Pa.





The Front and Rear Engine-Bed Castings

Engineman and firemans seats	Heywood-Wakefield Co., Gardner, Mass.
Seat covering	L. C. Chase & Co., Inc., New York.
Water gages; gage cocks	Nathan Manufacturing Co., New York.
Safety valves; boiler checks	Manning, Maxwell & Moore, Inc., Locomotive Equipment Division, Bridgeport, Conn.
Steam-heat gages; back-pressure gages; steam gages	Ashton Valve Co., Boston, Mass.
Steam-heat flexible joints	Franklin Railway Supply Co., Inc., New York.
Gage holders	T-Z Railway Equipment Co., Chicago.
Cocks and valves	Crane Co., Chicago. The Lunkenheimer Co., Cincinnati, Ohio. Walworth Company, New York.
Whistle	Manning, Maxwell & Moore, Inc., Locomotive Equipment Division, Bridgeport, Conn.
Bell ringer	Railway Service and Supply Corp., Indianapolis, Ind.
Sander equipment	Morris B. Brewster Company, Chicago.
Headlights and headlight generator	The Pyle-National Company, Chicago.
Classification lamps	The Adams & Westlake Co., Elkhart, Ind.
Ball joints	Barco Manufacturing Co., Chicago.
Universal joints	Manning, Maxwell & Moore, Inc., Locomotive Equipment Division, Bridgeport, Conn.
Flexible conductor	Kerite Insulated Wire & Cable Co., New York.
Cylinder and piston-valve bushings; piston valves	Hunt-Spiller Manufacturing Corporation, Boston, Mass.
Pistons	Locomotive Finished Material Co., Atchison, Kan.
Piston-rod and valve-stem packing	Paxton-Mitchell Co., Omaha, Neb.
Rod brasses; hub liners; crosshead liners; eccentric crank liners; expansion shoe wearing plates; frame shoes; bells; steam metal	Magnus Metal Corporation, Chicago.
Crossheads	Vanadium Corporation of America, New York.
Steel for crank pins, driving axles, main and side rods, and valve-gear details	The International Nickel Company, New York.
Drifting valves	Kieley & Mueller, Inc., New York.
McGill needle roller bearings (valve gear)	Pilliod Co., New York.
Cylinder cocks	The Prime Manufacturing Co., Milwaukee, Wis.
Drain cocks	The Okadee Company, Chicago.
Reverse gear	American Locomotive Co., New York.
Lubricators	Nathan Manufacturing Co., New York.
Lubricator dividers and terminal checks	Detroit Lubricator Co., Detroit, Mich.
Alemite grease	Socony Vacuum Oil Co., Inc., New York.
Rod grease	The Texas Company, New York.
Grease fittings	The Prime Manufacturing Co., Milwaukee, Wis.
Tender:	
Frames; lateral-motion device; front truck	General Steel Castings Corp., Eddystone, Pa.
Wheels	Bethlehem Steel Co., Bethlehem, Pa. Carnegie-Illinois Steel Corp., Pittsburgh, Pa.
Roller bearings	The Timken Roller Bearing Co., Canton, Ohio.
Clasp brakes	American Steel Foundries, Chicago.
Draft gear	W. H. Miner, Inc., Chicago.
Couplers	National Malleable and Steel Castings Co., Cleveland, Ohio.
Tank plates	Bethlehem Steel Co., Bethlehem, Pa.
Steam-heat pipe covering	Union Asbestos & Rubber Co., Chicago.
Paint	E. I. du Pont de Nemours & Co., Wilmington, Del. The Glidden Co., Cleveland, Ohio. Sherwin Williams Co., Cleveland, Ohio.

height of the water in the boiler on level track or ascending grades, and the lower water glass is for indicating the height of the water in the boiler on descending grades.

There are two saturated-steam turrets in front of the cab, one on either side. Each is supplied through a 3½-in. dry pipe from the dome. Another turret for superheated steam supplies the air pumps, stoker and turbo-generator. The whistle is also operated by superheated steam.

