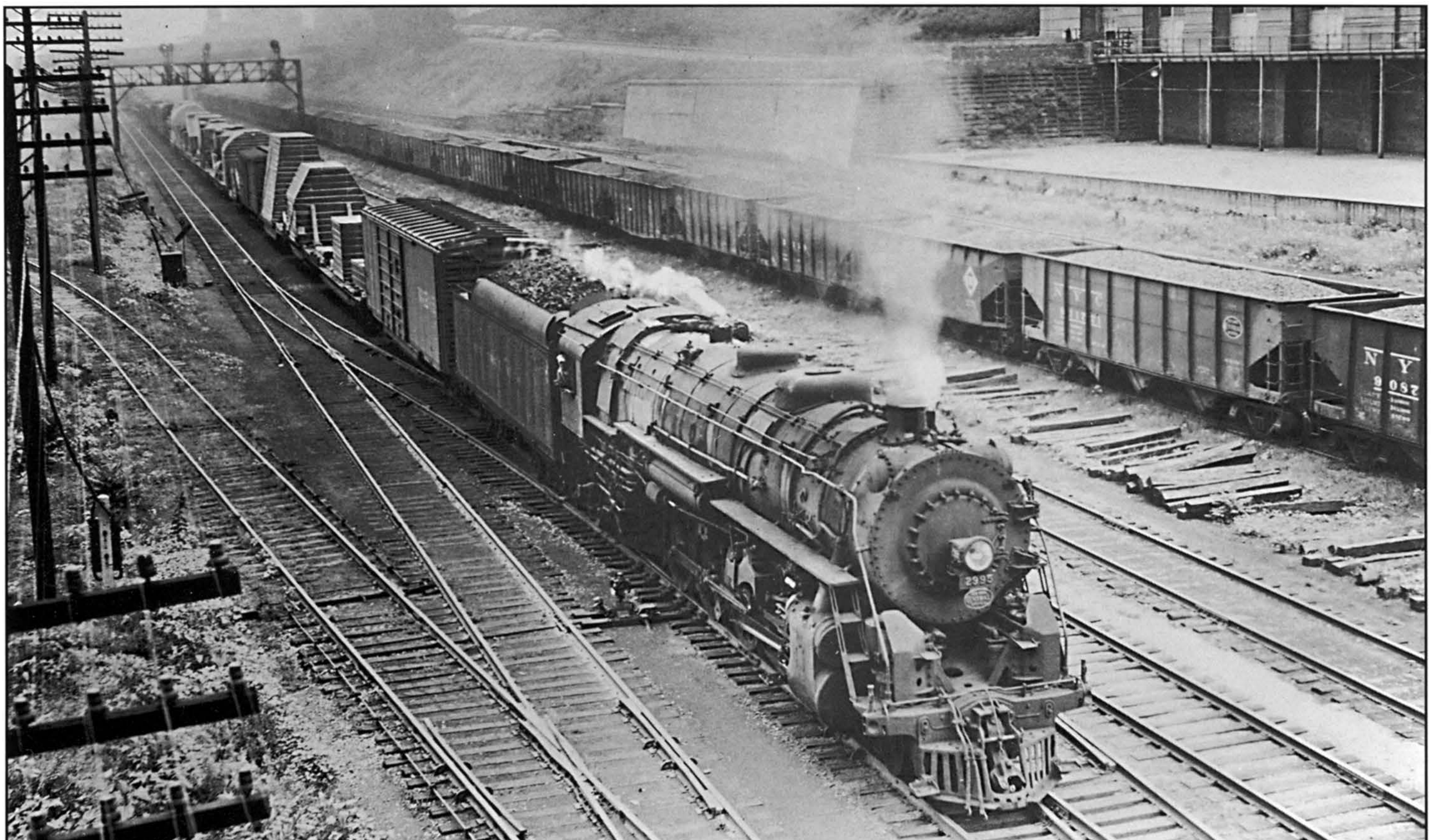
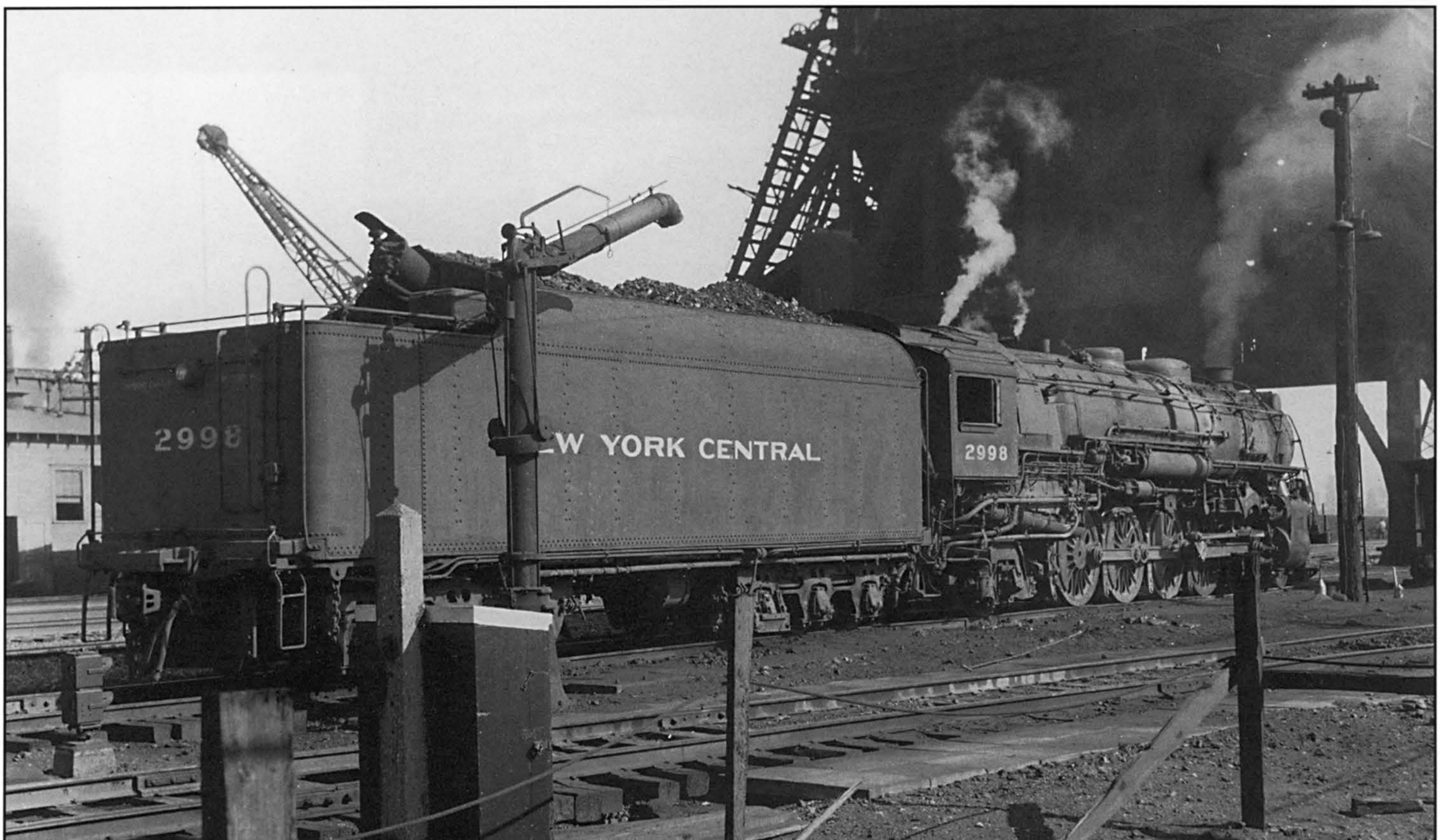


Class L2d (converted) 2995 with a westbound freight on the lake front line, Cleveland, Ohio. Special train for the west coast with war material, August 23, 1943. Now it can be revealed that the boxed items are stators, rotors and condensers from Schenectady and Oswego, N.Y. NYCS photo, neg. no. 6440.



Class L2d (converted) 2998 at Wesleyville, Pa. main line coal dock, October 1948. Engine faces east. Tenders on the 2995 and 2998 were unique, passenger style collars, no overflow control. Note Union Steel Casting Co. Web Spoke driving wheel centers. Photo by H. L. Vail, Jr.

The Late Mohawks

T. R. Gerbracht

I would like to describe and review the performance of the "late" Mohawks obtained by the New York Central, and acquaint readers of the *Central Headlight* with the characteristics and the performance of these fine locomotives, which were obtained by the New York Central starting in 1940. I have also included a table of weights and dimensions of the L3's and L4's, which demonstrate the evolution of the Mohawk type on the Central from the late 1920's to the final design, which was produced in 1943-44. It is significant that there were very few 4-8-2 type locomotives built after the NYC L4b class. By this time, many roads which required a locomotive with four driving axles had developed 4-8-4's.

