

Exhibit 7

COAL CARS

The First Three Hundred Years

by

MARTIN ROBERT KARIG III



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for my friend, Forman



John Forman Applegate, Fireman and Engineer

Pennsylvania Railroad, Penn Central Railroad, and Conrail

1942 to 1979



COVER PHOTO

This scene of coal cars awaiting shipment in Williamson, West Virginia, was captured on film by an unknown photographer in 1941. This photo is one of hundreds of photographs of coal cars and coal mining operations available from the Prints and Photographs On Line Catalog of the Library of Congress, which can be accessed at: <http://www.loc.gov/rr/print/catalog.html>. [Farm Security Administration and Office of War Information Collection; Courtesy: Library of Congress Prints and Photographs Division]

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Steel revolutionized freight car design. By 1900, car builders were manufacturing steel-reinforced wood cars, composite wood-and-steel cars, and all-steel cars. With so many applications, there was a heated debate within the community about the best way to employ steel as a building material.

Perhaps the most heated argument, other than whether steel should replace wood at all, was whether custom-made, pressed-steel shapes or standard, structural-steel shapes should be used in car construction. The pressed-steel components offered lighter weight but required the expense of custom dies to manufacture. The rolled-steel components cost less to fabricate but at the expense of greater weight.¹ This argument extended to every aspect of freight-car design, from body and truck bolsters, to truck side frames and brake beams, to the underframes of freight cars, and even their side posts. As new freight cars were introduced, trade journals made a point of discussing whether the builder was using pressed-steel or structural-steel components.

The first all-steel freight cars were not sponsored by a railroad but by the Carnegie Steel

Company, which had a vested interest in seeing steel replace wood as a building material. In 1894, it worked in partnership with the Fox Solid Pressed Steel Car Company to produce an all-steel freight car, a flat car with a capacity of 80,000 pounds. Two years later, Carnegie contracted with the Keystone Bridge Works to produce the first, all-steel hopper cars. These cars had a capacity of 80,000 pounds and were constructed of structural-steel components. Carnegie exhibited these cars at the Master Car Builders' convention in Saratoga, New York in 1896 and then put them into service on the Pittsburgh, Bessemer & Lake Erie Railroad.² A picture of one of these cars is shown in Figure 3.3 below.

While the PB&LE was evaluating the Carnegie cars, Charles T. Schoen, an outspoken advocate for the use of pressed-steel shapes in car construction, was working with the Pennsylvania Railroad to design a hopper car made entirely out of pressed-steel shapes at his Schoen Pressed Steel Company. He exhibited a prototype pressed-steel hopper car at the Master Car Builders' Convention in 1897.³

The investments of these two entrepreneurs



FIGURE 3.3

This photo shows the first all-steel hopper car built for an American railroad—Pittsburg, Bessemer & Lake Erie car number 5700. It was built for the Carnegie Steel Company by the Keystone Bridge Works in 1896 from structural-steel components. It's shown here with its original Fox pressed-steel trucks. [Courtesy: Hagley Museum and Library]

paid off. In 1897, the Pittsburgh, Bessemer & Lake Erie Railroad signed the first production contract for all-steel hopper cars with the Schoen Pressed Steel Company, and within a year, the Baltimore & Ohio, Pennsylvania, Lehigh Valley, and Erie Railroads had also placed orders for all-steel cars. As the result of these sales, Carnegie's company sold over 1,000,000 tons of steel for freight car construction over the next three years.⁴

The PB&LE's initial purchase of one thousand all-steel cars was not without risk. To minimize that risk and maximize its learning experience, the railroad chose to evaluate a number of different technologies in its purchase decision. Under the agreement, it purchased two variations of all-steel cars from the Schoen Pressed Steel Company—400 based upon Carnegie's design using structural-steel shapes, and 600 based upon Schoen's design using pressed-steel shapes. Both cars were rated at 100,000 pounds

capacity. The structural-steel design weighed 37,150 pounds whereas the pressed-steel design weighed only 34,350 pounds.⁵ The drawings for these cars are shown in Figures 3.4 and 3.7, and builders' photos are shown in Figures 3.5 and 3.6.

With the exception of the materials with which they were built, these two cars were remarkably similar in construction, incorporating features that would remain in common practice through the end of the steam era. Among them were the angle of the slope sheet, which was set at an angle of 30-degrees, and the use of "sawtooth" hoppers with suspended doors. Practices that would change over time were the employment of platform end sills and the angle of the cross-ridge or cross-cover sheets. On these two cars, the cross-ridge sheets were sloped at an angle of 60 degrees, which resulted in the slope sheets and the cross-ridge sheets meeting at the bottom of the hopper at an angle of 90 degrees.

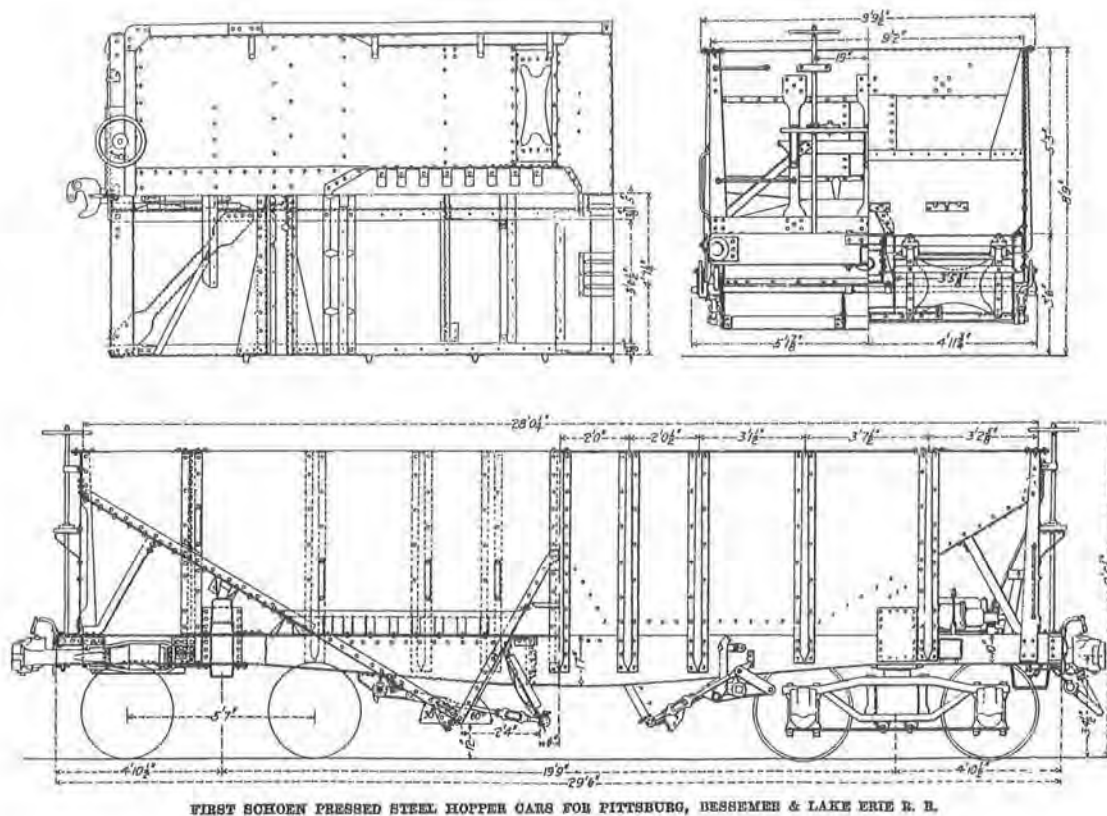


FIGURE 3.4

The Pittsburgh, Bessemer & Lake Erie's order for one thousand cars from the Schoen Pressed Steel Company in 1897 was the first production contract for all-steel hopper cars in the United States. Shown here are the drawings for the six hundred cars built using pressed-steel components.⁶ The steep, 60° angle of the cross ridge insured the car was self clearing and provided additional support for the sides. [*American Engineer and Railroad Journal*, May 1903]



FIGURE 3.5

This builder's photo shows the first pressed-steel hopper car built for the Pittsburgh, Bessemer & Lake Erie Railroad by the Schoen Pressed Steel Company. The car is equipped with Schoen pressed-steel trucks. Elevation drawings are shown in Figure 3.4. The Baltimore & Ohio and Pennsylvania Railroads also purchased cars of this general design. The Pressed Steel Car Company was formed in 1899 from the Schoen Pressed Steel Company and the Fox Pressed Steel Equipment Company. [Pressed Steel Car Company Photo; Courtesy: D.K. Retterer Collection]

In addition to evaluating the two different construction techniques, the railroad equipped these cars with a variety of steel trucks, including those designed by Schoen, Fox, Vogt, Buckeye, Cloud, and Kindl.⁷

One of the key advantages of the use of steel in hopper car construction is the ability of the sides to carry the load. In a wood car, "the carrying strength [is] provided in the underframing . . . The upper framing, therefore, is light and contributes little in carrying the load. Shrinkage and the working of the body loosens the structure generally and tightening of rods and reailing of sideing [sic] are considerable items in the expense of maintenance. It has been conclusively proved that by the use of steel in hopper cars, gondolas and box cars the side framing will successfully carry that portion of the load coming to the sides."⁸ What this meant, of course, was that larger-capacity cars could be built with less under-structure and hence, less weight. In its 1901 catalogue, the Pressed Steel Car Company boasted that from the moment the Pittsburgh, Bessemer & Lake Erie Railroad put its 100,000-pound-capacity, all-steel hopper cars into operation, "it showed a 73½ per cent paying-load-to-train-weight and showed train-mile earnings of \$5.38 per mile."⁹

The transition from wood to steel coal cars was not made without resistance. Railroads had large investments in their fleets of wood cars, and there was real concern expressed about steel cars weighing 140,000 pounds being interspersed with wood cars weighing half that amount. These fears were well-founded. Railroads began experiencing an

increasing number of wrecks caused by the smaller cars failing when mixed in trains with larger all-steel cars.¹⁰

Another consideration was the expense of converting to all-steel cars. That included not just the cost of the cars but also the costs of purchasing the tools and building the shops to maintain them.

These larger cars were also impacting railroads' physical plants. Steel rails and bridges were designed to handle the lighter, wood freight car. Indeed, very few locomotives of this period had loading per wheel as great as the new steel cars.¹¹ As a result, the toll that these new cars would take on a railroad's infrastructure could be extensive. For these reasons, in June 1897, a majority of motive-

Cost of Repairs, Wood versus Steel

During the first ten years of its experience with steel cars, the Pittsburgh & Lake Erie Railroad maintained careful records of its cost of repairs. These details are shown below:

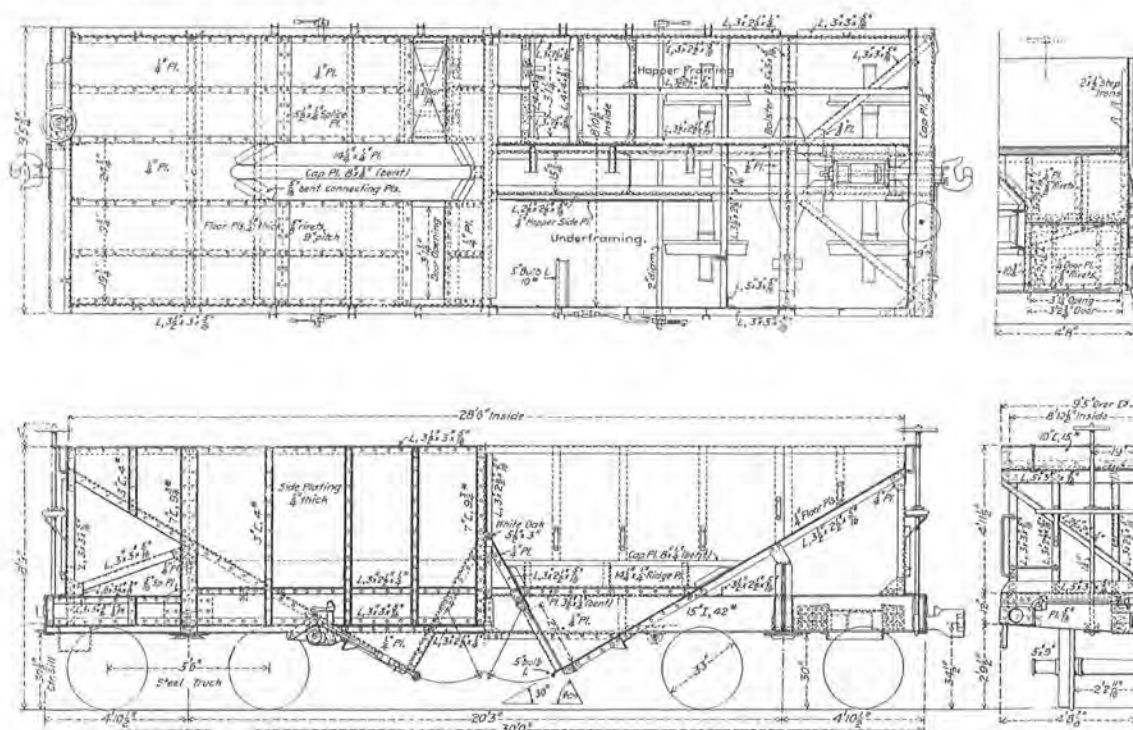
<u>Wood</u>	
Average number of repairs per year	7
Average cost per repair	\$16.23
<u>Steel</u>	
Average number of repairs per year	1 1/3
Average cost per repair	\$6.74

Source: *American Engineer and Railroad Journal*, October 1908



FIGURE 3.6

In 1897, the Pittsburgh, Bessemer & Lake Erie signed the first production contract for all-steel coal cars. It ordered one thousand hopper cars from the Schoen Pressed Steel Company, four hundred built using structural-steel components and six hundred built with pressed-steel components. This is the structural-steel car. Compare this car with the prototype in Figure 2.15 built by the Keystone Bridge Company.³¹ Note how the ends have been opened up to save weight. The elevation drawings for this car are shown below in Figure 3.7. [John H. White Jr. *Railroad Reference Collection*, Archives Center, National Museum of American History, Behring Center, Smithsonian Institution]



FIRST STRUCTURAL HOPPER CARS BUILT FOR THE PITTSBURGH, BESSEMER & LAKE ERIE R. R. BY THE SCHOEN PRESSED STEEL CAR CO., CARNEGIE DESIGN—1897.

FIGURE 3.7

These are the elevation drawings for first production structural-steel hopper cars built by the Schoen Pressed Steel Company for the Pittsburgh, Bessemer & Lake Erie Railroad in 1898. The drawing shows 5" x 9" journals (40 ton), but the car shown in Figure 3.6 has 5½" x 10" journals (50 ton). [American Engineer and Railroad Journal, May 1903]

TABLE 3.1

Comparison of coal cars made of wood, composite wood and steel, and all-steel construction

	Wood Hopper-Bottom Gondola, 1901	Seley Composite Hopper, 1902	Pressed Steel All-Steel Hopper, 1897
Total Weight of Car	38,900	33,700	34,200
Capacity in Pounds	85,000	80,000	100,000
Ratio of paying freight to total weight	68.60%	70.36%	74.52%

Sources: Ontario and Western Railway Historical Society Archives; Car Builders' Dictionary, 1903

power officers favored limiting those cars in interchange service to 30-tons capacity.¹²

Even C.A. Seley, who was instrumental in producing the first composite wood-and-steel cars with a capacity of 50 tons, suggested in 1900 that the limits of cast-iron wheel technology combined with the necessity of strengthening bridges and rights-of-way would cause railroads to limit cars to 40-tons capacity.¹³

This resistance notwithstanding, the economics of steel cars were too compelling to ignore, and once the revolution had begun, it couldn't be stopped. Steel became the building material for future coal-car production. The Pressed Steel Car Company's production statistics show how rapidly that transformation occurred. In 1897 it built 501 all-steel cars; in 1898, 2,931; in 1899, 9,624; in 1900, 16,671; and through November 1901, 23,381.¹⁴ With the exception of a short period during World Wars I and II when composite cars were produced due to steel

shortages, the all-steel car became the premier coal car for the next 50 years. The steel car won on several points. A period report estimated that steel cars would last from 1½ to 2 times as long as wood cars and their lifetime maintenance costs would still be less than the wood cars.¹⁵ Steel also won the efficiency battle. A comparison of the qualities of three different types of car construction is shown in Table 3.1.