The air-brake equipment is Westinghouse No. 8 ET. Two 8½-in. cross-compound compressors are mounted on the front end of the forward engine bed. Each compressor is served by a mechanically operated lubricator. Shields in front of the air compressors protect the air-brake fin-tube radiation. There is 15 ft. of radiation pipe between the air pumps and a sump reservoir and an eight-tube New York Air Brake intercooler between the sump reservoir and the main reservoir. In the sump reservoir is an automatic drain valve.

Single brake heads with two flanged brake shoes per head are applied on the driving wheels. A single long brake shoe is applied on the rear of each trailer-truck wheel. The engine truck is designed for the future application of brakes. There are anti-rattler devices throughout the brake rigging.

The Pilot and Bumper

The pilot is cast integral with the front bumper beam and the latter is provided with a rubber bumper. The top section of the pilot consists of a swing-type coupler furnished by the Buckeye Steel Castings Company, which, when in closed position, fits the contour of the pilot and removes all obstructions.

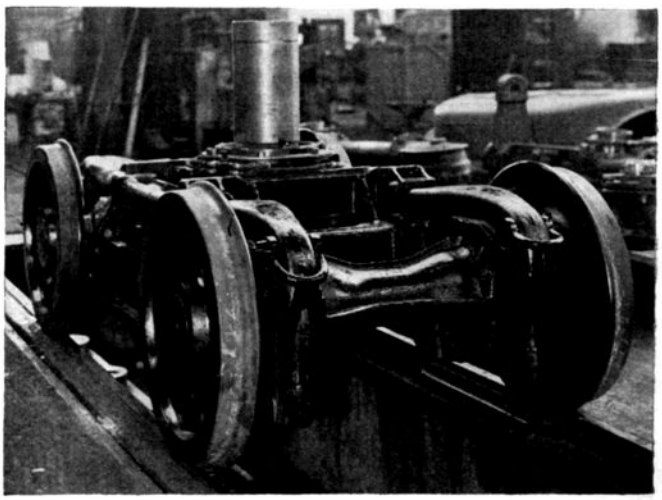
The Tender

The tenders are built on General Steel Castings water-bottom beds. They are carried on a four-wheel truck at the front end and five pairs of wheels mounted in pedestals cast integral with the tender bed. The equalizing system provides a three-point-load suspension. All wheels are 42 in. in diameter and have Timken roller bearings in outside journal boxes.

The four-wheel tender truck is equalized and has a roller centering device designed for 17 per cent initial and constant lateral resistance. There are no side bearings on the tender truck.

The five pairs of pedestal-mounted wheels are equalized together on each side of the tender, with one semi-

(Continued on page 528)



The Engine Truck

Union Pacific Gets Heaviest Articulated Locomotives

(*Continued from page 526*)

elliptic spring and two coil springs over each box. The front and back ends of each equalizing system are anchored to the bed casting through double cushioning coils in tandem. Casehardened spring rigging pins are fitted in Graphitex bushings.