The extended life of the basic NYC Mohawk probably reflected the conservative motive power policy and the somewhat unique topographical characteristics of the railroad itself. The absence of severe grades and the high traffic level permitted the operation of high horsepower locomotives with relatively low axle loadings and total weight. System-wide restrictive clearances limited absolute boiler and driving wheel diameter, which was a compromise so that a nominal height of fifteen feet was not exceeded. (The ninety-four inch boiler and seventy-two inch driving wheels of the L4 class "used up" thirteen feet ten inches of the nominal fifteen foot main line vertical clearance!) The L4 Mohawks were almost the final 4-8-2's built for U.S. service, and the final 4-8-2's built in quantity.

In the annals of motive power history of the New York Central, the Mohawks are overshadowed by their contemporaries, the wonderful J3a Hudsons, and by their outstanding successors and the ultimate steam locomotives, the Niagaras. The Hudsons and Mohawks formed the lineage used by the Central to develop the Niagara. A 4-8-2 larger than the L4b was being considered as an evolutionary development of the then current L4b. An analysis of the required boiler evaporation, and the size and weight of the boiler required to reach this evaporation resulted in the need for a 4-8-4 wheel arrangement, which became the Niagara.

In the years just prior to World War II, the Central began to see the need for a further evolution of their standard freight locomotive. The contemporary Mohawk, the L2d class, was last built in 1929, and the design was almost ten years old. The L2d's were doing a great job hauling freight, but there were technical developments which were available in the late 1930's which were being included in new locomotive designs, and their advantages were obvious.

Industry Trends

Boiler Pressure

Locomotives were being placed in service on other railroads with boiler pressures of up to 300 psi. By 1938, Union Pacific, Norfolk and Western and Santa Fe had all taken delivery of locomotives which ran at 300 psi steam pressure.[1] The Santa Fe and Kansas City Southern 2-10-4 Texas type locomotives which were delivered in 1937-1938 ran with 310 psi, the highest boiler pressure ever used for a conventional radial stay locomotive boiler. The New York Central's L2d's ran at 225 psi, the same as the J1 Hudsons. The use of higher boiler pressure implied higher boiler maintenance cost, but the feeling in motive power circles was that the greater steam energy provided by the higher pressure resulted in a savings in fuel and water. The higher boiler pressure meant that locomotives could be run at shorter cutoffs, with resultant savings in coal and water.

Running Gear

The use of higher boiler pressure also meant that the size and weight of the running gear, including cylinder and piston size and main and side rod weight could be reduced and provide the same power as a locomotive with larger cylinders and running at a lower boiler pressure. The Central had just proven this theory with the J3a Hudsons. The cylinder diameter of the J1 Hudson of the 1927-1931 period was 25 inches, with a stroke of 28 inches. In contrast, the J3a Hudson of 1937-1938 had a cylinder diameter of 22 inches and a stroke of 29 inches.[2] The high speed performance of the running gear of the J3a was significantly different than that of the J1 in terms of reduction in frame forces on the J3. More importantly, the J3 running gear design delivered a significant reduction in dynamic augment, or rail pound, compared with the J1. This was due to the use of lighter main and side rods and the corresponding need for less driving wheel counterbalance.

Boxpok and Disc Driving Wheels

By the mid 1930's, both General Steel Castings (GSC) and Scullin Steel had developed stronger but lighter weight driving wheel designs, which would eliminate most of the problems with spoked wheels. The Boxpok, or box-section-spoke wheel, and the Scullin wheel were each designed with added rim strength and material added in other high stress areas. One problem with spoked wheels was their tendency to flatten on those parts of the wheel circumference not directly supported by a spoke. On many railroads, spokes would develop cracks due to stresses, and these cracks were normally repaired by welding. The weight distribution in spoked wheels was not very closely controlled, and as a result this wheel type was difficult to counterbalance. New wheel designs by GSC and by Scullin were designed to greatly reduce or eliminate many of these problems.

By the late 1930's, NYC had first-hand experience with roller bearings and Boxpok and Scullin driving wheel designs on the J3a Hudsons. There may have been a desire to further evolve a good freight engine, the L2d, by including these cost saving features. This was a significant decision, as neither feature was in widespread use, even on high speed passenger engines.

Main Frames

The L2d Mohawks were built in 1929 with bolted main frames. Maintaining frame tightness and alignment on a locomotive equipped with a bolted frame was

(Continued on page 15)

A modern Mohawk predecessor. Class L2a 2733 (Alco, 1926) at Harmon, N.Y. November 1, 1936.
Photo by George E. Votava.

Class L2c 2836 (Alco, 1929) at Elkhart, Indiana, September 16, 1946.
Photo by Luvergne G. Isaac.

Class L2c 2837 (Alco, 1929) at Elkhart, Indiana, October 23, 1947.
Photo by Luvergne G. Isaac.

Class L2d 2983 (Alco, 1930) at Elkhart, Indiana.
Photo by Robert C. Schell, Jr., Spaugh collection.

Class L3a 3001 (Alco, 1940) at Elkhart, Indiana, new.
Photo by Robert C. Schell, Jr., Spaugh collection.

Class L3a 3001 on train no. 27, the *New England States*, at Riverside, Mass., March 1946.
Edson collection.

The Late Mohawks . . . *(continued from page 11)*

labor intensive. The General Steel Castings (GSC) one piece frame was first offered in 1929, and by 1936 almost all of the J1 Hudsons were equipped with this outstanding technical innovation.[3] The new J3a class, delivered in late 1937 through April, 1938, were built with a GSC cast steel frame. The one-piece frame resulted in an increase in total engine weight compared with the built-up frame. However, the one-piece frame maintained perfect alignment as well as providing uniform wear rates of the running gear. Frame related maintenance was eliminated due to the elimination of bolted joints. The one-piece frame and the use of roller bearing driving boxes were the two innovations which separated the lumbering, low speed steam locomotives from the high speed designs for both passenger and freight service which came later.

There was another significant advantage of the cast steel frame. The cylinders could be cast integral with the frame. Cast steel cylinders were much stronger than iron cylinders, and their use was consistent with the use of higher boiler pressures and the new lubricants which were being developed to be useful in locomotive designs with higher boiler pressures and boiler and superheater combinations which could provide superheat temperatures in excess of 700 degrees F.

Roller Bearings

By 1940, roller bearing journals were in the early stages of acceptance by railroads as a result of the outstanding performance of the Timken "Four Aces" 4-8-4, which was built and started its barnstorming tour in 1930. The "Four Aces", Road No. 1111, was a "Spec." locomotive built by Timken as a demonstrator of the advantages of roller bearings. The locomotive demonstrated on fourteen U.S. railroads before it was purchased by the Northern Pacific. The overall height of this locomotive, 15'-3" made it suitable for use on the Central, and it did demonstrate on the NYC, the PRR, the Milwaukee, and others. During its demonstration, the locomotive proved unusually reliable, and there was never a road failure attributed to the use of roller bearings.[4]

The extra cost of roller bearings over friction bearings was certainly questioned by the railroads, who were just recovering from the Depression. Those railroads which did accept the advantages of roller bearings normally specified roller bearings for high speed passenger power, and most freight engines used the standard brass friction bearings until after World War II ended. (There were some notable exceptions, such as Union Pacific, N&W, and some others.) For those who did want roller bearings during the War, premium bearing steel was in short supply and many railroads were forced to use outdated friction bearing technology. Based on the excellent performance of roller bearings on J1e Hudsons #5343 and #5344, and the performance of the J3's, a new design would certainly include a complete application of roller bearings on all axles of the engine and tender.

A steam locomotive has a rising power characteristic. That is, as speed increases, steam locomotives produce more power up to the evaporation limit of the boiler. In contrast, diesel-electric locomotives have an almost constant power characteristic, since their electric transmissions provide this flexibility over their entire speed range. Since all main line steam locomotives are most productive at speeds of 40 mph or more, the two developments of cast steel frames and roller bearings really made steam locomotives more cost competitive with diesel locomotives, when the measurement was locomotive productivity, or work accomplished per unit of time.

Economic Factors

Based on documented evidence, there were also economic factors favoring a locomotive which would be acceptable for either passenger or freight service. New York Central motive power, and that of most other railroads, was either passenger or freight, but was not generally used for both types of service. (On some parts of the railroad, Hudsons could be found in light freight service on break-in or in situations where an engine was immediately required and a freight engine was not available, but this was not a general practice.) NYC, in its motive power history, did successfully develop a dual-service 4-6-2 in 1910, the K11 class. A modern dual-service locomotive would permit much greater flexibility in assigning motive power, and permit much higher locomotive utilization. The next available dual-service engine could be assigned to the next train, whether it was passenger or freight.