The first decade of the steel-car era saw carmakers grappling with how to use this new building material, and the results of that experimentation can be enlightening as to the paths they followed.

In 1897, the Chesapeake & Ohio introduced a 40-ton wood, hopper-bottom gondola. Just five years later, the C&O took delivery of its first all-steel hopper cars, which used construction techniques similar to those used in the wood hopper-bottom gondola. The similarity between the two cars can be seen by comparing the cars in Figures 3.8 and 3.9.



FIGURE 3.8 (left)

The Ensign Manufacturing Company, which later became part of American Car & Foundry, built this 40-ton wood, hopper-bottom gondola for the Chesapeake & Ohio in April 1897. The man standing on the platform end sill provides a rough idea of the height of this car. [Courtesy: Chesapeake and Ohio Historical Society; Print No. COHS 20033]

FIGURE 3.9 (right)

The Pressed Steel Car Company built this all-steel, 50-ton hopper car for the C&O in February, 1901. Note the similarity between it and the wood car shown in Figure 3.8 above. [Courtesy: Chesapeake and Ohio Historical Society; Print No. COHS 22535]



The debate continued to rage about whether pressed-steel or structural-steel components were better for car construction. One of the more interesting and extreme examples that emerged from that debate was the Sterlingworth rolled-steel car. The Sterlingworth hopper-bottom gondola was built almost entirely of commercially available, rolled-steel shapes. The center and side sills were 8" I-

beams, and the sides were 12" channels bolted together. The Sterlingworth Railway Supply Company displayed the car at the 1901 Master Car Builders' Convention from which the car received wide publicity.¹⁶ Unfortunately, despite the acclaim, the company received few orders for the car, and it disappeared quickly.

A more common application of structural-steel

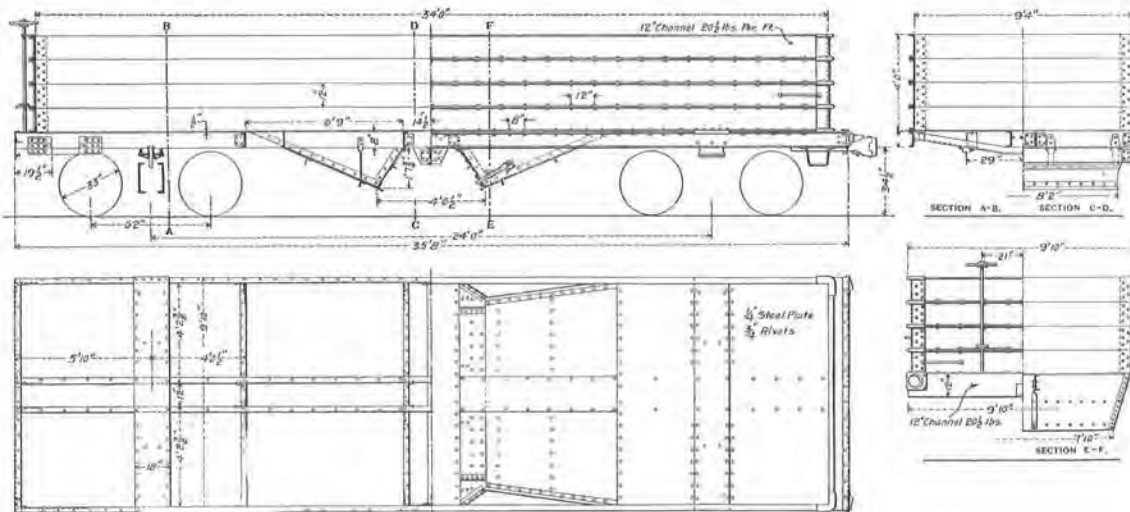


FIGURE 3.10

The Sterlingworth Railway Supply Company of Easton, Pennsylvania introduced this structural-steel, hopper-bottom gondola in 1900. The car was made up almost entirely of commercially-available, rolled-steel shapes. The center and side sills were 8" I-beams, and the sides were composed of 12" channels bolted together. Despite widespread publicity, only three railroads purchased this car: the Delaware, Lackawanna & Western; the New York, Ontario & Western; and Mexican International Railways.¹⁷ [*Car Builders' Dictionary*, 1903]



FIGURES 3.11

The New York, Ontario & Western was one of only two U.S. railroads to purchase the Sterlingworth hopper-bottom gondola. It is shown here as it was displayed at the 1901 Master Car Builders' convention in Saratoga, New York, in 1901 with its Joughins rolled-steel trucks. [Courtesy: Ontario and Western Railway Historical Society Archives]

The pressed-steel car in Figure 3.13 used construction techniques similar to those used in the

structural-steel car, but it used pressed-steel parts. The sides on both cars were rolled-steel sheets. The length of each side sheet can be discerned by the rivet pattern on the side post. Side posts with rivets facing each other indicate a seam where the sheets were butted together. Alternating rivet patterns indicate a side post in the middle of a side sheet.



The Philadelphia & Reading purchased these structural-steel, drop-bottom gondolas from the Cambria Steel Company in the early 1900s. The cars weighed 33,300 pounds and had a capacity of 100,000 pounds. [*Car Builders' Dictionary, 1906*]



This is the first Schoen all-steel gondola. It was built of pressed-steel components for the Pittsburg, Bessemer & Lake Erie in 1898. It had the same cubic capacity as the structural-steel car in Figure 3.12, but it weighed 3,400 pounds less. It had a nominal capacity rating of 80,000 pounds. [*American Engineer and Railroad Journal*, May 1903]

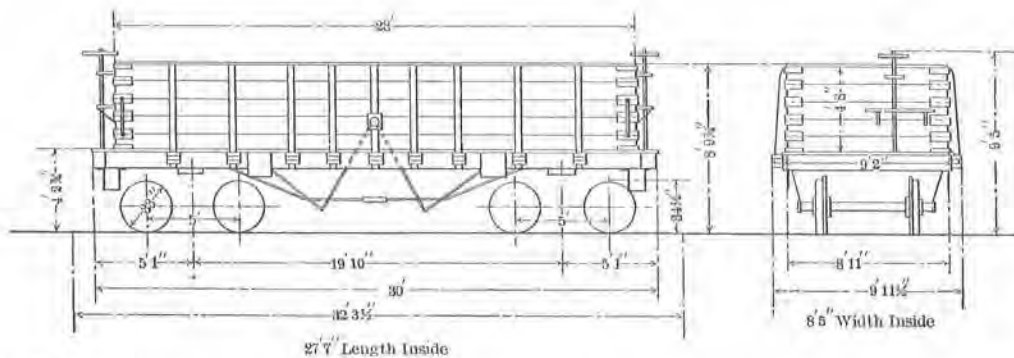


FIGURE 3.14
Pennsylvania Railroad Class GG Wood Hopper (1895). [*American Engineer and Railroad Journal*, October 1903]

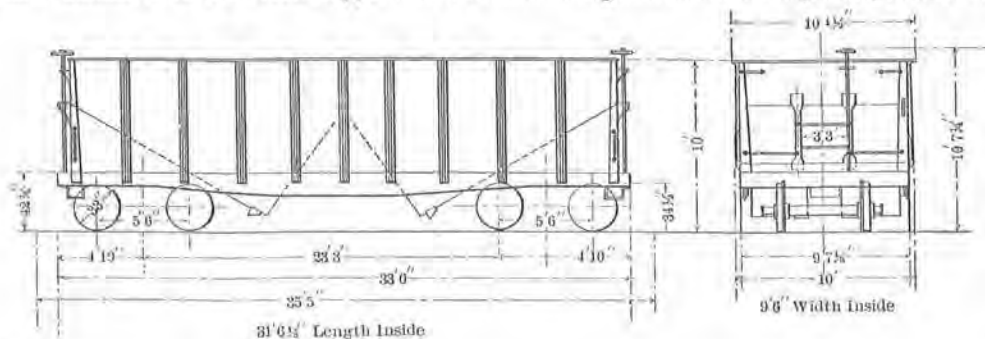


FIGURE 3.15
Pennsylvania Railroad Class GL All-Steel Hopper (1898). [*American Engineer and Railroad Journal*, October 1903]

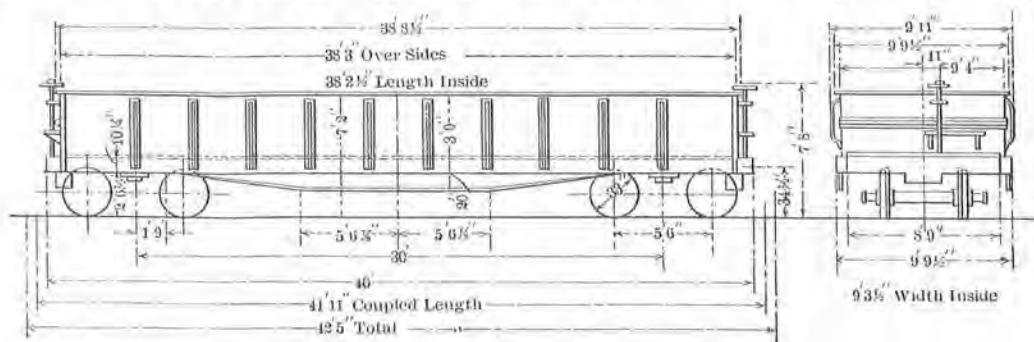


FIGURE 3.16
Pennsylvania Railroad Class GS All-Steel Gondola (1902). [*American Engineer and Railroad Journal*, October 1903]

Figures 3.14 through 3.16 show the Pennsylvania Railroad's transition from wood to steel coal cars. In 1895, the Pennsy began producing its wood GG class, the first self-clearing hopper car used by that system. The GG was one of the first hopper cars equipped with vertically-suspended doors. Its floors and cross-ridge were protected with iron.¹⁸ The car had a weight of 35,200 pounds and a capacity of 70,000 pounds, yielding a paying-freight-to-total-weight ratio of 66.5%. The lessons learned in building this car were used in the design of the first all-steel hopper cars.¹⁹ In 1898, the PRR joined with the Schoen Pressed Steel Company to design and produce its GL-class all-steel hopper. Note the similarity between this car and the PB&LE car in Figure 3.5. The GL had a weight of 39,150 pounds and was rated at a capacity of either 100,000 pounds or 110,000 pounds, depending upon whether it was equipped with chilled-cast-iron or rolled-steel wheels.²⁰ The lower weight yielded a paying-freight ratio of 71.9%. The Pennsy introduced its GS-class gondola in 1902 for coal service on its Lines West of Pittsburgh. Using pressed-steel components, this car had a weight of 38,400 pounds and a capacity of 100,000 pounds.²¹ Examples of all three cars are on display at the Railroad Museum of Pennsylvania.

As intense as the debate was concerning the use of pressed-steel versus rolled-steel construction, many of those issues were settled by 1904.

Three car designs emerged from the first decade of the 20th century that shaped the future design of coal cars. The first, which was introduced in 1900 and is therefore arguably a product of the 19th century, was the composite wood-and-steel construction "Seley" car. The second was an all-steel hopper car derived from an early design of the Standard Steel Car Company, and the third was the Pennsylvania Railroad's GLA all-steel hopper. All three of these coal cars were noteworthy for their designs, appeal to multiple railroads, and length of service.

Railroads were not ready to abandon wood, especially in the coal trade. Sulfur impurities in coal combine with moisture to create sulfuric acid that attacks the unprotected surfaces of metal. Therefore, several railroads still preferred to use wood where contact was made with coal,²² but they also desired the strength and durability of steel. Thus, the composite freight car arose. The most frequently cited example of this type of construction is the composite design of C. A. Seley, mechanical engineer for the Norfolk & Western. These cars had a steel under-frame, steel-truss framing, and a wood box. By combining these two building materials, Seley was able to take advantage of the properties of both.

The evolution of Norfolk & Western hopper cars shows the learning process involved with the use of steel as a building material. In the early 1890s, the N&W began producing all-wood hopper cars. In 1899, when steel became available, the railroad used the material to produce 100,000-pound-capacity, composite wood-and-steel hopper cars using the same building practices that it had used with its wood hopper cars. Seley's innovation was the use of

a steel-truss structure on the car's sides. In 1900, Seley introduced his design in a 40-ton gondola, which is shown in Figure 3.17 below. By using this steel framing, Seley was able to capitalize on the strengths of steel by using the sides of the cars to carry a portion of the load, just as in cars of all-steel construction. The result was a car with significantly less weight.²³

The design was so successful that later that year, the N&W employed the concept in a hopper car. The side-truss configuration enabled the car builders to save 1,900 pounds in empty car weight while retaining the same cubic capacity of its earlier composite car.²⁴ In 1902, the railroad introduced a 40-ton hopper car using the side-truss design. The evolution of these cars on the Norfolk & Western is shown in Figures 3.18 through 3.20 in the next two pages.

The center sills of the Seley hopper were "15 in., 33-lb. channels; the side sills, 8 in., 11 1/4-pound channels, and the side posts and bracket, 5 in. channels, connected at their upper ends by gusset plates and also attaching to a heavy angle iron forming the top chord of the truss. This angle also serves as a coping for the wooden lining."²⁵ Clearly, the rolled-steel advocates won the debate in the construction of this car, and the selection of these materials provided a clear advantage for those railroads that sought to manufacture and repair cars in their own shops out of commonly available material.