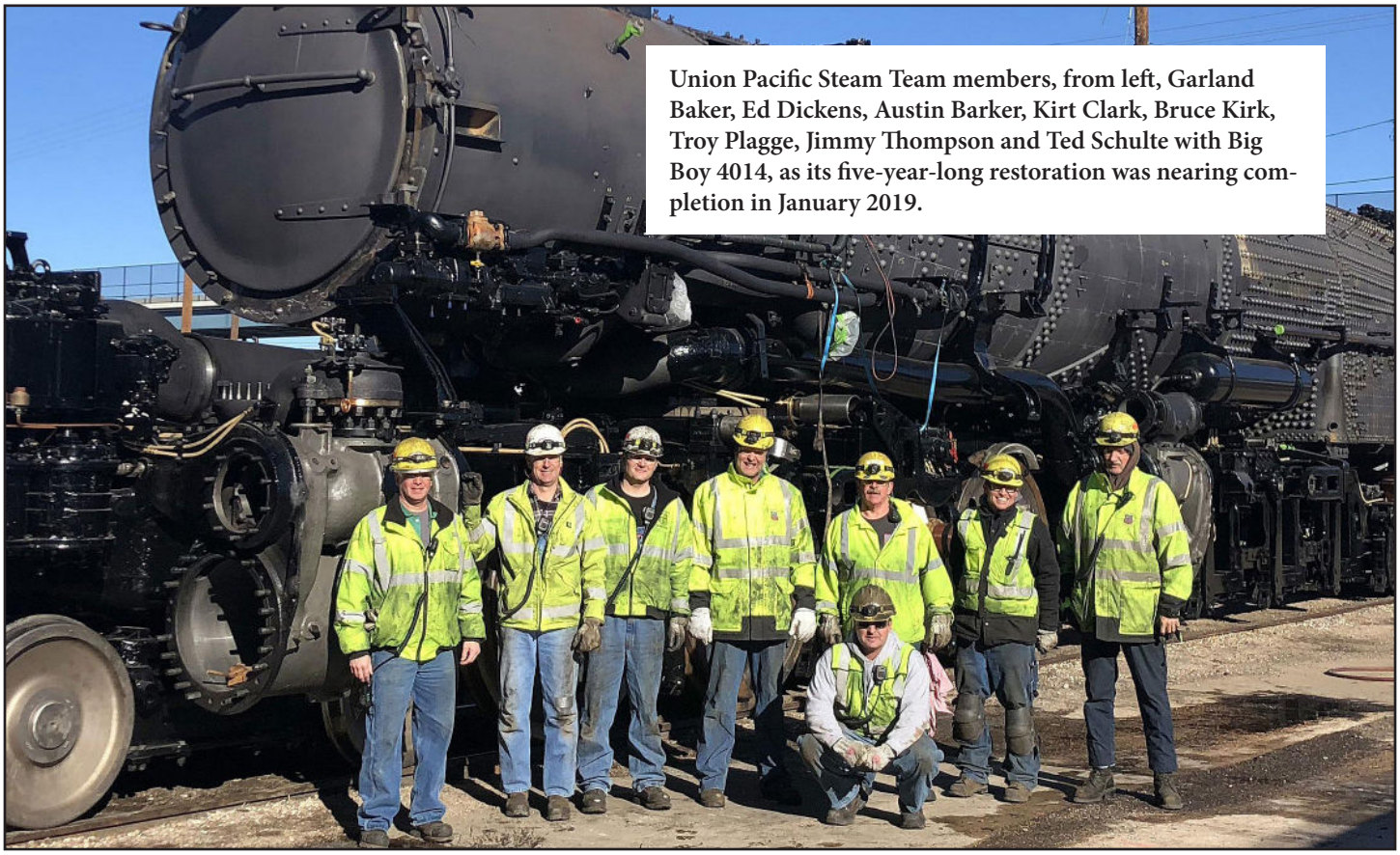
All five pairs of wheels mounted in fixed pedestals are fitted with the General Steel Castings centering device. This consists of rubber blocks, sandwiched between steel plates, which are inserted between the semi-elliptic spring saddles and the top of each box. The vertical guides for the spring saddle on the frame prevent lateral movement of the top of this device but do not interfere with the lateral movement of the journal boxes against the resistance of the shear distortion of the rubber. On the four forward pairs of fixed wheels provision is made for a lateral movement of 1¼ in. On the rear pair of wheels the movement is restricted to ¾ in.*

A Nathan DV-7 lubricator with eight feeds is mounted on the tender bed and driven from the stoker engine. These feeds supply oil to all tender-truck boxes and to the tender-truck center plate.

Between the engine and tender there is a Franklin E2 radial buffer. The engine and tender connections include U. S. armored rubber hose for the air-brake lines; Franklin metallic joints in the steam-heat train line, and Barco flexible joints in the stoker steam connections.

Couplers, furnished by the National Malleable and Steel Castings Company, and Miner A94XB draft gears are installed at the rear of the tender.

The general dimensions and weights of these locomotives are shown in a table. Another shows a partial list of manufacturers whose materials and equipment form a part of the locomotives.



Union Pacific Steam Team members, from left, Garland Baker, Ed Dickens, Austin Barker, Kirt Clark, Bruce Kirk, Troy Plagge, Jimmy Thompson and Ted Schulte with Big Boy 4014, as its five-year-long restoration was nearing completion in January 2019.

Three photos: Union Pacific