The L2 Test Engines

In 1939, Paul Kiefer, Chief Engineer Motive Power and Rolling Stock of the Central, authorized the modification of two L2d Mohawks with those changes which his team believed were necessary to evolve the basic 4-8-2 design into one capable of 80 mph speeds, a modern dual service locomotive.[5] Two late L2d's were chosen, road numbers 2995 and 2998. The reasons why the Mohawk design was chosen for further evolution is unclear. By this time, the Central was obviously convinced of the value of a large firebox with its large direct heating surface, and the need for a four-wheel trailing truck to support it. The B&A class A1 2-8-4 of 1925 and the success of the Hudson should have led directly to a 4-8-4. By 1940, there were very capable 4-8-4 designs on many railroads, and a few of them were dual service designs. It could be that the early signs of an impending war would not permit the time to develop and build an all new design. The New York Central Hudsons with three driving axles were already highly evolved, and, in retrospect, there would never be a finer evolution of a six-coupled steam locomotive than the J3a. A four-driving-axle design would have more growth potential and, with the possibility of war, Kiefer might have visualized that extreme demands would be placed on motive power, requiring a more versatile locomotive which could do dual service.

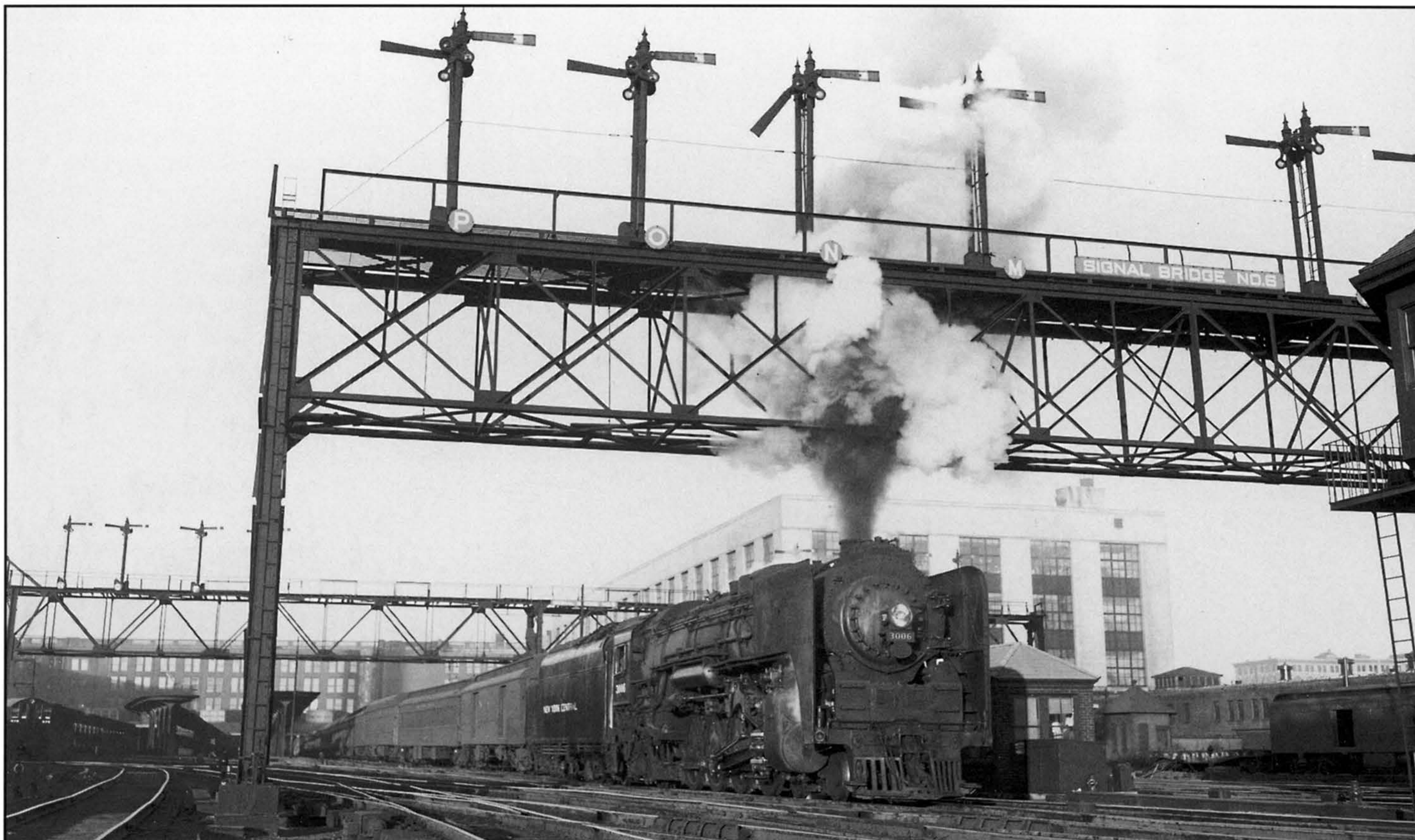
Reduced Reciprocating and Revolving Weight

Kiefer paid particular attention to the running gear and its required balance on the two L2 test locomotives, a requirement for a 69 inch drivered freight engine to operate successfully and cost effectively at 80 mph. As a starting point to reduce the weight of the reciprocating (vs. the rotating) parts, Kiefer bushed the cylinders to reduce the diameter of each piston from 27 inches to 25-1/2 inches,[6] which also reduced the weight of each piston by 11%. Timken lightweight crossheads were used, which further reduced the reciprocating weight. A light

(Continued on page 19)

Class L3a 3004 on Train no. 33, the *New England Wolverine*, at South Station, Boston, Mass., April 16, 1951, ready to depart on the last steam run from Boston on the B.&A. Edson collection.

Class L3a 3006 westbound at Newtonville, Mass. The Massachusetts Turnpike now occupies the two right tracks and the scene is completely changed. Edson collection.



Class L3a 3006 on train no. 27, the *New England States*, at South Station, Boston, Mass., November 27, 1946.
NYCS negative 7533-2, Edson collection.

Class L3a 3008 westbound at Wellesley Farms, Mass., February 18, 1947.
Edson collection.

Class L3a 3008, westbound, taking water at Worcester, Mass. station, June 8, 1946.
NYCS neg. no. 7324-3.

Class L3a 3011 at the Elkhart, Indiana coal dock. Photo by Robert C. Schell, Jr., Spaugh collection.

The Late Mohawks . . . *(continued from page 15)*

weight set of main and side rods were used, which reduced revolving weight, requiring less counterbalance weight.[7] By increasing the boiler pressure from 225 psi to 250 psi, Paul Kiefer was able to maintain essentially the same starting tractive effort in spite of the use of smaller cylinders, which would be a requirement for a dual-service locomotive in freight service. The original locomotive class had a calculated starting tractive effort of 60,620 lb. from the main engine. The modifications resulted in a calculated starting tractive effort of 60,080 lb. (Publicity showed 60,100 lb.) The trailer axle mounted a two-cylinder, steam-driven booster engine, which was retained at least on 2998, could be used to add another 13,750 lb. of tractive effort. (at 250 psi.)[8]

Cross Balance of Driving Wheels

Both engines had their four sets of driving wheels cross balanced.[9] The British derived the formulae for this process in the mid 1930's, and the Hudsons were the first New York Central locomotives to which cross balancing was applied.[10] Cross balancing was accomplished by adding a relatively small amount of additional counterbalance weight to each driving wheel, in addition to the weight necessary to balance the main and side rods. This additional weight was located to counteract the downward acceleration of the main rod and side rods as the wheel sets rotated, and which had a tendency to lift the driving wheel <u>on the opposite side</u> of the locomotive. The forces and reactions of each wheel set assembly were "coupled" as a rigid assembly at each end of each driving axle. This added wheel weight was calculated and positioned in order to significantly reduce the effect of these "coupled" forces.

Due to the intrinsic nature of a double-acting steam-driven piston engine on each side of a two-cylinder locomotive and the relative location of each set of side rods, these power pulses fluctuated in the shape of a sine wave on each side of the locomotive as each complete driving wheel revolution was made. These coupled forces cannot be completely eliminated by balancing in a system which uses externally coupled side rods. One reason for the inability to completely balance the assemblies is the fact that the center of mass of the side rods cannot be in the same plane as the driving wheel counterweights, since the rods have to pass over the face of the counterweights for the wheels to rotate.

There is a second reason which makes a complete dynamic balance impossible. On U. S. two-cylinder steam locomotives, the set of rods on the right side of the locomotive were quartered on the driving wheels ninety degrees ahead of the rods on the left side of the engine. For example, if an engine was stopped with the side rod location on the engineer's side of the locomotive at the six o'clock position on the driving wheels, the set of rods on the fireman's side of the engine would be located at the nine o'clock position on the wheel face. With the rod locations established in this way with respect to one another, it would not be possible to have a steam locomotive stop and its rods to be in a position where it could not restart, which might be the case if the rods on one side of the engine were exactly 180 degrees opposite those on the other side. This relative rod positioning was called right hand lead. (The Pennsylvania Railroad used left hand lead on all of its engines, the only U.S. railroad to do so.)