Although these cars were applauded when introduced, some experts still questioned why a railroad would choose composite construction instead of all-steel construction.²⁶ This notwithstanding, several railroads adopted this design, including the St. Louis & San Francisco, the New York, Chicago & St. Louis (Nickel Plate), the Louisville & Nashville, the New York, Ontario & Western, and the

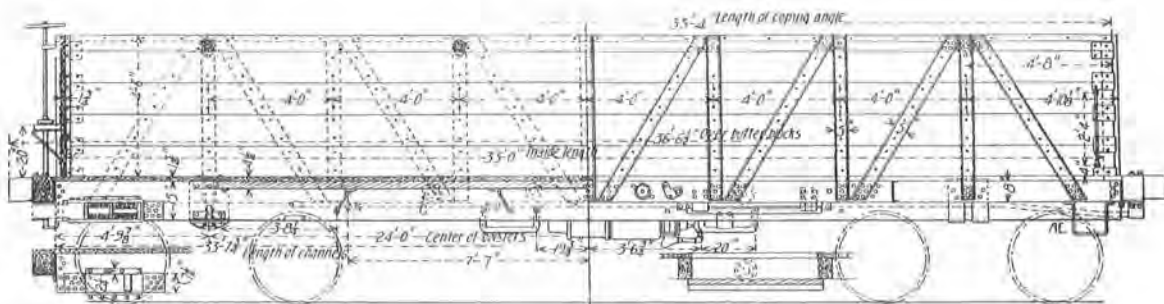


FIGURE 3.17

In 1900, the Norfolk & Western introduced this composite wood-and-steel gondola with a revolutionary side-truss design that enabled the sides of the cars to support a portion of the load, thus reducing the understructure required. The design is attributed to the N&W's mechanical engineer, C. A. Seley. [*American Engineer and Railroad Journal*, April 1900]

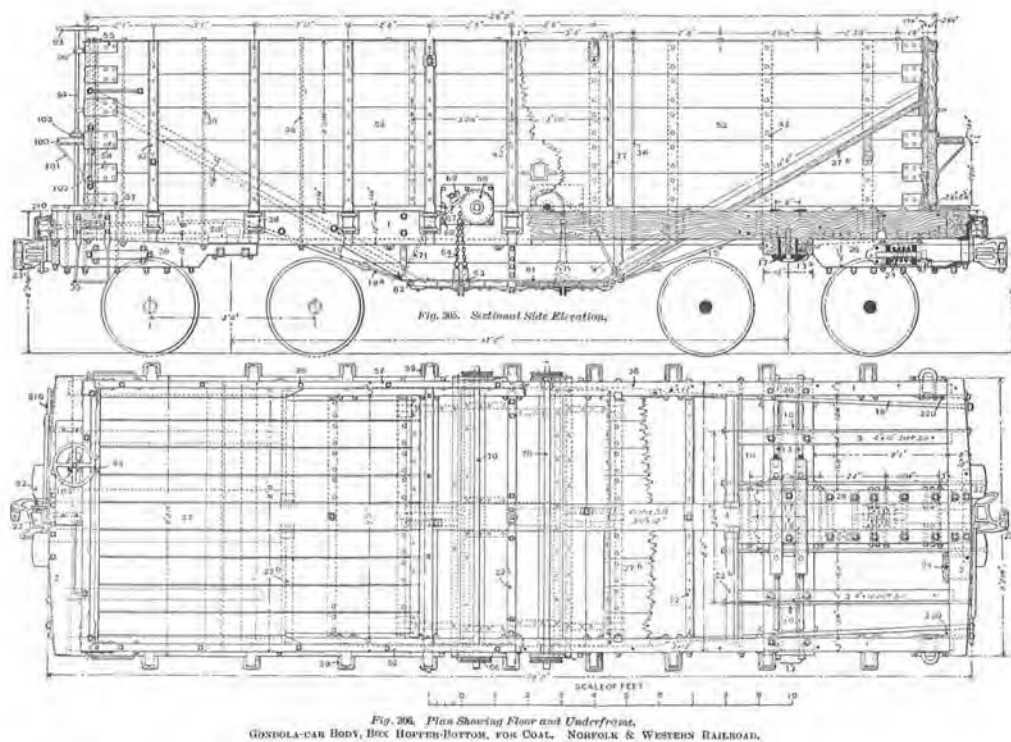


FIGURE 3.18
Norfolk & Western wood hopper car. [The Car Builder's Dictionary, 1895]

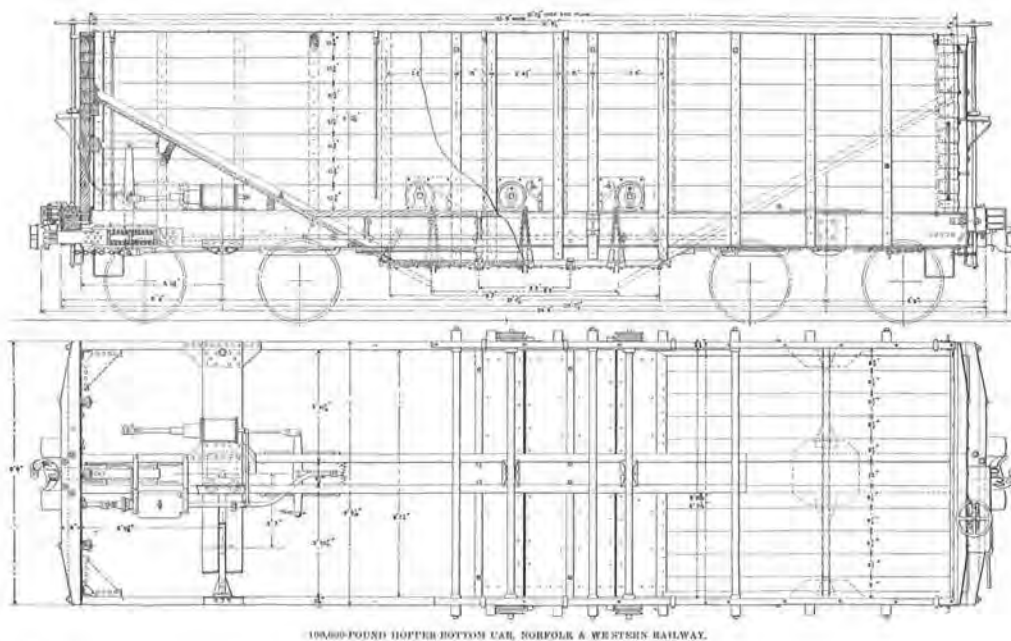


FIGURE 3.19
Norfolk & Western composite wood-and-steel hopper car. [Railroad Car Journal, June 1899]

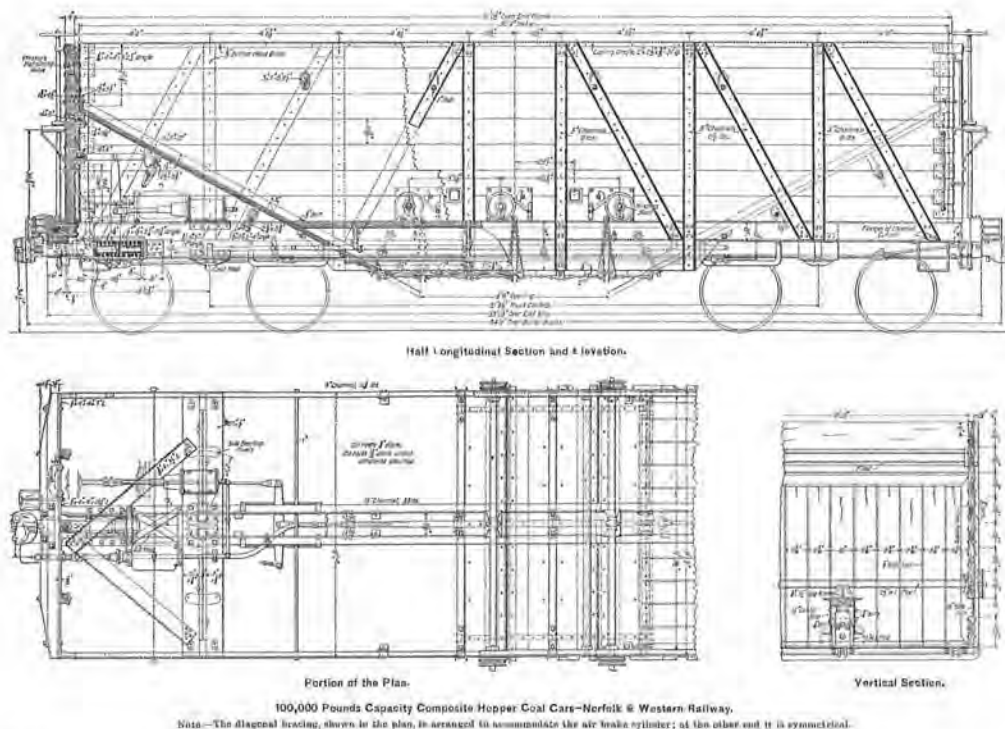


FIGURE 3.20

Norfolk & Western 50-ton composite wood-and-steel "Seley" hopper car. [*American Engineer and Railroad Journal*, June 1902]

In 1893, the Norfolk & Western introduced the all-wood hopper shown in Figure 3.18. It had a capacity of 60,000 pounds. As steel became available, the N&W produced the composite wood-and-steel hopper car shown in Figure 3.19. It had a light weight of 39,900 pounds and a capacity of 100,000 pounds. Consistent with the practice of the day, a 10% overage of the marked capacity was allowable, so this car routinely carried up to 110,000 pounds of coal assembled in unit trains that didn't leave the line. The building techniques used in the construction of that hopper car were similar to the techniques that railroad builders had been using for wood construction, with the underframe carrying the entire load of the car. The underframe consisted of four 15-inch, rolled-steel channels, two for the center sill and one for each side sill. The boards making up each side were bolted to wooden posts which were secured in cast-iron pockets and bolted in place. Worthy of note in this design, the chains for the door-operating mechanism were attached outside the body of the car, because the railroad had some experience with wet coal freezing and jamming the door-operating mechanisms in cold weather. The railroad produced one thousand of these cars beginning in 1899.²⁷ In 1900, the Norfolk & Western experimented with a new gondola design that used steel-channel truss work to support the sides. This new design enabled the designers to reduce the size of the side sill because the truss work helped carry the load of the car. This design proved so successful that the railroad adopted it for use on its hopper cars. In 1901, the N&W produced the 50-ton composite hopper car design shown in Figure 3.20 above. By using the steel truss work composed of 5" channels, the builders were able to reduce the side sill from a 15" steel channel to an 8" steel channel. The railroad designed the car so that many of the components of its original composite design could be used on the new one. In all, this new design resulted in a weight savings per car of 1,900 pounds.²⁸ The design is attributed to the railroad's mechanical engineer, C.A. Seley, and they have commonly been referred to as "Seley" hopper cars. It remained popular with many railroads well into the second decade of the 20th century, and some of these cars remained in service well into the 1940s. The design was so effective that, during World War II, when steel was at a premium, elements of the design were resurrected for use in the industry's war emergency hopper car, which can be seen in Figure 4.53. It is interesting to note that Seley used a Pratt truss in his gondola design, shown in Figure 3.17, but used a Howe truss in his hopper design, shown above.

Southern.²⁹ The Delaware & Hudson built composite hopper cars using variants of this design through the 1930s.

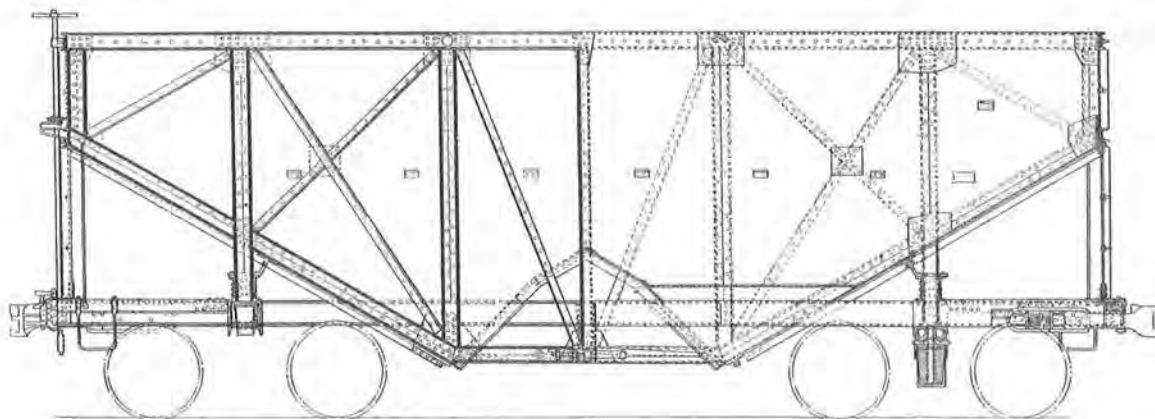
The Standard Steel Car Company began producing all-steel coal cars in 1902. The first cars it built followed a design similar to that shown in Figure 3.9. They were delivered to the Chesapeake & Ohio in August of that year. Within a few months, however, the company was producing cars of its own

design. These cars were constructed of structural-steel components and can be identified by their alternating steel-channel and steel-angle side posts, and steel-angle end posts. Another feature of this car was the 45° slope of the cross-ridge sheets, which can be discerned by the rivet pattern on the side sheets at the center of the car. Earlier cars had used a 60° angle on these cross-ridge sheets. This steeper angle provided additional stability to the side and



FIGURE 3.21

One of the greatest users of the Seley design was the Delaware & Hudson Railroad, which continued to build cars of this design into the 1930s. The car shown here was built by the Standard Steel Car Company in April 1905. It had a capacity of 1,484 cubic feet and a light weight of 36,900 pounds. Due to the seasonal nature of the hard coal business, anthracite railroads tended to store coal in their cars during slack periods. The desire to avoid corrosion due to that long term storage may account for the D&H's attachment to these cars. [Standard Steel Car Company Photo; Courtesy: D.K. Retterer Collection]



Vanderbilt Steel Hopper Coal Car—Lackawanna Iron & Steel Company.

FIGURE 3.22

Seley was not the only car designer who employed trusses to support the sides of a coal car. Cornelius Vanderbilt patented this all-steel hopper-car design in 1901. Vanderbilt's design differed from Seley's in that the trusses ran the entire depth of the car, from the top chord to the bottom of the hoppers. By using the trusses to support the load, he was able to reduce the size of the center sill and eliminate the side sills entirely.³⁰ While the design received much publicity, it was not widely used. [American Engineer and Railroad Journal, November 1901]

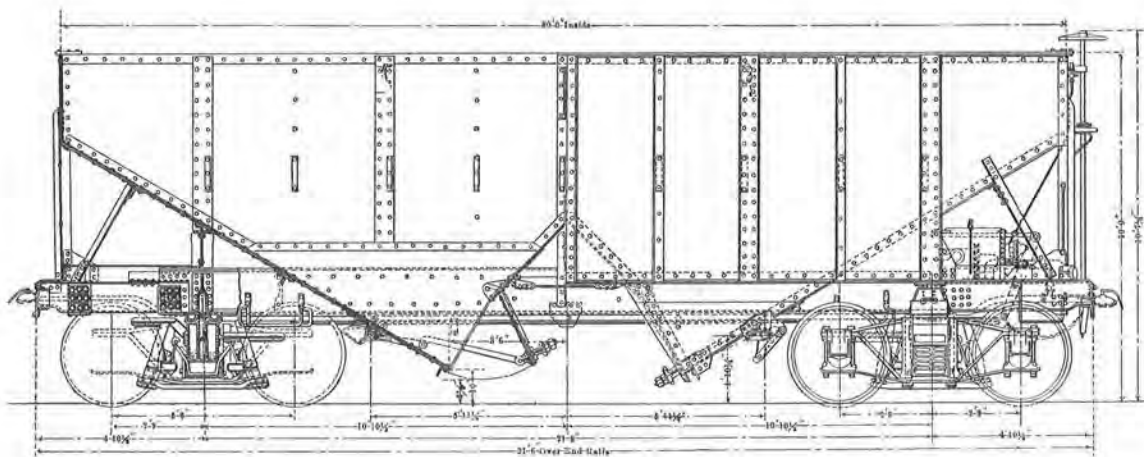


FIGURE 3.23

The Standard Steel Car Company introduced this all-steel, 50-ton hopper car design in 1903. The car had an inside length of 30' 0", inside width of 9' 5 1/2", and a height to the top rails of 10' 0". This produced an overall capacity of about 1,700 cubic feet, though slight deviations in dimensions yielded other capacities. The car had 15" steel-channel center sills. The 1/4"-thick side sheets were 5' 5 1/4" wide and were joined at the seams by 7" rolled-steel-channel side posts. Between the seams, the company used 3" rolled-steel-angle side posts. The car had rolled-steel-angle end posts. It could be outfitted with a variety of platform-end-sill arrangements. The slope sheets were set at an angle of 30°, and the cross-ridge sheets were sloped at an angle of 45°, joining at their apex at 90°. The distance between the hopper bottoms was 7' 0". [Car Builders' Dictionary, 1906; Courtesy: Simmons-Boardman Publishing Corporation.]