The relatively little additional weight added to each driving wheel to balance for couples was extremely successful in permitting a smoother running engine which could run at shorter cutoffs, while greatly reducing damage to rail and roadbed. By the use of lightweight revolving and reciprocating parts, Kiefer was able to reduce the dynamic augment at each wheel set. A standard L2 had a dynamic augment or rail pound of 13,900 lb. on the #1 and #4 wheel sets, and 15,400 lb. on the main drivers and the #3 drivers. The converted #2998 had a dynamic augment of 7,950 lb. on the main driver set, at driving wheel diameter speed which, for this example, was 69 mph.[11]

Roller Bearings

Of the two engines, only #2998 received a complete set of roller bearings on all engine and tender axles. (No. 2995 retained its brass bearings on its driving axles.)[12] Both engines received lightweight main and side rods and lightweight crossheads and pistons. In spite of the use of lightweight reciprocating parts, total engine weight in working order increased from 367,000 lb. to 385,100 lb.[13]

Other Changes

Both engines received other modifications which were applied to contemporary passenger power, such as a cast pilot with drop coupler, and the application of new number plates with the famous NYC oval.[14]

The tender used behind the two converted L2's was also unique. Although its general dimensions were identical to other L2d Mohawks, sheet D-158 of Dimensions and Classification of Locomotives of the New York Central System shows a surge tank at the top of the water space of the tender, required for the higher water scooping speeds for passenger service.

Performance

As result of these modifications and resultant testing at speeds between 60 and 85 mph, the Railroad claimed that rail stresses imposed by these 69-inch drivered converted freight locomotives were no greater than those of 79-inch drivered passenger power.[15] The placard in front of #2998 at the New York World's Fair of 1940 indicated that 3800 cylinder horsepower was available at 45 mph. According to NYC documents, drawbar horsepower was increased from 3330 at 39 mph. to 3640 at 43 mph.[16]

Both engines appeared to have been moderately successful. The changes made to the running gear certainly set the stage for the L3a Mohawks of 1940. The relatively low speed at which peak horsepower occurred, at 43 mph, indicated that Kiefer had more work to do on a capable boiler before a 4-8-2 could approach the high speed performance of a J3 Hudson.

Both L2 Mohawks were really orphans in the passenger pool, in a sea of 255 J1 and J3 Hudsons. Both engines lasted until 1953 however, with #2995 retired on October 9, 1953, and #2998 retired March 27, 1953. Their interest to steam fans is that they were the direct predecessors of the L3 class of 1940.

(Continued on page 23)

Class L3a 3012 at Elkhart, Indiana. Photo by Robert C. Schell, Jr., Spaugh collection.

Class L3a 3012 with train no. 33, the *New England Wolverine*, leaving South Station, Boston, Mass., November 27, 1946. NYCS neg. no. 7533-1.

Class L3a 3016 with train no. 22, the *Lake Shore Limited*, at Worcester, Mass., March 25, 1950. Note the clock tower of the old Worcester station, still standing at that time. Photo from Bob's Photo, Edson collection.

Class L3a 3016 at Union Station, Indianapolis, Indiana, 1955. Photo from Dick Jacobs, Edson collection.

Class L3a 3016 with train no. 433, the *Cleveland-Cincinnati Special*, at Berea, Ohio, 1954.

Class L3a 3022 in freight service. Photo from Edward C. Williams.

The Late Mohawks . . . *(continued from page 19)*

The L3a Class — The First Modern Mohawks

In October of 1940, the New York Central started accepting delivery of 50 L3 class Mohawks.[17] They were described as the first dual-service steam locomotives on the railroad. They were larger in many dimensions and greater in weight than the converted L2d's. The 69 inch standard freight engine driving wheel diameter, which was recommended by the Association of American Railroads (AAR), was retained, and the 25-1/2 x 30 cylinder diameter and stroke was carried over from the converted L2d, as was the 250 psi steam pressure. Paul Kiefer must have had some lingering doubts regarding his final decision of driving wheel diameter, as the cast steel engine bed frame was dimensioned so that 72 inch diameter drivers could be used.[18] The total engine wheel base of the L3 class increased exactly one foot over the L2 class with this decision, from 42'-1" to 43'-1".[19] (The first engine of this class, No. 3000, received, either during construction or as a retrofit, 72 inch driving wheels, and an increase in steam pressure from 250 psi to 260 psi.[20] Kiefer, in taking this action, must have still doubted the ability of a 69 inch drivered locomotive to be successful in passenger service at the speeds NYC ran. He also no doubt knew that, at times, contemporary Hudsons were operated significantly in excess of the official 80 mph speed limit, and reports of higher speeds approaching 100 mph probably concerned him.)

Evaporating and superheating surfaces of the new L3 were made larger than those of the L2 class, and this and other changes resulted in an increase in weight to 388,500 lb.[21] In the twenty-five Alco built L3a dual-service engines with road numbers 3000-3024, Kiefer had essentially modernized an L2d with higher steam pressure and greater heating surface including a larger combustion chamber, Boxpok driving wheels with cross balance, smaller diameter cylinders, a cast steel engine bed, a drop coupler pilot, and a complete set of roller bearings on all engine and tender axles.

Modern Mohawks for Freight

There were also twenty-five L3b engines built, all of them destined for freight service. The L3b class, engines 3025-3049, were identical to the L3a's except for three major items: the use of foot boards in place of a cast pilot, use of friction bearings on the driving boxes in place of roller bearings, and the use of a two-cylinder, steam-driven booster engine on the trailing truck axle.[22] The total weight of the freight L3b's increased, to 393,500 lb., probably due to the addition of the booster which increased tractive force by 13,900 lb., to 74,100 lb. [23] (The builder's card for Lima #3037 shows 74,000 lb.[24]) The L3a class had provision for boosters, but they were never installed.[25]

Detail Differences

There were minor detail differences between the passenger L3a's and the freight L3b's. The passenger L3a's were equipped with Nathan DV-5 lubricators, while the freighters were equipped with Detroit lubricators. The Nathan lubricators used on the passenger engines had 10 feeds and lubricated 37 points. The Detroit lubricators had fourteen feeds and served 53 points. (The roller bearing driving axles of the L3's did not require lubrication of the driving box hub faces or driving box wedges, so no lubrication of these items was required.[26] No wedges are required with roller bearing journals.) Due to the number of points lubricated, the Nathan had a capacity of 26 pints, while the Detroit lubricators had a capacity of 32 pints.

The passenger L3a's were equipped with Franklin F-2 precision reverse gear, while the freight L3b's were equipped with Barco M-13 reverse gear.[27] The passenger L3a's were also equipped with an air signal, train signal, and steam heat.[28]

Of the L3b's, Alco built ten of the engines (3025-3034) and Lima provided 3035-3049, a total of fifteen engines. There were two major differences in appearance between the Alco and the Lima L3b's. The Alcos were equipped with Worthington 5-1/2 SA feed water heaters ahead of the stack, and the Lima engines were equipped with drum style Elesco K5OL heaters in a recess in the smoke box front at the top. The majority opinion is that the appearance of the Lima engines was not enhanced with this placement of the Elesco. Ten of the fifty engines received Union Web Spoke drivers in lieu of Boxpok.[29]

Running Gear

Paul Kiefer carried forward the running gear design approach which was successfully used on the two test bed L2d's, numbers 2995 and 2998. The use of lightweight rods and reduced reciprocating weight was one secret of higher speed. All four driving wheel sets of the L3's were cross balanced. This required the application of 115 lb. per side as added weight to the number one and number four wheels, 166 lb. at the #2 or main wheels, and 132 lb. at the #3 wheels. With this counterbalance added, dynamic augment or rail pound was reduced from 15,400 lb. at the main wheel set of the L2d Mohawk, to 7950 lb. on the L3 at wheel diameter speed. There were similar reductions at the other wheel sets. The #1 and #4 wheel dynamic augment of the L2d was 13,900 lb. On the L3, these values were 5,500 lb.[30]

While the passenger L3a's were equipped with carbon-vanadium driving axles, the L3b's had medium carbon steel axles. On both types, all driving axles were hollow bored, four inches in diameter.[31] Both types used Timken design lightweight crossheads, pistons, and piston rods.