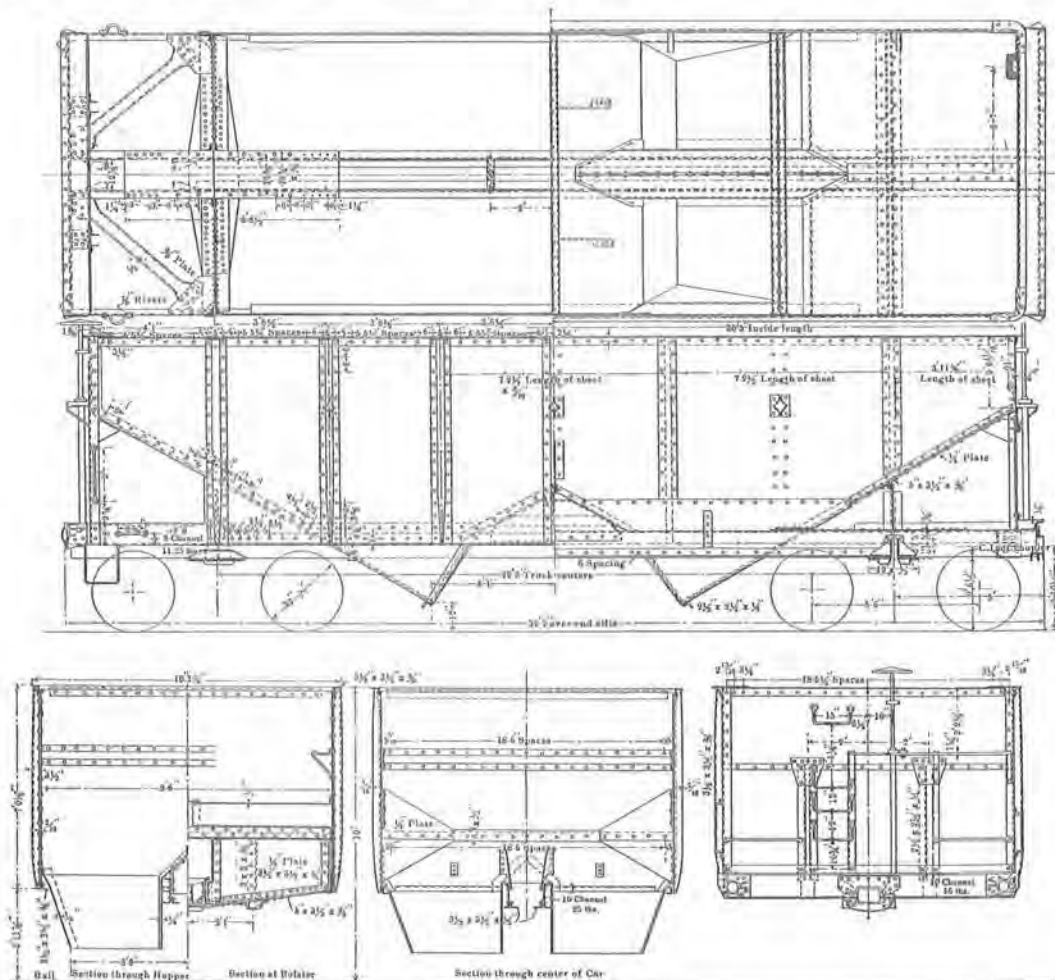


FIGURE 3.24

The Philadelphia & Reading Railroad was among the first to purchase the Standard Steel design. This builder's photo from June 1903 shows the layout of the side posts and end posts. The slope of the floor sheets and cross-ridge sheets can be discerned by the rivet pattern on the side sheets. This car is equipped with a Standard Steel, center-operated, door-operating mechanism. Note the pressed-plate striking plate. This also served as the attaching point for the brake staff and as the step required by the M.C.B.A. Safety Appliance Standards to allow trainmen access to the ladder in the center of the end of the car. [Standard Steel Car Company Photo; Courtesy: D.K. Retterer Collection]

The early Standard Steel design proved to be very popular. Among the railroads purchasing these cars were the Delaware, Lackawanna & Western; Lehigh Valley; Pittsburgh & Lake Erie; Philadelphia & Reading; Wheeling & Lake Erie; Central of New Jersey; and notably, the Pennsylvania Railroad.

The shift away from pressed-steel underframes took place quickly when two of Pressed Steel's largest customers, the Pennsylvania and Baltimore & Ohio Railroads, turned to cars employing structural-steel underframes. The Pennsy stopped purchasing its GL class in 1903 and was developing an alternative of its own design. In the meantime, it purchased 700 of the early Standard Steel cars for its Lines West of Pittsburgh in July 1904. These became its GLB class.³¹



The Pennsylvania Railroad began taking deliveries of its GLA-class, all-steel hopper cars in early 1905. This class was built as a follow on to its GL, and it incorporated many of the lessons learned from that car. The pressed-steel center sill was replaced with one of rolled steel, and the pressed-steel side sill was dropped altogether. The width of the side sheets was increased resulting in a reduction of the number of side posts from nine to seven. The angle of the cross-ridge sheets was reduced from the 60° used in the GL to 30°, and the distance between the hopper bottoms was reduced from 9' 2" to 8' 2". The inside length was reduced from 31' 6 1/8" to 31' 5" while the height to eaves of 10' 0" was retained. The cars had a capacity of 1,683 cubic feet, and, as in the case of the GL class, the Pennsy rated them at 50 tons capacity if they had cast-iron wheels and 55 tons with steel wheels.²² One of the identifying features of the GLA is the distinctive, Pennsy-style end design. [*American Engineer and Railroad Journal*, May 1905]

Three hopper-car designs were introduced in 1905 that effectively settled the pressed-steel versus structural-steel debate. They did this by combining the elements of both in their construction. The first was the Pennsylvania Railroad's GLA 50-ton, twin-hopper car. After purchasing over 20,000 pressed-steel, GL-class hopper cars, the Pennsylvania Railroad began to realize that the pressed-steel center sills were proving troublesome.³³ It abandoned the GL-design in favor of a similar-sized car of structural-steel construction.³⁴ This was the GLA.

The GLA took advantage of the lessons learned from the pressed-steel GL. The GL had employed pressed-steel, "fish-bellied" center and side sills. Unfortunately, the center sill proved to be too weak, having a cross-sectional area of only 12¾ square inches at the bolster. The Pennsy made several important changes in the GLA's structural design. First, it replaced the pressed-steel center sill with a structural-steel center sill having a cross-sectional area that was never allowed to be under 23 square inches. This heavier center sill meant that the new car could stand up to the most severe handling that it would face in use.³⁵ Then, it completely eliminated the side sill between the bolsters and allowed the sides to carry the load. These changes resulted in a more rugged car that had a capacity equivalent to the pressed-steel GL-class car while weighing 550 pounds less.³⁶

The next change it made was to reduce the slope of the cross ridge sheets to 30°, the same angle as the slope sheet. This shallower angle increased the capacity of the car and would ultimately become the industry standard for the angle of the cross ridge throughout the steam era.



FIGURE 3.26

This photo of the end of an NYO&W GLA provides a good view of its brake arrangement and the distinctive, Pennsy-style end design with its twin, rolled-steel-angle end posts and trapezoidal-shaped end post gussets. [Courtesy: Walter Kierzkowski Collection]

The Pennsy equipped these cars with the Simonton door-operating mechanism, which had proven its worth in other railroad service. Simonton used a scissoring mechanism to open and close the doors. Once in the closed position, hooks latched the doors shut while in transit, thus eliminating a problem experienced with other door-operating mechanisms.³⁷

Although the Pennsylvania Railroad kept the pressed-steel GL in service for another 40 years, its transition to the GLA effectively settled the pressed-



FIGURE 3.27

The Standard Steel Car Company was one of a number of car manufacturers that produced the GLA twin-hopper car for the Pennsylvania Railroad. Car number 675001 was among the first GLA's manufactured in February 1905. Note the distinctive arch shape on the bottom edge of the platform end sill. Also note that the car has brake wheels on the right side of both ends of the car. [Standard Steel Car Company Photo; Courtesy: D.K. Retterer Collection]

steel versus structural-steel debate in high capacity hopper cars.

The GLA's success grew not just from its widespread use on the Pennsylvania Railroad, but from its use by many of the coal companies that were served by the Pennsy. By purchasing the same cars as the railroad, these companies enjoyed lower initial production costs, and they shared the same logistical base, which lowered their life-cycle costs. In effect, the GLA became a de facto standard in the Pennsylvania coal fields. Almost 30,000 GLA's were eventually produced, and many remained in service through the 1950s. Used GLA's were also put into service by other railroads, including the Lehigh Valley; Baltimore & Ohio; Cambria & Indiana; and the New York, Ontario & Western.²⁸

The second car introduced in 1905 was the Baltimore & Ohio's N-10-class steel hopper car with structural-steel underframe built by the Pressed Steel Car Company. These cars were longer than earlier cars, having an inside length of 31' 6", with

nine, pressed-steel side posts, and short platform end sills. Instead of following the GLA's example of a 30° angle of the cross ridge, the builders set that angle at 45°, which caused the cross-ridge sheets to meet at their apex at a 90° angle. The B&O purchased over 7,000 of these cars. Photos of the N-10 class are shown in Figures 8.66 and 8.67 on page 240, and drawings for this car were published in the 1906 edition of the *Car Builders' Dictionary*. As in the case of the GLA, some of the coal companies served by the B&O also bought cars of this design.

The third design introduced in 1905 went on to become one of the most widely-produced cars of the early 20th century. This design was built in the tens of thousands and was widely adopted by a number of railroads, including the Baltimore & Ohio; New York Central; New Haven; Chesapeake & Ohio; Central of New Jersey; Lehigh Valley; New York, Ontario & Western; Pittsburgh & Lake Erie; Lehigh & New England; Bessemer & Lake Erie; and Buffalo, Rochester & Pittsburgh, among others. Cars follow-

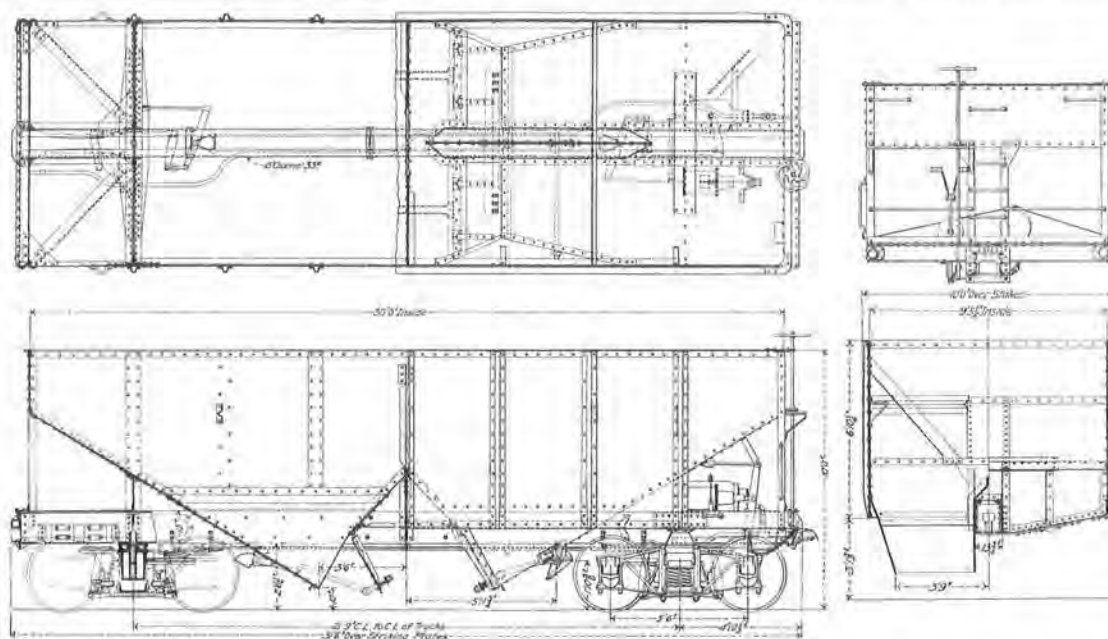


FIGURE 3.28

This twin-hopper-car design was an evolutionary development of the design introduced by the Standard Steel Car Company in 1903. The cars retained the 30' 0" internal length, 10' 0" height to eaves, 45° slope of the cross-ridge sheet, and 7' 0" separation between the bottoms of the hoppers. The major changes from the 1903 design included increasing the width of the side sheets that made up the sides of the car, replacing the nine structural-steel side posts with seven pressed-steel side posts, adding rolled-steel platform end sills, and fitting the rolled-angle end posts between the end sill and the end sheet and securing them to the end sheet with triangular-shaped end-post gussets. This design proved very popular and is easily identified by those features. Variants of this design included cars with different lengths and heights and end-post designs. Because of the car's ubiquity, its design had been labeled by some historians as being an "early standard." It will be identified in this book as the "1905 Common Design." [*Car Builders' Dictionary*, 1906; Courtesy: Simmons-Boardman Publishing Corporation]

ing this design were manufactured by all of the major car makers, including the Cambria Steel Car Company, American Car & Foundry, Pressed Steel Car Company, Ralston Car Company, and Standard Steel Car Company. Because it was built by so many different manufacturers and used by so many different railroads, it became, in effect, another "de facto" standard and will be referred to in this book as the "1905 Common Design."

At the end of 1905, after producing over 6,000 cars of its original, all structural-steel design, the Standard Steel Car Company introduced a revised design, which retained many of the features of its original car while incorporated other elements to save weight and cost. Significant among these were increasing the width of the sheets making up the sides so that the number of side posts was reduced from nine to seven, replacing the structural-steel side posts with pressed-steel side posts, adding a rolled-steel platform end sill, and using rolled-angle end posts affixed to the end sheet with triangular-shaped gusset plates. It retained the 45° angle of its original design's cross-ridge sheets rather than adopt the 30° angle used in the GLA. Like Standard Steel's earlier car, the 1905 Common Design had a center sill composed of twin 15" steel channels. Elevation drawings are shown in Figure 3.28.

The first cars produced to the 1905 design had an interior length of 30' 0" and height to the eaves of 10' 0", but variants were built in a range of sizes, with heights varying from 10' 0" to 10' 6" and inside lengths ranging from 30' 0" to 30' 6" with capacities of 50 and 55 tons. These cars were equipped with door-operating mechanisms and freight car trucks to

Standard Car Designs

Any design has key features that set it apart from all other designs. While some of these features may not be immediately visible to the viewer, others features that are visible make it easy to identify one car from another. In establishing criteria for standard designs throughout this book, those features that set one design apart from another are identified.

For example, in the case of the "Seley" cars, the visible, distinguishing feature of this design is the side truss system employed to support the weight of the car. Since the N&W employed this system in both gondolas and hopper cars, it would be difficult to use other features to identify this "standard."

With all-steel hoppers cars, the visible features to identify a class or series are the number and style of hoppers and doors; the inside dimensions; the height from the rail to the eaves; the angle of the cross ridge or cross cover; the number, style and spacing of side posts; the presence or lack of side post gussets; the construction of the end sill; the construction of the end posts; and the presence and shape of end-post gussets. In later construction, the shape of the end side sheets is also considered.

Cars that meet most but not all of the identified criteria are identified as variants of the design.

suit the purchaser. They were upgraded with new brakes, door-operating mechanisms, and trucks during their lives, and many remained in service well into the 1950s.

The 1903 Standard Steel design continued to



FIGURE 3.29

The New Haven purchased some of the first cars that Standard Steel Car Company built to the 1905 Common Design. This car was part of a lot of 26 cars numbered from 100001 to 100026 purchased in April 1906. These cars had an inside length of 30' 0", inside width of 9' 5 1/2", and height to the eaves of 10' 0", providing an internal capacity of 1,680 cubic feet. [Standard Steel Car Company Photo; Courtesy: D.K. Retterer Collection]

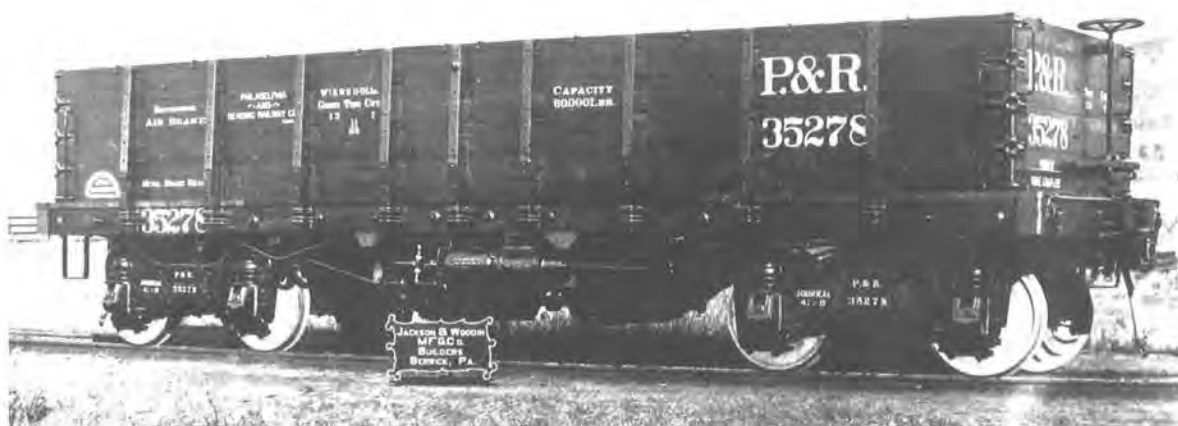


FIGURE 3.30

P&R 35278 was built for the Philadelphia & Reading by the Jackson & Woodin Manufacturing Company of Berwick, Pennsylvania, in November 1898. It is typical of the all-wood, hopper-bottom gondolas that were being built during the transition era from all-wood to all-steel construction. The car is equipped with Fox pressed-steel trucks. Jackson & Woodin was one of thirteen companies that combined to become the American Car & Foundry Company in 1899. [Courtesy: Bob's Photo]



FIGURE 3.31

Within five years of their being introduced, heavier, all-steel cars were taking a heavy toll on railroads' smaller, all-wood cars. Railroads had a choice of scrapping the older cars or attempting to upgrade them to withstand the rigors of being placed in service with the heavier cars. In 1908, the New York, Ontario & Western Railway began installing steel underframes on its wood, hopper-bottom gondolas. NYO&W car number 12164, originally built in 1891 by the Lafayette Car Works, was one of the first cars to receive a rolled-steel underframe. The car was equipped with Wolff cast-steel trucks. [Courtesy: Ontario & Western Railway Historical Society Archives]

enjoy popularity even after these other designs were introduced. In 1906, the Pressed Steel Car Company produced a number of the earlier cars for the Lehigh Valley,³⁹ and in 1908, American Car & Foundry produced a batch for the Delaware, Lackawanna & Western.⁴⁰ Cars using those early design elements were produced into the 1920s.

The introduction of all-steel cars did not mean the end of railroads' wooden fleets. As early as 1897, pundits were predicting the end of wooden coal cars because of their inefficiency compared to steel cars.⁴¹ Some railroads continued to buy all-wood freight cars even as the merits of all-steel construction were being recognized. However, as these wooden cars were mixed in trains with heavier, all-steel cars, problems began to develop.

In 1900, the *American Engineer and Railroad Journal* reported that "... the mixture of heavily loaded steel cars with wooden ... cars in through freight trains is causing such frequent failures of wooden cars, that a new and strong argument for steel underframes ... is rapidly making itself felt. Large numbers of wooden cars are being sent to the shops for repairs, and numerous wrecks are caused by the failure of wooden cars, when forming parts of trains of big steel cars. The weak cars are being pulled apart or crushed by the application of the air brake."⁴²

Railroads quickly recognized the problem, but they could not afford to abandon their wooden

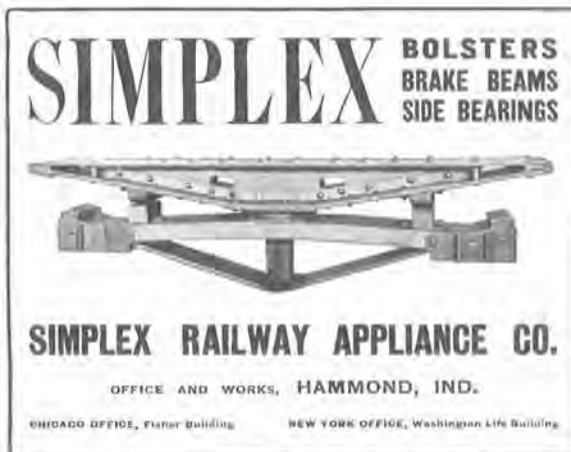


FIGURE 3.32

This 1903 ad for the Simplex Railway Appliance Company shows the Simplex steel bolsters that many railroads used in rebuilding their wooden cars in the early 1900s. [*Car Builders' Dictionary*, 1903; Courtesy: Simmons-Boardman Publishing Corporation]

fleets outright. Therefore, they began to upgrade their wood cars to carry heavier loads and survive when placed in trains with heavier, all-steel cars.

To answer this need and protect the railroads' investment in wood coal cars, manufacturers began offering steel components with which railroads could upgrade their wooden cars. Steel body

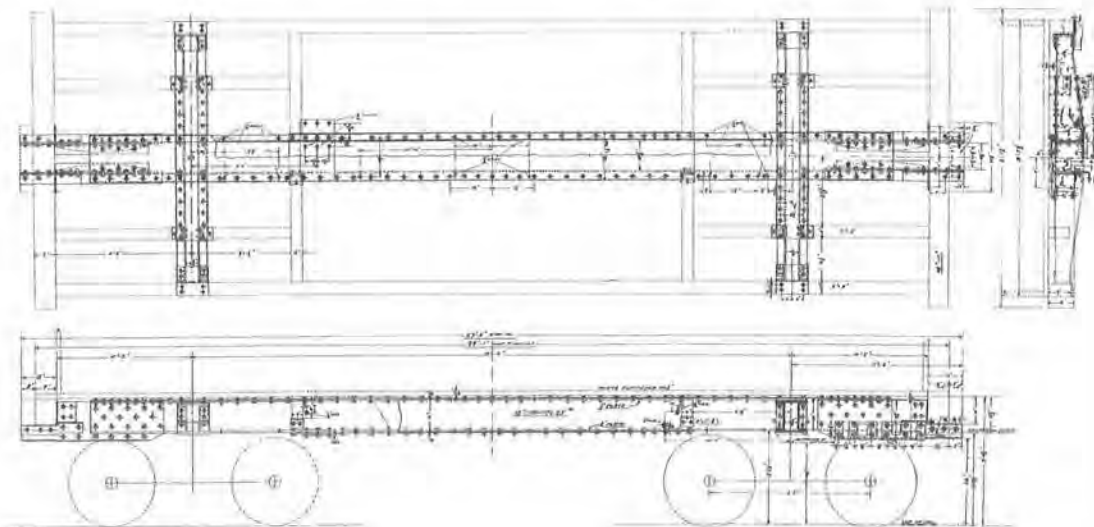


FIGURE 3.33

In the early 1900s, manufacturers began offering steel underframes to replace the wood underframing in all-wood cars so that they could withstand the handling in trains intermixed with larger, all-steel freight cars. Shown here is a Martin rolled-steel underframe built by the Standard Steel Car Company in Pittsburgh for a 30-ton wood car. [Courtesy: Ontario and Western Railway Historical Society Archives]

bolsters and underframes were popularly offered as a way of extending the lives of railroads' wooden fleets. Figure 3.32 shows Simplex truck and body bolsters, which were a favorite of many railroads in increasing the capacity of their wood coal cars. Figure 3.33 shows a Martin steel underframe produced by the Standard Steel Car Company, which was designed to reinforce an all-wood, 30-ton hopper-bottom gondola.

Despite the economics of the self-clearing hopper car, railroads continued to purchase gondolas during the first three decades of the 20th century for two main reasons. First, not all of the railroad's cus-

tomers were equipped with the facilities that would enable a hopper car to dump its load between the rails. Therefore, they'd require a car that permitted them to offload either by shovel or in smaller amounts between or beside the rails. Secondly, the seasonal nature of the coal trade meant that during the off-season, dedicated coal cars would lay empty not generating any revenue. A gondola could easily carry coal during the heating season and other products during the off season. Coal cars would be built either as drop-bottom gondolas, which were the most versatile, or hopper-bottom gondolas, which were best suited for the coal trade.



FIGURE 3.34

During the transition years, a number of railroads purchased these larger, hopper-bottom and drop-bottom gondolas instead of converting to cars constructed of steel. DL&W 70955 was built as an all-wood, hopper-bottom gondola in December 1900. In February 1921, the Delaware, Lackawanna & Western had the car rebuilt with a steel underframe by the Buffalo Steel Car Company. This car had a capacity of 1,368 cubic feet and a nominal capacity of 80,000 pounds. [Andrew Merrillees Collection; Courtesy: National Archives of Canada/PA164107]



FIGURE 3.35

Just three years after the Lackawanna built the hopper-bottom gondola shown in Figure 3.34, the Pittsburgh & Lake Erie purchased this 80,000-pound-capacity, all-steel, hopper-bottom gondola from the Standard Steel Car Company. The car is built of structural-steel components, though pressed-steel side stakes were used at the junction of the car's side sheets. Note the end buffers and drop-door mechanisms. [Standard Steel Car Company Photo; Courtesy: D.K. Retterer Collection]



FIGURE 3.36

The Pennsylvania Railroad began buying its 100,000-pound capacity, pressed-steel GS-class gondolas for its Lines West of Pittsburgh in 1902. Shown here is a GSA-class, drop-bottom gondola built in November 1905. The drop-door mechanism is visible along the side sill. [Standard Steel Car Company Photo; Courtesy: D.K. Retterer Collection]



FIGURE 3.37

The Bessemer & Lake Erie purchased these all-steel, drop-bottom gondolas from the Standard Steel Car Company in July 1905. The car was constructed of structural-steel components, but, as it had done with its hopper cars, the builder has converted to the use of pressed-steel side posts. The door-operating mechanism can be seen along the side of the car. [Standard Steel Car Company Photo; Courtesy: D.K. Retterer Collection]



FIGURE 3.38

The Seaboard System purchased these 40-ton, wood-sided, drop-bottom gondolas from the Pressed Steel Car Company in May 1907. The door-operating mechanism is visible along the side of the car. [Pressed Steel Car Company Photo; Courtesy: D.K. Retterer Collection]



FIGURE 4.1

The Pennsylvania Railroad's first H21-series hopper was produced in the railroad's Altoona shops in 1909 to carry coke. Because coke has only 60% of the weight of the coal the Pennsy normally carried, the railroad needed a car with greater volume to carry the same weight. These cars were originally equipped with 50-ton arch bar trucks and twin, horizontally-mounted, drop doors, sometimes referred to as "clamshell" doors, as depicted in the elevation drawings shown in Figure 4.3 and pictured in Figure 4.2 below. Shortly after the H21 was introduced, the Pennsy's Lines West began converting its H21 fleet into coal cars, replacing the original 50-ton trucks with 70-ton Crown trucks. By the mid-1920s, the railroad had made this modification to all of its H21's. These modified cars became the Pennsy's H21A series.¹ In the mid-1920s, the railroad began replacing the drop-door hopper bays with "sawtooth" hopper bays equipped with vertically-suspended hopper doors, which increased the car's capacity from 2,508 to 2,547 cubic feet. Notice that the sawtooth hoppers at each end of the car discharge towards each other. The car shown here is an H21A series with those modifications. [Photographed at the Strasburg Railroad, Strasburg, Pennsylvania]



FIGURE 4.2

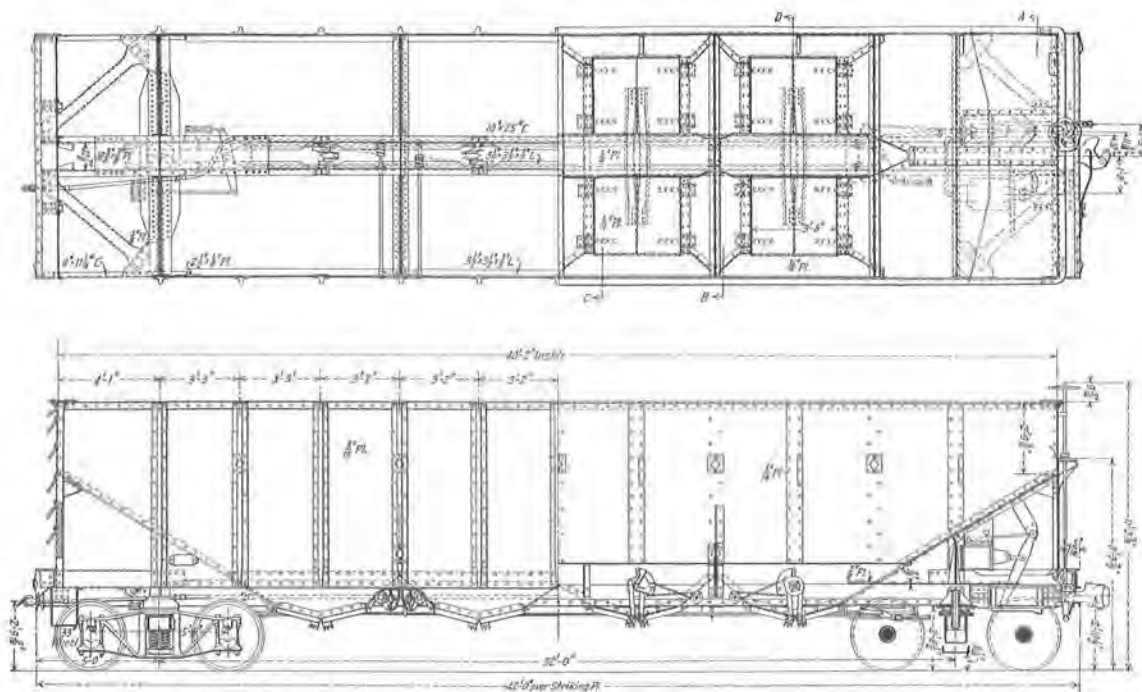
The H22 was developed as an alternative to the H21 for carrying coke. The dimensions of the car were essentially identical to the H-21, that is, it had a 40' 2" inside length and 9' 6" inside width, providing an internal capacity of 2,508 cubic feet. Rather than having solid steel sides, it had slatted gates that slid out of the way to facilitate loading. The slats also provided air circulation. The railroad initially procured 4,500 cars of this classification, 200 from Cambria Steel Car Company, 800 from Standard Steel Car Company, and 3,500 from Pressed Steel Car Company. In 1922, the company began replacing the slatted gates with steel plate, reinforcing the top chord with bulb angle, and replacing the 50-ton trucks with 70-ton trucks. These became the railroad's H22A series. Ultimately, most of these cars were converted into H21A's.² [Standard Steel Car Company Photo; Courtesy: D.K. Retterer Collection]

As car builders and railroads gained confidence in steel car construction, they began building cars with ever greater capacities.