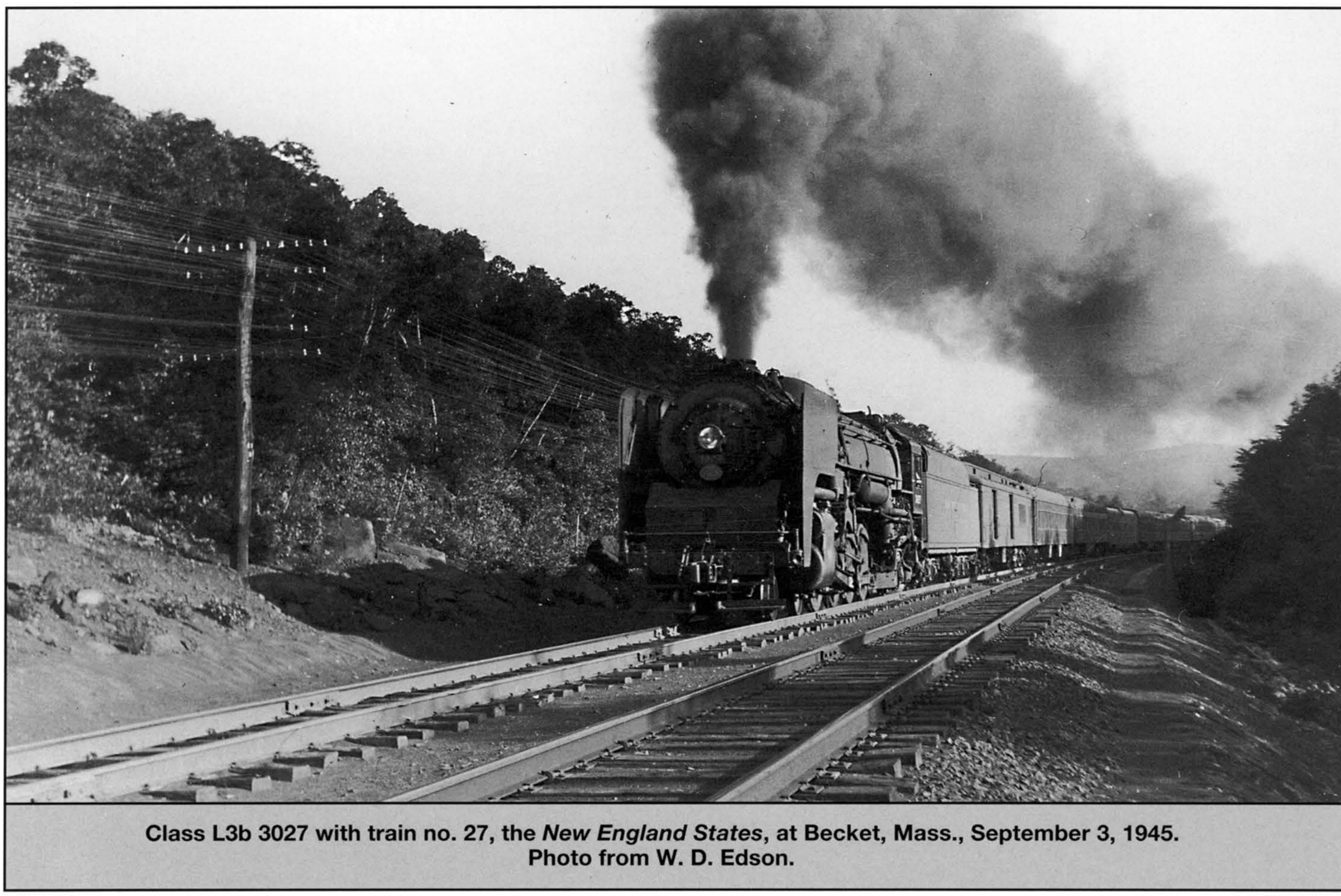
There were additional differences between the passenger L3a class and the friction journal L3b's. On the roller bearing passenger power, the main driving axle journal size was 12-9/16, and the other axle journals were 11-5/8 inches. On the friction journal freight engines, the main driving axle bearing was 12-1/2 by 14 inches, and the other axles were all 11 inches by 13 inches.[32] The Alco passenger engines used the Alco lateral motion device on the #1 and #2 axles, and provision was made for installation on the third (intermediate) and fourth driving axles, if necessary.[33] The freight L3b's were not equipped with lateral motion devices.

On the passenger L3a's, the engine trucks were braked, with a brake cylinder on the truck frame.[34]

On all L3's provision was made for trailing truck brakes. On the freight locomotives, provision for installation of a booster engine was made, and boosters were

(Continued on page 27)

Class L3a 3022 with train no. 312, coming off the River Rouge bridge at Delray, Michigan. Photo from top of way car of 8AM Rouge Liner by Ernest L. Novak, June 29, 1954.



Class L3b 3027 with train no. 27, the *New England States*, at Becket, Mass., September 3, 1945. Photo from W. D. Edson.

Class L3b 3031 at Elkhart, Indiana, October 23, 1946. Photo by Luvergne G. Isaac.

Class L3b 3032 on the turntable at the Elkhart, Indiana roundhouse.
Photo by Robert C. Schell, Jr., Spaugh collection.

Class L3b 3035, new at the Lima Locomotive Works, November 1940. Class L3b 3025-3034 were built by Alco, class L3b 3035-3049 by Lima. Photo by Philip E. Buchert.

Class L3b 3035 westbound at Hoffmans, N.Y., June 27, 1948. Edson collection.

The Late Mohawks . . . *(continued from page 23)*

applied by the railroad.[35] The passenger L3a's also had Graham-White sanders on the trailing truck, with automatic sanding. Since no booster was applied, this must have been for braking.

The Boiler

While the primary design focus for the L3 class was frame and running gear improvements to permit higher speeds, there were differences within the boiler of the L3 class compared with the L2d to provide the necessary steam to increase cylinder and drawbar horsepower. Boiler inside diameter remained the same as that used on the L2 class, at an inside diameter of 82-7/16 inches, and a maximum diameter at the third course of 94 inches. (This was a slightly larger boiler than that used for the J3a Hudsons, which had an inside diameter of 80-5/8 inches, and a maximum diameter of 91-1/2 inches.) The length of the combustion chamber was increased from 51 inches to 63 inches.[36] The number of 2-1/2" diameter tubes were increased from 40 on the L2d to 50 on the L3. Total evaporating surface increased only slightly, from 4555 square feet to 4676 square feet. The direct heating surface of the firebox was increased from 353 to 373 square feet (including arch tubes), probably as a result of the use of the 63-inch combustion chamber on the L3.[37] Tube evaporating surface was actually reduced from 836 square feet to 601 square feet, while flue area went from 3366 square feet to 3702 square feet, a conscious effort by Kiefer to bring the boiler into balance to generate the maximum amount of steam. A larger superheater was used on the L3, with superheating surface increasing from 1931 square feet used on the L2d, to 2082 square feet.[38]

The result of all of this effort was the introduction of the Central's first dual-service engine of modern design. (NYC did design and use dual-service engines in its history. One of the most successful of these designs (after 1900) was the K11 Pacific of 1910. Readers are referred to the excellent summary of the K11 design by a NYCSHS member, Mr. Ray McKnight. This article, titled *The Kay-Eleven's* appeared in the 2nd quarter 1981 issue of the *Central Headlight*.)

The Tenders

The trend to larger, higher capacity tenders was continued with the advent of the L3 Mohawks. The L3 tenders were a new and larger water bottom design. The tenders had a coal capacity of 43 tons, and a water capacity of 15,500 gal. The stoker engine was relocated to a cavity in the water space on the left side of the tender immediately back of the coal space, and accessed for maintenance by a door in the exterior tender wall on the fireman's side of the engine.[39] All tenders used on the L3's when built were equipped with water scoops, with no overflow control. The tender rode on six pairs of rolled 41 inch wheels, and all journals were roller bearing equipped. The L3a tenders were equipped for steam heat for passenger service.[40]

Performance

Photographs and reports exist which indicate that the L3's were tested over the road, and a boiler performance report also exists. A photo of #3016 on test appeared, dated August 19, 1941.[41] A report by W. F. Collins of the New York Central, the genius behind the Selkirk boiler drafting arrangement, compared NYC Hudson #5408 and Mohawk #3022, and reached the conclusion that the Mohawk boiler was superior to the J3a Hudson boiler on the basis of the use of the Worthington feedwater heater in place of the K-40 Elesco with which the J3a's were built.[42] No extensive test report exists for the L3's, but some test figures were published. A *Practical Evaluation of Motive Power,* authored by Kiefer in 1947, shows a maximum indicated horsepower of 5200 at 72 mph. for the L3.[43] The summary article for the L4 class, which appeared in *Railway Mechanical Engineer* in August 1943, quotes a maximum indicated horsepower of 5260 for the L3, and a maximum drawbar horsepower of 4120 at 58 mph.[44] An advertisement by Alco which appeared in the 1941 *Locomotive Cyclopedia* stated that "the dual type group, that is, the 25 equipped to operate at 80 mph., develop approximately 4400 cylinder horsepower at 50 mph."

The L3c Class

The first fifty L3's were so successful that an order was placed for an additional fifteen locomotives from Alco for delivery early in 1942.[45] These final fifteen L3's were class L3c. They were essentially identical to the Alco L3b's except for an increase in weight, to 399,000 lb.[46] They were strictly freight engines, and were placed in the same freight pool as Nos. 3025-3049, and were used all over the System.

The L3a Test Engine

When the Central took delivery of the L3a's, one was either delivered modified or modified soon after delivery. No. 3000 was equipped with 72 inch driving wheels, and 36 inch engine truck wheels in place of the 33 inch wheel sets standard to the L3's. This locomotive was 1-1/2" higher than the remainder of the L3 class with these changes. To preserve starting tractive effort, the steam pressure of this engine was increased from 250 psi to 260 psi.[47]

There is no record of the performance of this engine compared with her sister L3a's, but the changes must have been successful, as the L4's which were built initially in December, 1942 had the larger drivers. (Steam pressure of the L4's reverted to 250 psi, however.)

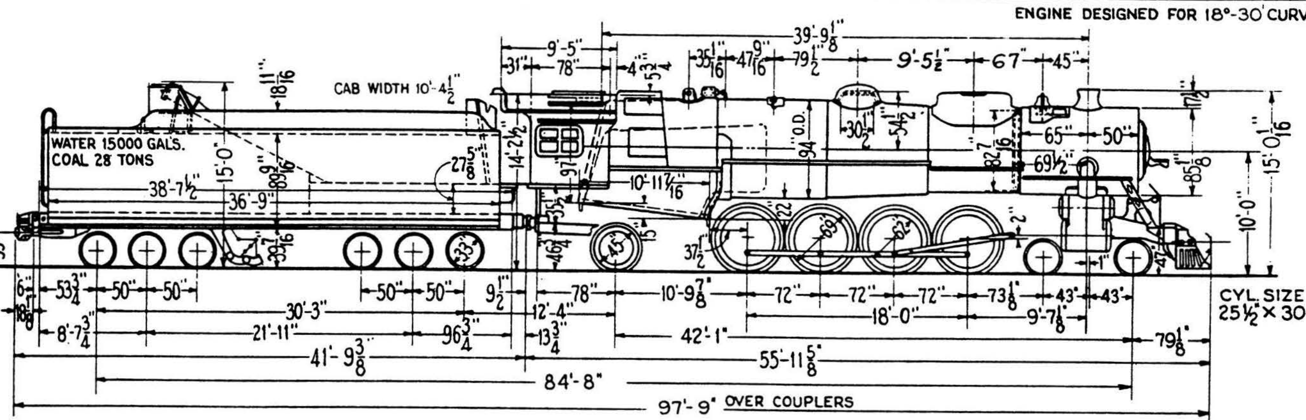
L3's in Service

The passenger L3a's saw extensive use during the War, and were extensively used on heavy passenger and mail and express trains, especially those making numerous stops. In this service their advantages over Hudsons were obvious. Their greater adhesive weight and high capacity tenders (largest on the railroad until the centipede tenders of 1943) permitted faster acceleration from slowdowns and longer sustained runs due to increased tender capacity. After the War, and with dieselization in progress and sufficient Hudsons and new Niagaras on the scene, the passenger L3a's became redundant, and twelve engines were transferred to the Boston and Albany. Using published photos and a West Springfield log book for 1949-1950 as a source, it appears that 3002-3006, 3008, 3010, 3012, 3014, 3016, 3018, 3020-3022, and 3024, and others made it to the B&A. (Some freighters with footboards also saw service on the B&A, including 3033, 3034, 3036, 3044, 3046, 3056, 3060 and 3064.) The L3's were especially useful on the mountainous B&A, and supplanted the B&A's own J-2 Hudsons. L3a Mohawk #3004 actually pulled

(Continued on page 30)

D-158

ENGINE DESIGNED FOR 18°-30' CURVE



STEAM PRESSURE...................... 250 lbs.
KIND OF MAIN VALVE............ 14 in. Piston
FIREBOX, LENGTH INSIDE .... 120⅛ in.
FIREBOX, WIDTH INSIDE .... 90¼ in.
GRATE AREA....................... 75.3 sq. ft.
TUBES, NUMBER LARGE.............. 180 3½ in.
TUBES, NUMBER SMALL............... 77 2¼ in.
TUBES, LENGTH OVER SHEETS ...... 20 ft. 6 in.
HEATING SURFACE, TUBES.......... 4202 sq. ft.
HEATING SURFACE, FIREBOX & ARCH TUBES...................... 354 sq. ft.
TOTAL HEATING SURFACE.......... 4646 sq. ft.
HEATING SURFACE, SUPERHEATER .. 1931 sq. ft.
TRACTIVE FORCE, ENGINE........... 60100 lbs.
TRACTIVE FORCE, BOOSTER.......... 13750 lbs.
TRACTIVE FORCE, ENG. & BOOSTER .. 73850 lbs.

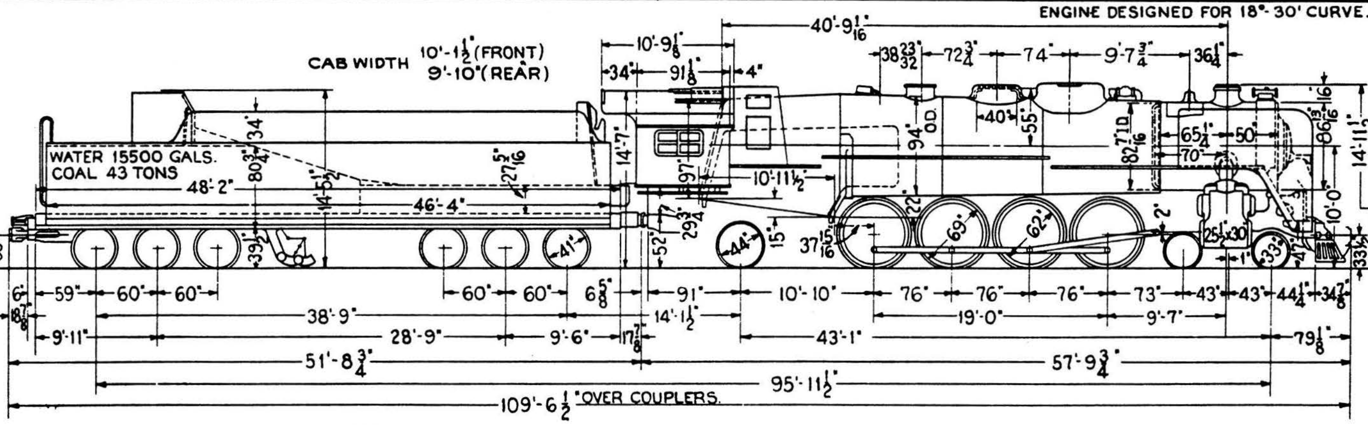
PRINTED 1-1-46

RATING, ENGINE 60.1%
RATING, ENGINE & BOOSTER 73.8%

CLASS L-2D (CONV.)

D-159

ENGINE DESIGNED FOR 18°-30' CURVE.



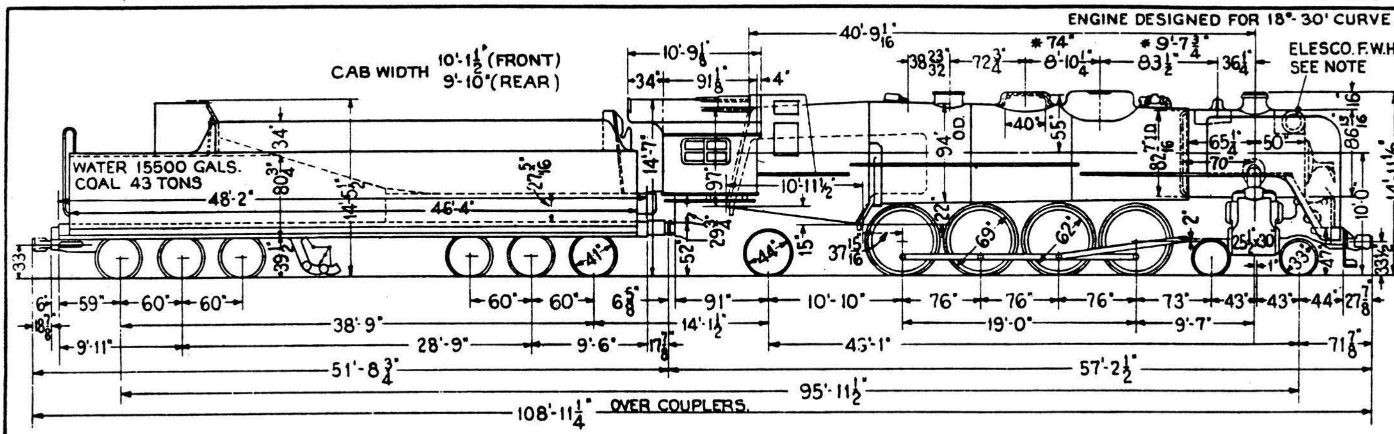
STEAM PRESSURE...................... 250 lbs. (SEE NOTE)
KIND OF MAIN VALVE............ 14 in. Piston
FIREBOX, LENGTH INSIDE .... 120⅛ in.
FIREBOX, WIDTH INSIDE .... 90¼ in.
GRATE AREA...................... 75.3 sq. ft.
TUBES, NUMBER LARGE.............. 198 3½ in.
TUBES, NUMBER SMALL.............. 50 2¼ in.
TUBES, LENGTH OVER SHEETS ...... 20 ft. 6 in.
HEATING SURFACE, TUBES........ 4303.0 sq. ft.
HEATING SURFACE, FIREBOX & ARCH TUBES.................... 373.0 sq. ft.
TOTAL HEATING SURFACE........ 4676.0 sq. ft.
HEATING SURFACE, SUPERHEATER .. 2082 sq. ft.
TRACTIVE FORCE, ENGINE............ 60100 lbs.
TRACTIVE FORCE, BOOSTER..........
TRACTIVE FORCE, ENG. & BOOSTER ..