The Pennsylvania Railroad began its investment in larger cars at the turn of the twentieth century with the introduction of its GP and GPA class, all-steel, 50-ton hopper cars. These cars were equipped with longitudinal drop doors and had an inside length of 40' 2 1/8". The GP, which had solid sides and a height to eaves of 12' 0", had a capacity of 3,123 cubic feet. The GPA had coke racks, a height of 12' 5" and a capacity of 3,187 cubic feet.³ These cars were designed to haul the railroad's growing traffic

in coke, which weighs approximately 28 pounds per cubic foot as compared to the 46 pounds per cubic foot that Pittsburgh bituminous coal weighs. Therefore, in order to carry 50 tons of coke, a coke car had to be significantly larger than a 50-ton coal car.

In 1909, the railroad introduced the H21, with four crosswise hoppers and 2,508 cubic feet—21% less capacity than the GPA but almost 50% more capacity than the railroad's GLA twin-hopper car. The H21 was also designed as a coke car and was initially rated at only 50 tons. This limitation was based upon the trucks with which it was equipped. Over the next ten years, however, the H21 was



Pennsylvania Railroad All-Steel 50-Ton Capacity Hopper Coke Car. Builder, Cambria Steel Company.

FIGURE 4.3

These are the elevation drawings for the 50-ton, H21-series as it was originally designed in 1909 to carry coke. The car's inside length of 40' 2", inside width of 9' 6", and height to eaves of 10' 6 1/2" yielded a capacity of 2,508 cubic feet. The four hopper bays were equipped with twin, horizontally-mounted drop doors. The railroad employed the same design for the end of the car as it used in its GLA, that is, an extended platform end sill and twin, rolled-steel-angle end posts secured to the end sheet with trapezoidal-shaped gusset plates. Beginning in the mid-1920s, the Pennsy began replacing the drop-door hopper bays with sawtooth hopper bays equipped with vertically-suspended hopper doors. This increased the capacity by 39 cubic feet. [*The Car Builders' Dictionary, 1912 Edition; Courtesy: Simmons-Boardman Publishing Corporation*]

transitioned from a coke car to a coal car by equipping the car with heavier freight car trucks, which enabled the railroad to increase the cars' nominal capacity from 100,000 pounds to 140,000 pounds. The car was originally equipped with four hopper bays with twin, horizontally-mounted, drop doors. These drop-bottom hopper bays were later replaced with "sawtooth" hopper bays with vertically-suspended doors. This modification added 39 cubic feet to the car. Ultimately, the Pennsy purchased over 39,000 variants of the H21 series, and many remained in service through 1970.⁴

By 1912, the Norfolk & Western was ready to stretch the boundaries of coal-car construction by introducing the first mammoth coal car. It was an all-steel, flat-bottom gondola with drop doors and a design capacity of 100 tons. It was designed specifically for service between the railroad's Pocahontas fields and its deep-water terminal at Lambert's Point near Norfolk, Virginia, where it would be unloaded in the terminal's rotary car-dumping machine. The cars were equipped with specially designed, six-wheel trucks with articulated frames to distribute the weight evenly over the rails.⁵

The Norfolk & Western continued its develop-

ment of heavyweight gondolas through the teens, and, in 1920, it introduced a new 100-ton design. In addition to a number of other weight-saving features, the car employed side-bearing trucks. Instead of having the weight of the car supported through the center plate and truck bolster, all of the car's weight passed through the side bearings directly onto the truck side frames. To reduce turning friction, the builders installed conical-shaped roller side bearings between the body bolster and truck frame. Shifting the weight to the truck bolster provided several advantages for the car. It saved weight by eliminating the need for a heavy truck bolster, and it distributed the weight over all twelve wheels. This revised design enabled the designers to reduce the overall weight of the car from 65,200 pounds to 53,500 pounds, while at the same time increasing its capacity from 2,829 to 3,123 cubic feet.⁶

The Norfolk and Western continued its development of large-scale gondolas until its design evolved into its GKd series, which it introduced in the late 1920s. Other railroads that joined the N&W in its quest to build mammoth gondolas for use in rotary dump machines included the Chesapeake & Ohio and the Virginian.

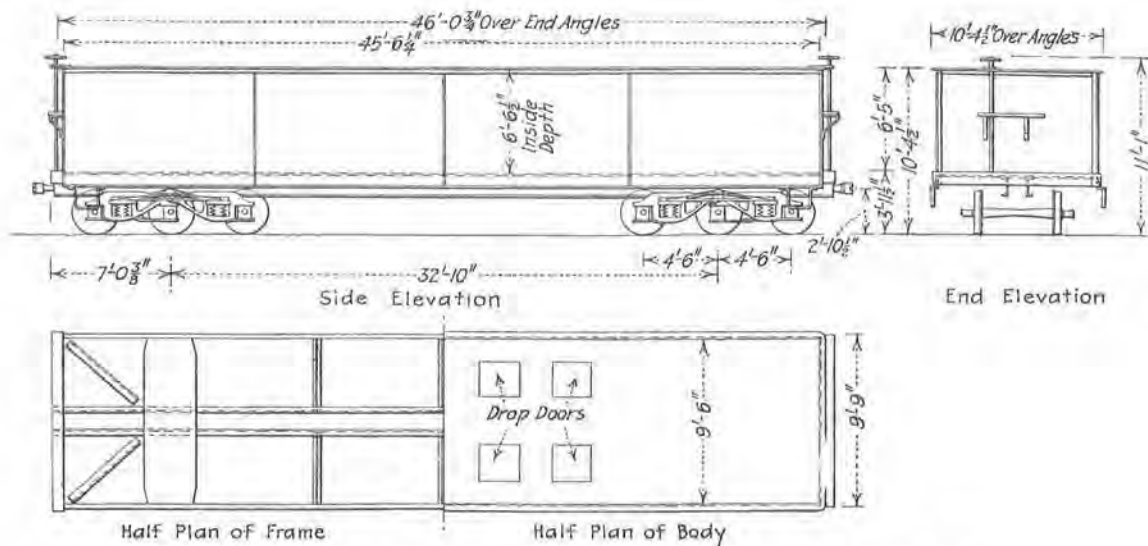


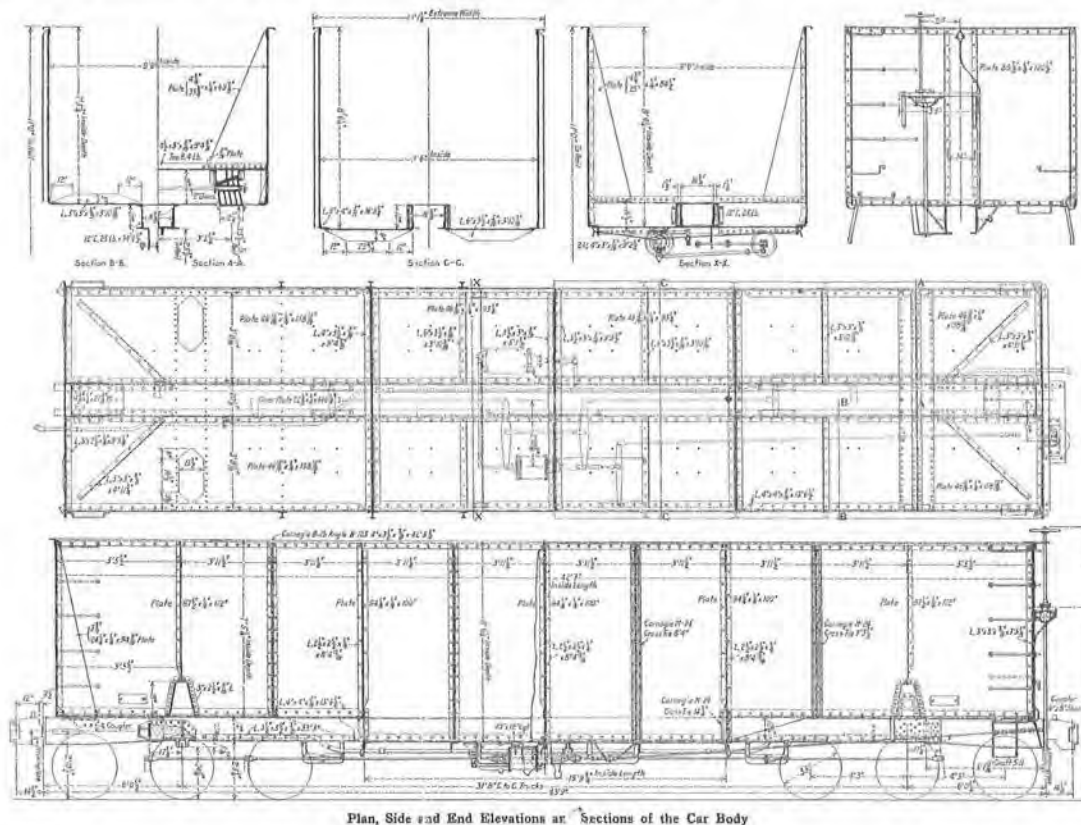
FIGURE 4.4

The Norfolk & Western introduced the first of its 100-ton capacity gondolas in 1912. These cars were rated at a nominal capacity of 90 tons, but because it was typical to allow a 10% overage of the marked capacity, they were actually designed to carry 100 tons. The builders used structural-steel components in its construction, using two heavy steel channels for the center sill. The car also employed an innovative six-wheel articulated truck to distribute the heavy load over the rails.⁷ [Engineering News, January 16, 1913]



FIGURE 4.5

N&W 100629 was one of 750 cars the Norfolk & Western built in its GKA series, its first generation of 100-ton gondolas designed to be unloaded in rotary dump machines. This series had an inside length of 45' 6 1/4", inside width of 9' 6", inside height of 6' 6 1/2", and capacity of 2,829 cubic feet. They were numbered from 10000 to 100749. This car was built in April 1914. [Courtesy: Norfolk Southern Corporation]



Plan, Side and End Elevations and Sections of the Car Body

FIGURE 4.6

In 1920, the Norfolk & Western introduced its third-generation 100-ton gondola shown here. This was the lightest car of its capacity introduced up to that date. To save weight, engineers designed the car to be supported on the side bearings rather than through the center plate. The railroad produced 500 of these cars in 1921 and 1922. Despite their very high revenue factor of 78.88%, all were retired by 1934 due to heavy corrosion.⁶ [Railway Age, April 15, 1921, p. 926; Courtesy: Simmons-Boardman Publishing Corporation]

Beyond the large-size models, the gondola continued to be a popular way to haul coal through the first three decades of the 20th century. The advantage of the drop-bottom gondola was that it was a multi-purpose car, that is, it could haul coal one day and other materials the next. The disadvantage was the fact that early drop-bottom gondolas and hopper-bottom gondolas were not self-clearing—they required physical effort to discharge the load.

In 1906, the Pressed Steel Car Company developed an alternate design for a drop-bottom gondola that addressed these disadvantages. Rather than discharge its load through the rails, the car discharged the load to the sides. This innovative design produced a car with an inside length of 34' 0", a volume of 1,530 cubic feet, and a nominal capacity of 50 tons. The car had sixteen drop doors, and, in effect, the entire bottom dropped out of the car, permitting a full 99% of the car's contents to be self-cleared. The doors were hinged in the center of the car to permit the discharge of the entire contents to the side. The doors over the trucks dropped to allow a 23" opening, while the doors in the center of

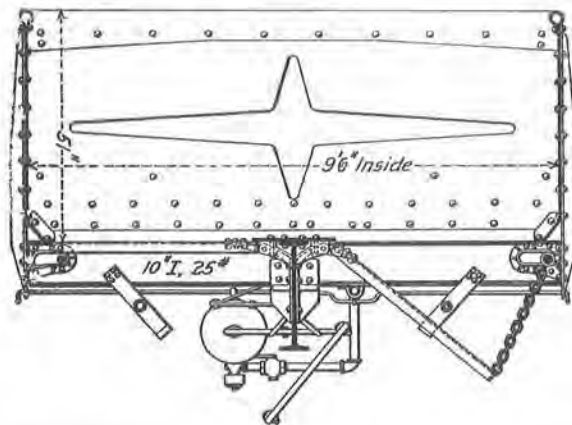


FIGURE 4.7

This elevation drawing shows the operation of the side-discharge drop doors of the Bettendorf 50-ton drop-bottom gondola shown in Figure 4.8. Note the location of the winding chain and its use in operating the drop doors. [Car Builders' Dictionary, 1912; Courtesy: Simmons-Boardman Publishing Corporation]

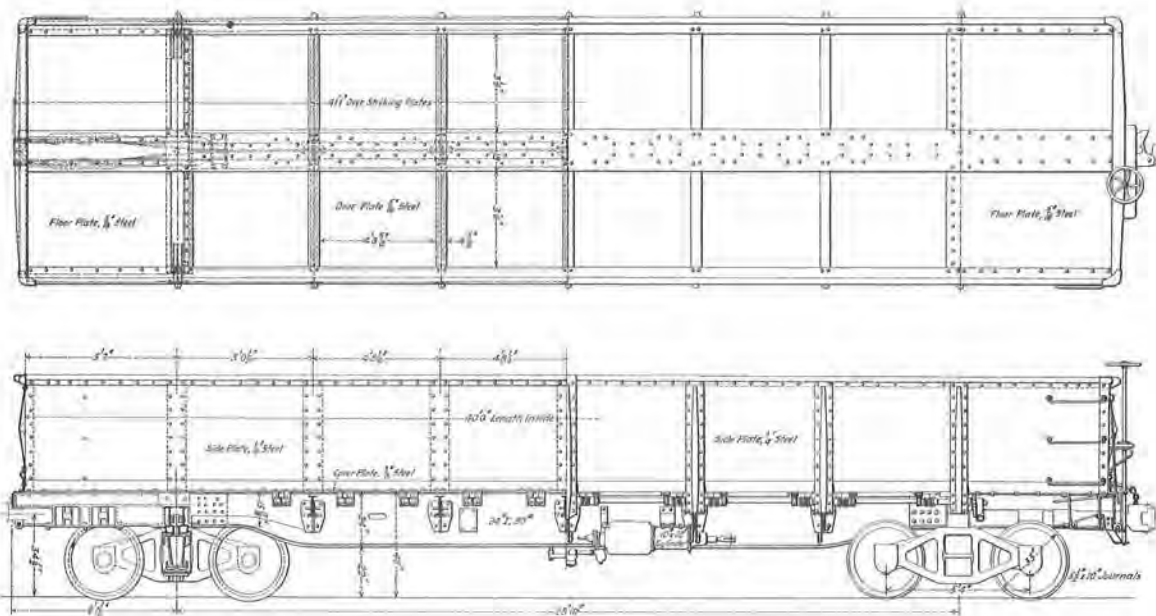


FIGURE 4.8

In 1906, the Pressed Steel Car Company introduced a side-discharge, drop-bottom gondola for use in hauling coal. This design proved so popular that a number of other car manufacturers began producing similar designs. The elevation drawings shown here are for an all-steel, drop-bottom 50-ton gondola built by the Bettendorf Company for the Chicago, Burlington & Quincy Railroad, similar in design to the Pressed Steel Car shown in Figures 4.9 and 4.10. This car had an inside length of 40', an inside width of 9' 6", and an inside height of 4' 3", yielding a capacity of 1,615 cubic feet. [1912 Car Builders' Dictionary; Courtesy: Simmons-Boardman Publishing Corporation]

the car dropped to permit a 26" opening. They were operated by a winding chain attached to a "creeping shaft" that ran the length of the car. When the doors were closed, it could perform as an ordinary flat-bottom gondola without any hoppers interfering with the load. Two railroads belonging to the Frisco System, the Chicago & Eastern Illinois and the Kansas City, Fort Scott & Memphis, were the first to employ these gondolas. Each received 100 cars.⁹

This design proved extremely popular among the railroads, and in particular among the western and midwestern railroads. Indeed, most other car manufacturers followed Pressed Steel's lead and

produced similarly designed cars, some of which were entirely self-clearing and some of which were mostly self-clearing, as in the Pressed Steel design shown below.