NOTE:
ENG 3000 HAS 260 LBS BOILER PRESSURE, 72" DRIVING AND 36" ENG. TRUCK WHEELS. ENG. HEIGHT ABOVE RAIL 1½" GREATER THAN SHOWN.

PRINTED 1-1-46

RATING 60.1%

CLASS L3A



STEAM PRESSURE......................250 lbs.
KIND OF MAIN VALVE............14 in: Piston
FIREBOX, LENGTH INSIDE.............120⅛ in.
FIREBOX, WIDTH INSIDE...............90¼ in.
GRATE AREA..................... 75.3 sq. ft.
TUBES, NUMBER LARGE.............198 3½ in.
TUBES, NUMBER SMALL............. 50 2¼ in.
TUBES, LENGTH OVER SHEETS......20 ft. 6 in.
HEATING SURFACE, TUBES........4303.0 sq. ft.
HEATING SURFACE, FIREBOX & ARCH TUBES...................373.0 sq. ft.
TOTAL HEATING SURFACE........4676.0 sq. ft.
HEATING SURFACE, SUPERHEATER..2082 sq. ft.
TRACTIVE FORCE, ENGINE...........60100 lbs.
TRACTIVE FORCE, BOOSTER..........14000 lbs.
TRACTIVE FORCE, ENG. & BOOSTER..74100 lbs.

NOTE:
FOR SMOKEBOX CONTOUR OF WORTHINGTON F.W.H. SEE L3A DIAGRAM.

* APPLIES TO WORTHINGTON F.W.H. LOCOS.

RATING, ENGINE 60.1%
RATING, ENGINE & BOOSTER 74.1%

PRINTED 1-1-46

CLASSES L3B & L3C

ENGINE NO.	ENGINE CLASS	DATE BUILT	DIAGRAM PAGE	WEIGHT GROUP	TENDER CAPACITY GALS. WATER	TENDER CAPACITY TONS COAL	VALVE GEAR	AIR PUMPS	STOKER	FEED WATER HEATER	BOOSTER	WATERSCOOP	AIR SIGNAL	STEAM HEAT	LAT. MOTION	TRAIN CONTR.	COAL PUSHER	ROLLER BEARING ENG. TRK.	ROLLER BEARING DRIVERS	ROLLER BEARING TRAILER	ROLLER BEARING TENDER
+2995	"	"	158	371	"	"	"	"	"	"	B	W	A	H	L	C	P	E			N
2996	"	"	157	370	"	"	"	"	"	"	B	W	A	H		C					N
2997	"	"	"	"	"	"	"	"	"	"	B	W	A	H		C					
+2998	"	"	158	371	"	"	"	"	"	"	B	W	A	H	L	C	P	E	D		N
2999	"	"	157	370	"	"	"	"	"	"	B	W	A	H		C					
3000	L3A	10-1940	159	375	15500	43	"	"	HT	WOR		W	A	H	L	C	P	E	D	R	N
3001	"	"	"	"	"	"	"	"	"	"		W	A	H	L	C	P	E	D	R	N
3002	"	"	"	"	"	"	"	"	"	"		W	A	H	L	C	P	E	D	R	N
3003	"	"	"	"	"	"	"	"	"	"		W	A	H	L	C	P	E	D	R	N
3004	"	"	"	"	"	"	"	"	"	"		W	A	H	L	C	P	E	D	R	N
3005	L3A	10-1940	159	375	15500	43	BAK	2	HT	WOR		W	A	H	L	C	P	E	D	R	N
3006	"	"	"	"	"	"	"	"	"	"		W	A	H	L	C	P	E	D	R	N
3007	"	"	"	"	"	"	"	"	"	"		W	A	H	L	C	P	E	D	R	N
3008	"	11-1940	"	"	"	"	"	"	"	"		W	A	H	L	C	P	E	D	R	N
3009	"	"	"	"	"	"	"	"	"	"		W	A	H	L	C	P	E	D	R	N
3010	"	"	"	"	"	"	"	"	"	"		W	A	H	L	C	P	E	D	R	N
3011	"	"	"	"	"	"	"	"	"	"		W	A	H	L	C	P	E	D	R	N
3012	"	"	"	"	"	"	"	"	"	"		W	A	H	L	C	P	E	D	R	N
3013	"	"	"	"	"	"	"	"	"	"		W	A	H	L	C	P	E	D	R	N
3014	"	"	"	"	"	"	"	"	"	"		W	A	H	L	C	P	E	D	R	N
3015	"	"	"	"	"	"	"	"	"	"		W	A	H	L	C	P	E	D	R	N
3016	"	"	"	"	"	"	"	"	"	"		W	A	H	L	C	P	E	D	R	N
3017	"	12-1940	"	"	"	"	"	"	"	"		W	A	H	L	C	P	E	D	R	N
3018	"	"	"	"	"	"	"	"	"	"		W	A	H	L	C	P	E	D	R	N
3019	"	"	"	"	"	"	"	"	"	"		W	A	H	L	C	P	E	D	R	N
3020	"	"	"	"	"	"	"	"	"	"		W	A	H	L	C	P	E	D	R	N
3021	"	"	"	"	"	"	"	"	"	"		W	A	H	L	C	P	E	D	R	N
3022	"	"	"	"	"	"	"	"	"	"		W	A	H	L	C	P	E	D	R	N
3023	"	"	"	"	"	"	"	"	"	"		W	A	H	L	C	P	E	D	R	N
3024	"	"	"	"	"	"	"	"	"	"		W	A	H	L	C	P	E	D	R	N
3025	L3B	"	160	376	"	"	"	"	"	"	B	W	A	H	L	C	P	E		R	N
3026	"	1-1941	"	"	"	"	"	"	"	"	B	W	A	H	L	C	P	E		R	N
3027	"	"	"	"	"	"	"	"	"	"	B	W	A	H	L	C	P	E		R	N
3028	"	"	"	"	"	"	"	"	"	"	B	W	A	H	L	C	P	E		R	N
3029	"	"	"	"	"	"	"	"	"	"	B	W	A	H	L	C	P	E		R	N
3030	"	"	"	"	"	"	"	"	"	"	B	W	A	H	L	C	P	E		R	N
3031	"	"	"	"	"	"	"	"	"	"	B	W	A	H	L	C	P	E		R	N
3032	"	"	"	"	"	"	"	"	"	"	B	W	A	H	L	C	P	E		R	N
3033	"	"	"	"	"	"	"	"	"	"	B	W		H	L	C	P	E		R	N
3034	"	"	"	"	"	"	"	"	"	"	B	W		H	L	C	P	E		R	N
3035	"	11-1940	"	"	"	"	"	"	"	ELS	B	W		H	L	C	P	E		R	N
3036	"	"	"	"	"	"	"	"	"	"	B	W		H	L	C	P	E		R	N
3037	"	"	"	"	"	"	"	"	"	"	B	W		H	L	C	P	E		R	N
3038	"	"	"	"	"	"	"	"	"	"	B	W		H	L	C	P	E		R	N
3039	"	"	"	"	"	"	"	"	"	"	B	W		H	L	C	P	E		R	N
3040	L3B	11-1940	160	376	15500	43	BAK	2	HT	ELS	B	W	A	H	L	C	P	E		R	N
3041	"	12-1940	"	"	"	"	"	"	"	"	B	W	A	H	L	C	P	E		R	N
3042	"	"	"	"	"	"	"	"	"	"	B	W		H	L	C	P	E		R	N
3043	"	"	"	"	"	"	"	"	"	"	B	W		H	L	C	P	E		R	N
3044	"	"	"	"	"	"	"	"	"	"	B	W		H	L	C	P	E		R	N
3045	"	"	"	"	"	"	"	"	"	"	B	W	A	H	L	C	P	E		R	N
3046	"	"	"	"	"	"	"	"	"	"	B	W		H	L	C	P	E		R	N
3047	"	"	"	"	"	"	"	"	"	"	B	W	A	H	L	C	P	E		R	N
3048	"	"	"	"	"	"	"	"	"	"	B	W	A	H	L	C	P	E		R	N
3049	"	1-1941	"	"	"	"	"	"	"	"	B	W		H	L	C	P	E		R	N
3050	L3C	3-1942	"	377	"	"	"	"	"	WOR	B	W		H	L	C	P	E		R	N
3051	"	"	"	"	"	"	"	"	"	"	B	W		H	L	C	P	E		R	N
3052	"	"	"	"	"	"	"	"	"	"	B	W		H	L	C	P	E		R	N
3053	"	"	"	"	"	"	"	"	"	"	B	W	A	H	L	C	P	E		R	N
3054	"	"	"	"	"	"	"	"	"	"	B	W		H	L	C	P	E		R	N
3055	"	"	"	"	"	"	"	"	"	"	B	W		H	L	C	P	E		R	N
3056	"	"	"	"	"	"	"	"	"	"	B	W		H	L	C	P	E		R	N
3057	"	"	"	"	"	"	"	"	"	"	B	W		H	L	C	P	E		R	N
3058	"	"	"	"	"	"	"	"	"	"	B	W		H	L	C	P	E		R	N
3059	"	"	"	"	"	"	"	"	"	"	B	W		H	L	C	P	E		R	N
3060	"	"	"	"	"	"	"	"	"	"	B	W	A	H	L	C	P	E		R	N
3061	"	"	"	"	"	"	"	"	"	"	B	W		H	L	C	P	E		R	N
3062	"	"	"	"	"	"	"	"	"	"	B	W		H	L	C	P	E		R	N
3063	"	"	"	"	"	"	"	"	"	"	B	W		H	L	C	P	E		R	N
3064	"	4-1942	"	"	"	"	"	"	"	"	B	W		H	L	C	P	E		R	N

A-AIR SIGNAL
B-BOOSTER
C-TRAIN CONTROL
D-ROLLER BEARINGS. DRIVERS
E- " " ENG. TRUCK
H-STEAM HEAT
L-LATERAL MOTION DEVICE
N-ROLLER BEARINGS. TENDER
P-COAL PUSHER
R-ROLLER BEARINGS. TRAILER
W-WATERSCOOP
+ CLASS L2D CONVERTED FOR HIGH SPEED SERVICE. AUG. 1939

WEIGHTS

GROUP	CLASS	LOCOMOTIVE WORKING ORDER ENGINE TRUCK	LOCOMOTIVE WORKING ORDER TOTAL DRIVERS	TRAILING TRUCK FRONT	TRAILING TRUCK REAR	TOTAL ENGINE	TENDER LOADED	TENDER EMPTY	TOTAL ENG. AND TENDER	NOTES
371	L2D (CONV.)	65400	257000		62700	385100	"	"	698600	
375	L3A	70400	262000		56100	388500	374200	159000	762700	
376	L3B	65100	265000		63400	393500	375800	160600	769300	
377	L3C	66800	267700		64500	399000	374200	159000	773200	

The Late Mohawks . . . *(continued from page 27)*

the last steam passenger train on the B&A, on April 16, 1951.[48] In the early 1950's, when the B&A dieselized, the Mohawks were returned and many of them saw service on the Big Four until they were eventually retired. Their relative longevity can probably be attributed, at least in part, to the quality materials used for their construction, and the excellent maintenance practices of the B&A. Their versatility as a dual service locomotive made them a valuable asset to the Operating Department.

As built, the passenger L3's are considered by many to be the best looking of all Mohawks. The Hudson style smokebox front and cast steel pilot with drop coupler and two air pump shields gave them a Hudson front end appearance. The four sets of disc drivers were slightly small at 69 inches but their low height and overall length gave them a nice balance, and the tender size and shape was in harmony with the engine. Later "improvements" such as the addition of smoke deflectors and the use of a one piece front air pump cover detracted from the looks of these engines, but they kept a New York Central look to the end.

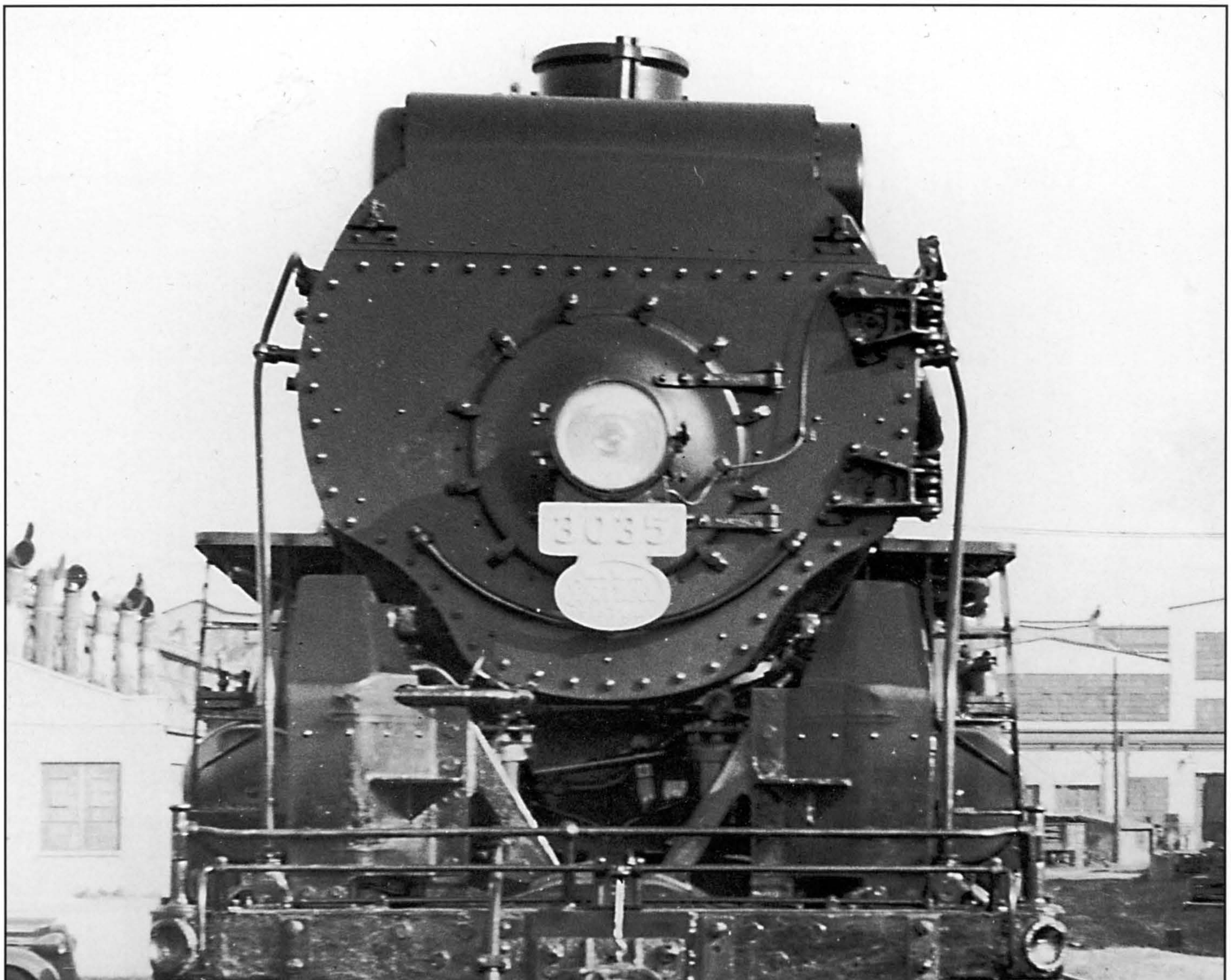
(To be concluded 2nd Quarter 2001 issue)

Class L3b 3038 at Rensselaer, N.Y., July 1947. Gene Baxter collection.

Class L3b 3044 at Harmon, N.Y., July 30, 1950. Photo by George E. Votava.

Class L3b 3048 at the Elkhart, Indiana coal dock. Photo by Robert C. Schell, Jr., Spaugh collection.

Class L3c 3053 at the Elkhart, Indiana ash pit. Photo by Robert C. Schell, Jr., Spaugh collection.



Class L3b 3035 new at Lima Locomotive Works, November 1940. Photo by Philip E. Buchert.