The success of these designs is measured in their use by the railroads. Drop-bottom gondolas were the primary means of transporting coal for many of the western and midwestern railroads. For example, of over 19,000 open-top cars that the Burlington Route used for hauling coal in 1929, only 1,750 were hopper cars. Similarly, in that same year, the Illinois Central had over 18,280 drop-bottom gondolas compared to only 3,480 hopper cars.¹⁰

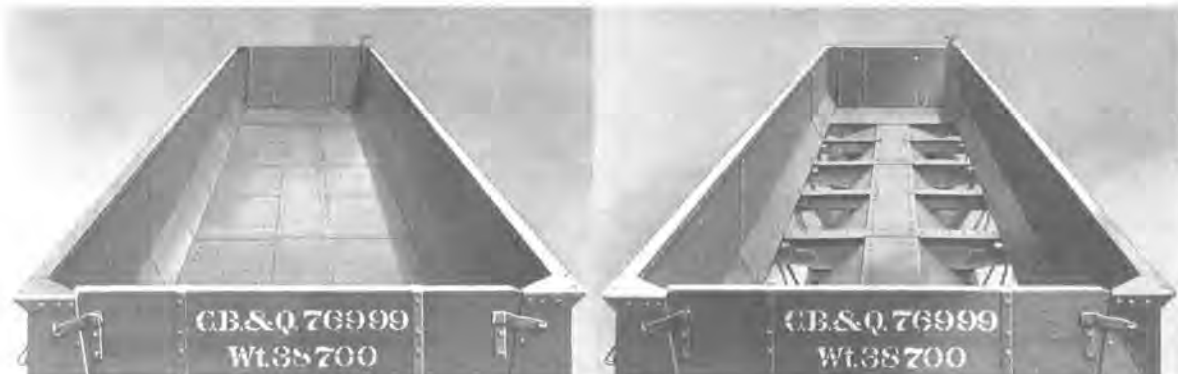


FIGURE 4.9

This high end view shows the operation of the drop doors on the side-discharge, drop-end, drop-bottom gondola built for the Chicago, Burlington & Quincy by the Pressed Steel Car Company in 1910 as a lot of 500 numbered 76500 to 76999. This car compensated for the fact that it was not entirely self-clearing with its versatility. Note the ends, which can be unlatched and dropped to accommodate mill-type loads. [Pressed Steel Car Company Photo; Courtesy: D.K. Retterer Collection]

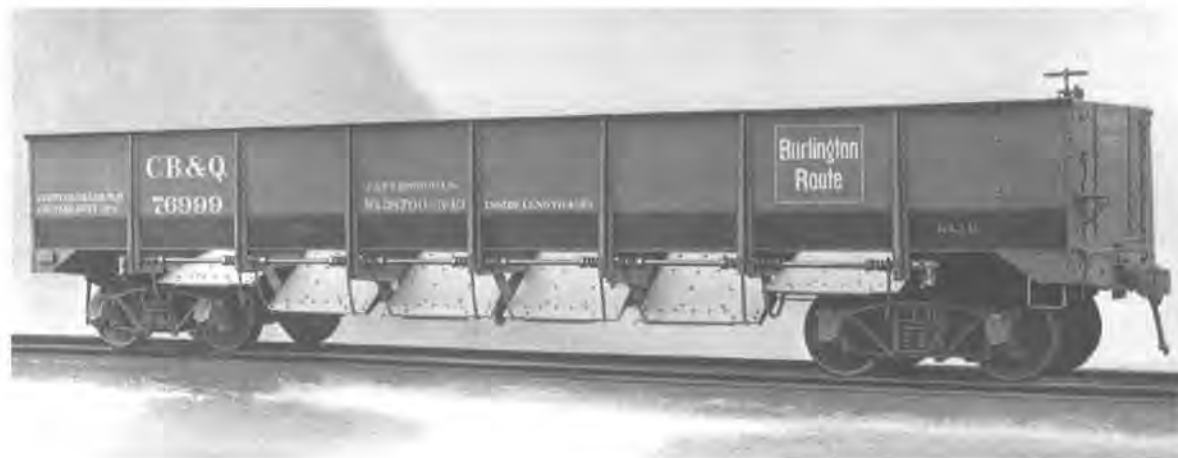


FIGURE 4.10

This side view of the CB&Q car shown in Figure 4.9 shows the winding shaft and chain mechanism used to operate the drop doors. The car shown here had an inside length of 40' 0", inside width of 9' 4 1/2", inside height of 4' 4", and capacity of 1,595 cubic feet. [Pressed Steel Car Company Photo; Courtesy: D.K. Retterer Collection]

One more development impacted freight-car construction during the second decade—the push for standardization. Two factors drove this development, both were cost-related. The most pressing was the desire to reduce the cost of foreign car repairs, but an important second reason was the desire to reduce development and manufacturing

costs. The A.R.A. approached this matter in two ways. The first was to develop standards for parts, such as trucks, side frames, bolsters, and draft gear, and where specific standards could not be developed, to develop standard dimensions for those parts to facilitate their interchange.¹¹ The next step was to develop a standard car design.

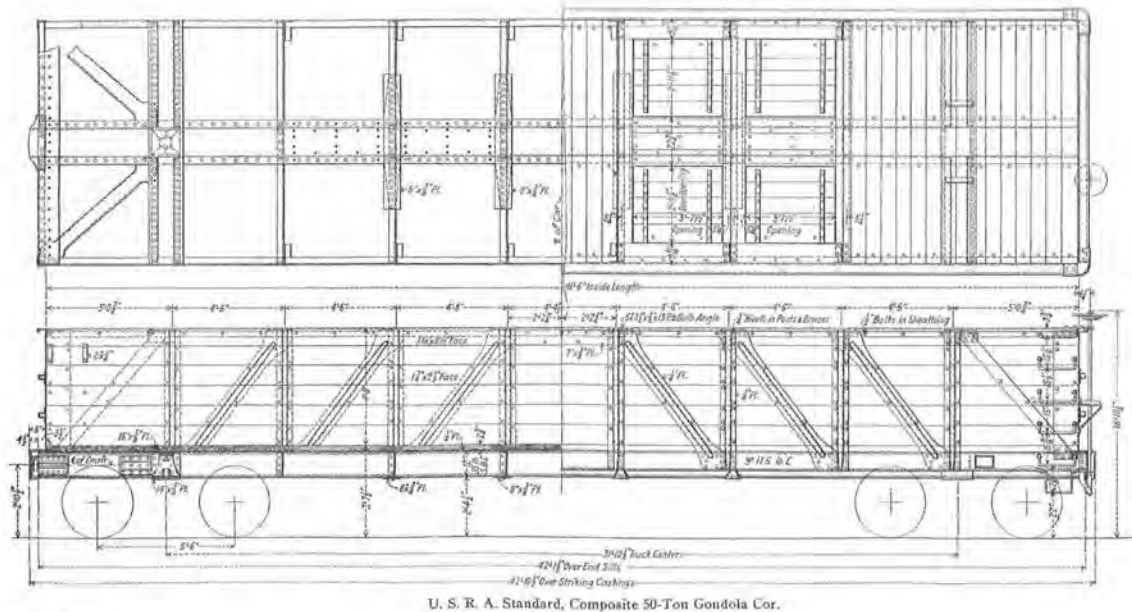


FIGURE 4.11

The United States Railway Administration purchased 20,000 of these composite wood-and-steel-construction, side-discharge, drop-bottom gondolas during its reign. The pressed-steel truss work on the car's side is reminiscent of the Seley design. The had an inside length of 41' 6", inside width of 9' 1 3/8", and inside height of 4' 8", providing a capacity of 1,770 cubic feet. [Car Builders' Dictionary and Cyclopedia, 1919; Courtesy: Simmons-Boardman Publishing Corporation]



FIGURE 4.12

The Illinois Central received 2,650 U.S.R.A. 50-ton, composite, drop-bottom gondolas numbered 126000 to 128649 built by Pressed Steel Car Company (1,300), Standard Steel Car Company (300), American Car & Foundry (150), Haskell & Barker (750), and Magor Car Corporation (150).¹² Car number 126777, shown here, was built by Standard Steel. [Standard Steel Car Company Photo; Courtesy: D.K. Retterer Collection]

The Master Car Builders Association began efforts to develop a standard steel coal car in 1897.¹³ During the next twenty years, several de facto standards emerged, such as the GLA and the 1905 Common Design cars described earlier, but it took America's entry into World War I to produce true, standard-design coal cars.

As rail traffic to support the American Expeditionary Force exploded after the country's entry into World War I, bottlenecks developed throughout the system, and the nation's rail system ultimately collapsed. As a result, on December 31, 1917, the government seized control of the railroads and placed them under the control of the United States Railroad Administration (U.S.R.A.)¹⁴

One of the first acts of the U.S.R.A. was to develop standardized designs for everything from locomotives to freight car trucks in order to rationalize production to meet wartime needs and minimize repair and logistics costs. Within three months, the U.S.R.A., working with the A.R.A.'s Committee on Car Construction, produced designs for several standard freight cars, including a 50-ton, composite, drop-bottom gondola, a 55-ton, all-steel, twin-hopper car, and a 70-ton, all-steel, triple-hopper car.¹⁵

Over 45% of the 100,000 freight cars that the U.S.R.A. purchased from the nation's 17 leading car builders were coal cars. Of those, 20,000 were

50-ton, composite, drop-bottom gondolas, and 22,000 were the administration's 55-ton, all-steel twin-hopper cars. Virtually every major railroad received its share of these cars.¹⁶

The composite gondola's center sill consisted of twin, 12" steel channels. The sides of the car were reminiscent of the Seley design with pressed-steel side stakes arranged in a trusswork to help support the weight of the car. Its 41' 6" inside length and 4' 8" interior height yielded a capacity of 1,770 cubic feet. The car employed the same side-discharge, drop-door system discussed earlier. Drawings and photos are shown in Figures 4.11 and 4.12.

The U.S.R.A. twin-hopper design capitalized on the lessons learned in previous cars, and the design was sufficiently popular that it remained in production for at least ten years after the U.S.R.A. returned control to the railroads. The designers employed a center sill of twin, 12" steel channels. By eliminating the platform end sill, which had been common on earlier cars, they were able to increase the inside length of the car while actually decreasing its overall length. They adopted a 30° slope for both the slope sheets and the cross-ridge sheets, and they increased the car's height to eaves to 10' 8". These three features enabled the designers to increase the car's capacity while reducing its overall footprint.

Comparing the U.S.R.A. twin-hopper car with



FIGURE 4.13

The U.S.R.A. 55-ton, all-steel hopper as originally designed is shown in this photo. Note the Enterprise Type-C door-operating mechanisms, U.S.R.A. Andrews-style, channel-section trucks, Carmer uncoupling mechanisms, and lever hand brake. The 30° angle of the cross-ridge sheets can be discerned from the rivet pattern on the outside of the side sheets between the hopper bays. The first U.S.R.A. hopper was produced in July 1918 by American Car & Foundry.¹⁷ This car was produced that same month by the Standard Steel Car Company. Note that the total weight on rail of 161,000 pounds, which is consistent for a 50-ton car prior to 1920. [Standard Steel Car Company Photo; Courtesy: D.K. Retterer Collection]

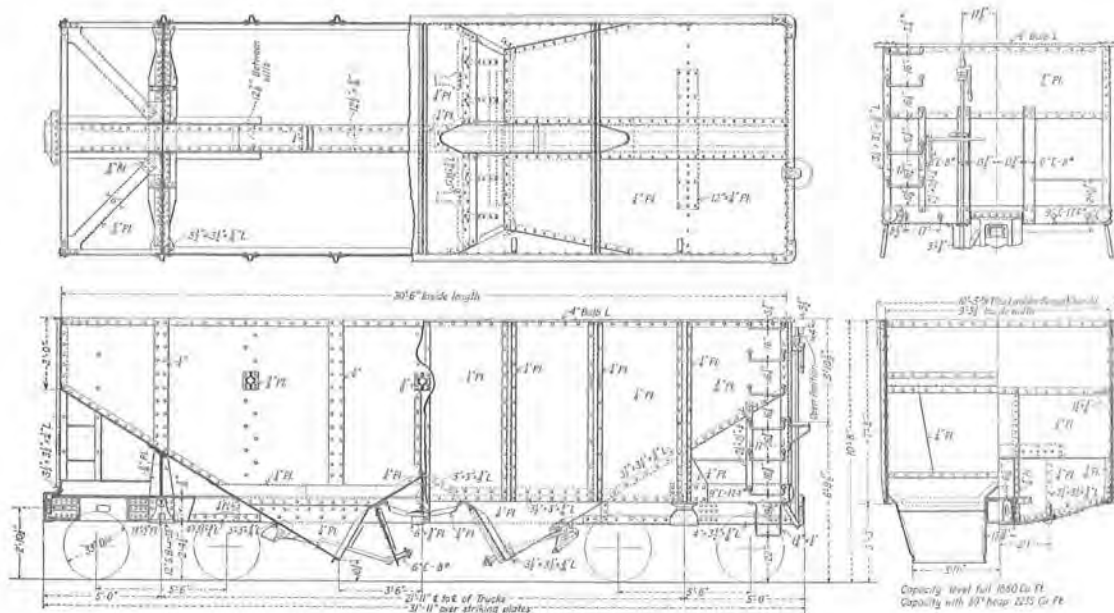


FIGURE 4.14

The U.S.R.A. twin-hopper was the first, true standard coal car, and it became one of the most popular designs of the early 20th century. It had an inside length of 30' 6", inside width of 9' 5 1/2", and height above rails of 10' 8", yielding a capacity of 1,880 cubic feet with a nominal load of 55 tons. The designers employed a 30° slope for both the floor sheets and the cross-ridge sheets, and they set the distance between the hoppers at 7' 0". They eliminated the platform end sills and used steel-channel end posts, which overlapped the end sheet. Taken in combination, these became the identifying features for this design. The cars purchased by the U.S.R.A. employed a drop-handle, ratchet hand brake and Enterprise Type-C door-operating mechanisms, but cars built after the war were equipped with a variety of mechanisms to meet user needs. The U.S.R.A. cars were the last standard car to employ body cross ties. Subsequent designs employed cross-ridge braces and heavier side rails to reinforce the sides and facilitate loading and unloading. [Car Builders Dictionary & Cyclopedia, 1919; Courtesy: Simmons-Boardman Publishing Corporation]



FIGURE 4.15

The U.S.R.A. 55-ton, all-steel-hopper design was adapted and produced throughout the 1920s and into the 1930s. The New Haven had a large inventory of U.S.R.A.-type hopper cars. In addition to the 1,500 it received from the U.S.R.A., the railroad built 433 new cars following the U.S.R.A. design in its shops in 1929 and 1930. These cars deviated slightly from the original design. They were equipped with power hand brakes, lifting coupler levers, Wine door locks, and Dalman, single-level, A.R.A.-standard trucks. [Courtesy: Bob's Photo]

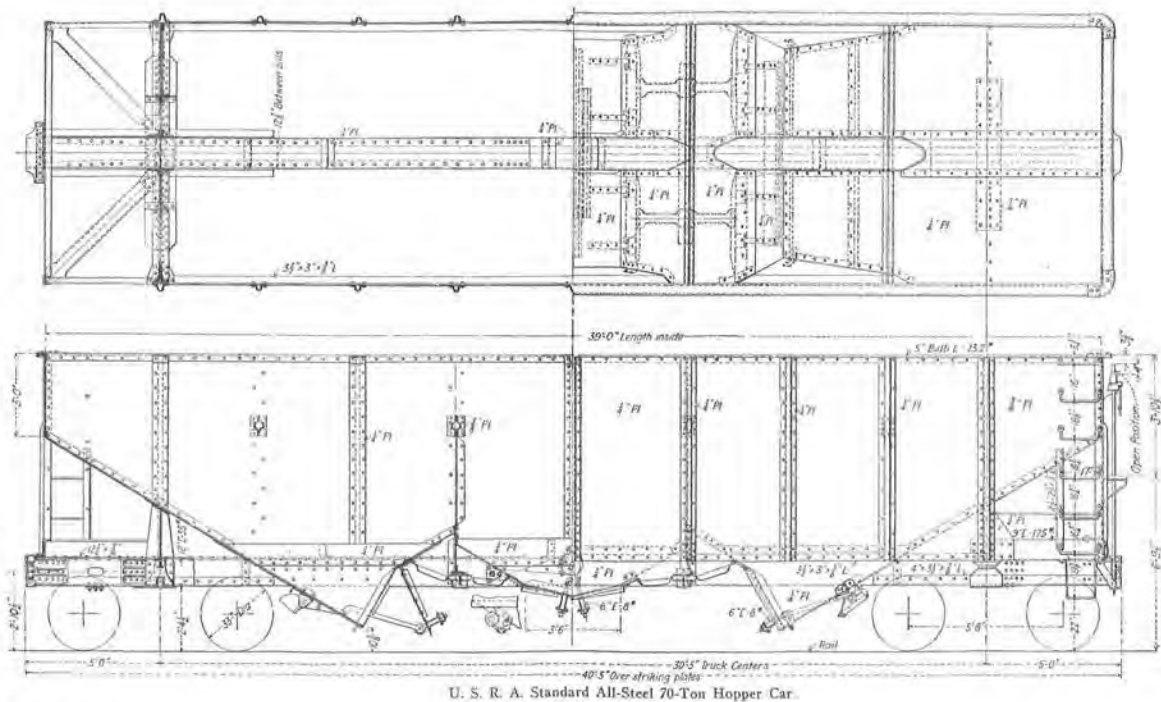


FIGURE 4.16

Shown here are the elevation drawings for the U.S.R.A. 70-ton triple-hopper car. Although none of these cars were ordered by the U.S.R.A. during World War I, several railroads produced these cars after the war. The car had an inside length of 39' 0", an inside width of 9' 5 1/2", and a height to eaves of 10' 8". Its capacity was 2,508 cubic feet level full and 2,978 cubic feet with a 30° heap. [Car Builders Dictionary & Cyclopedia, 1919; Courtesy: Simmons-Boardman Publishing Corporation]



FIGURE 4.17

NYC 425000 was one of 9,000 cars built to the U.S.R.A. triple-hopper car design by the New York Central following World War I. These cars were numbered 425000 to 433999. Beginning in the late 1920s, many of these cars were modified by replacing the center, drop-door hopper bay with a sawtooth hopper. This increased the capacity from 2,508 to 2,518 cubic feet. [Standard Steel Car Company Photo; Courtesy: D.K. Retterer Collection]

earlier cars, the 1905 Common Design had an inside length of 30' 0", overall length of 31' 6", height of 10' 0", and capacity of 1,670 cubic feet. The GLA had an inside length of 30' 5", overall length of 32' 3", height of 10' 0", and capacity of 1,683 cubic feet. The U.S.R.A. had an inside length of 30' 6", overall length of 31' 11", height of 10' 8", and capacity of 1,880 cubic feet. Photos and drawings of the car as originally designed and as adapted in the post-war years are shown in Figures 4.13–4.15.

Based upon the success of the U.S.R.A. designs and driven by the need to reduce production and repair costs, the A.R.A.'s Committee on Car Construction began an effort in the early 1920s to develop standard car designs. Its goal was to develop designs for two self-clearing hopper cars, one with a capacity of fifty tons and one with a

capacity of seventy tons. Using 52 pounds per cubic foot as a measure, this meant that their 50-ton car would have to have a capacity of 2,500 cubic feet and their 70-ton car needed 3,000 cubic feet. In 1926, the committee offered the design shown in Figure 4.18 for the members' consideration.

These designs were remarkable for two reasons. First, the two cars were designed to take maximum advantage of common components. The 50-ton car was a three-bay hopper with a length of 34' 9" and a height from rail to eaves of 10' 6". The 70-ton car was created by inserting a 6' 6" section with a fourth hopper into the center of the 50-ton car, creating a car 41' 3" long.¹⁸ Second, the cars had offset sides with internal side stakes, which enabled the car designers to maximize car capacity while staying within A.R.A. clearances.

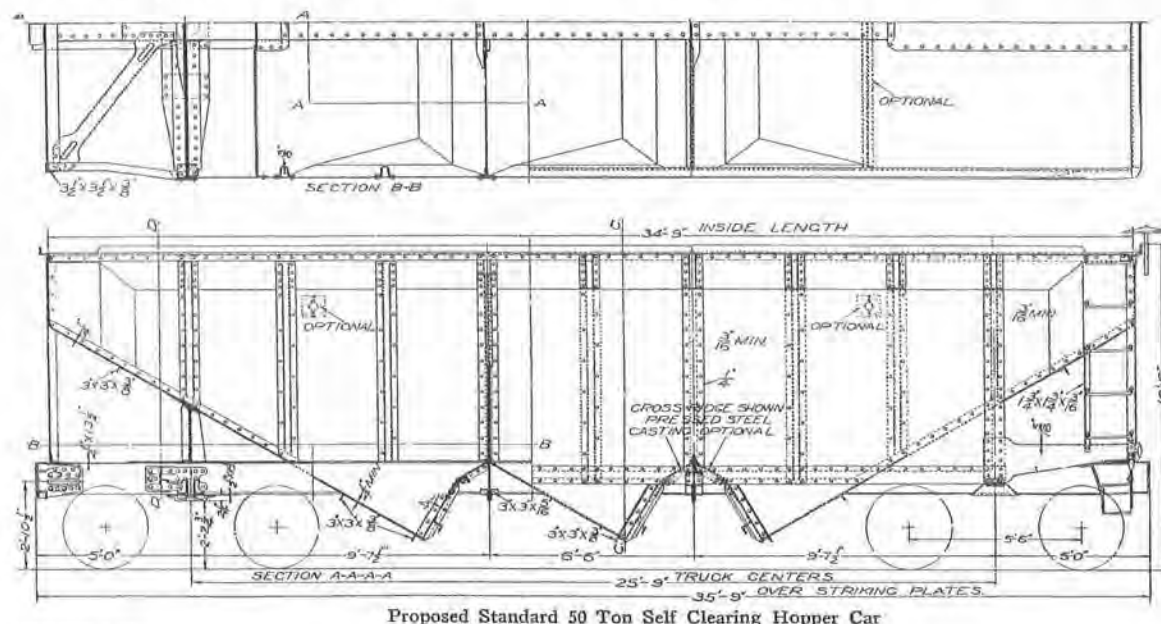


FIGURE 4.18

In 1926, the A.R.A.'s Committee on Car Construction submitted a proposal for standard 50-ton and 70-ton hopper cars. The elevation drawing for the three-bay, 50-ton car is shown here. It had an inside length of 34' 9", inside width of 10' 0", and capacity of approximately 2,500 cubic feet. By inserting a 6' 6" section with a fourth hopper into the center of the car, it became a four-bay hopper car with an inside length of 41' 3", a volume of approximately 3,000 cubic feet, and a nominal capacity of 70 tons. The concept of the design was that production and repair costs could be reduced by using common components for both cars.¹⁹ The designs proposed in 1926 were never approved as standard, however, the Baltimore & Ohio used these designs as the basis for its W-2 classes of hopper cars. Photos of the B&O cars are shown in Figures 4.19 and 4.20. Rather than adopt this design, the members of the A.R.A. asked to have the height increased from 10' 6" to 10' 8", the same height as U.S.R.A. hopper cars.²⁰ As a result, the committee revised its drawings, and in 1928, the members approved an amended design as Recommended Practice. With the height of the cars increased, the designers were able to reduce the length of the cars while maintaining the capacity. The revised 50-ton car had an interior length of 34' 0¹¹/₁₆", and the revised 70-ton car had an interior length of 40' 5".²¹ The designs for these cars originally employed the Enterprise narrow-end design as discussed in Figure 4.21. However, in 1930, the Recommended Practice was changed to use the Wine narrow-end design with the Enterprise design as an alternate.²² [Railway Age, June 12, 1926, p. 1718, Courtesy: Simmons-Boardman Publishing Corporation]

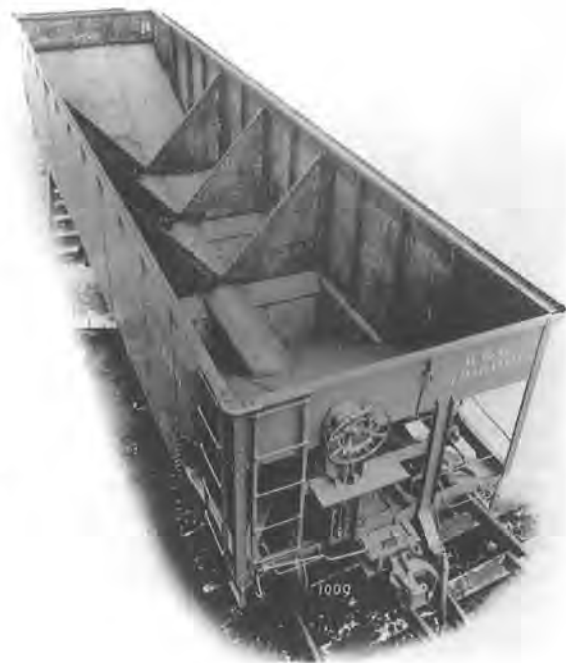


FIGURE 4.19

The Baltimore & Ohio's W-2 classes generally followed the design that the A.R.A. proposed as standard in 1926.²³ The car shown here is a W-2-class car built by the Standard Steel Car Company in 1926 with a capacity of 2,736 cubic feet and an empty weight of 53,100 pounds. It had steel-channel end posts, similar to those used on the U.S.R.A. 55-ton, twin-hopper car, and eleven pressed-steel side stakes. The car sides were composed of five sheets butt-jointed together with reinforcing plates. The end side sheets followed the Enterprise narrow-end design. The double row of rivets down the center of the side were used to secure the cross-ridge gussets to the side of the car. [Standard Steel Car Company Photo; Courtesy: D.K. Retterer Collection]

FIGURE 4.20

This photo shows the interior of the B&O's Class W-2B. This series had the same dimensions as the W-2 shown above, but the cars were equipped with power hand brakes and Duryea cushioned underframes, which can be seen in this photo.²⁴ The addition of the cushioned underframe reduced the capacity of the car by 20 cubic feet to 2,716 cubic feet. Note the large cross-ridge gussets or cross-ridge braces. The use of these cross-ridge braces eliminated the need for body cross ties to support the sides of the car. They were also less likely to interfere with chutes that dropped into the car's interior during loading to minimize breakage of the coal. The results proved so successful that body cross ties are rarely seen in cars after this period. The use of chutes to load these cars can be seen in Figure 1.29. [Standard Steel Car Company Photo; Courtesy: D.K. Retterer Collection]



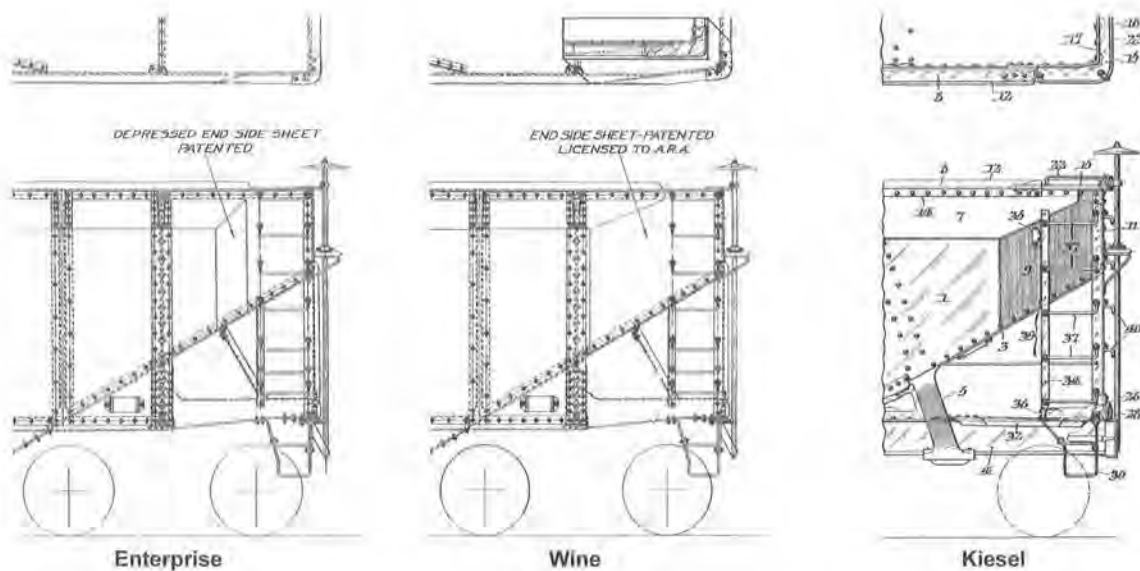


FIGURE 4.21

In 1921, car builders began using offset sides to increase the capacity of open-top cars. John A. Pilcher of Roanoke, Virginia was awarded patent no. 1,433,096 on October 24, 1922 for his offset-side design, which placed the side stakes on the inside of the car to provide the maximum width possible for lading. In his design, a filler block or wedge was inserted inside the top rail to prevent coal from hanging up during dumping operations. The next step in the evolution was to shape the offset into the sides to eliminate the need for the wedge. Over the next decade, three designs emerged for the "narrow ends" of offset-side hopper cars. Each of these designs can be identified by the way in which the end side sheets were formed to transition from the end of the offset to the corner post. The Enterprise design, shown to the left above, received patent no. 1,537,051 in May 1925. In it, the offset side continued beyond the last side stake and then stepped down in a short incline to provide a recess in which a ladder or grab irons could be placed and still stay within clearance limits. The length of this recess varied depending upon the width of the ladder. Its face ran parallel to the face of the offset side. A crease ran at a 45° angle from the top of the offset to the side rail. The Enterprise design was used by the A.R.A. in the design that it proposed as a standard for 50-ton and 70-ton hopper cars in 1926, and it was incorporated into the Recommended Practice approved by the association in 1928. Note that the A.R.A. referred to the Enterprise design as the "Depressed End Side Sheet." The Wine Railway Appliance Company received patent no. 1,698,866 in 1929 for the design shown in the center. In this design, the offset side sloped from the last side stake to the end post. At the top corner, the bracket that joined the side and end top rails was inclined at the same angle as that of the slope of the end side sheet, with the effect of reducing the width of the end of the car to allow room for grab irons without affecting the car's clearances. This can be seen in the top view in the upper center drawing above. The end sheet was creased from the top of the offset at the last side post to the point where it joined the top rail approximately 19" before the corner post. In 1930, Wine received patent no. 1,786,380 for an improved bracket that maintained this end-side-sheet design but extended the side of the bracket so that the side rail and end railed joined at a 90° angle. The purpose of this change was to support the corners during rotary dumping operations. The drawing of this change is shown as an inset in the top view of the Wine drawing. Also in 1930, Wine waived its rights to this design to members of the A.R.A., and as a result, the A.R.A. replaced the Enterprise design with the Wine narrow-side design in its Recommended Practice.²⁵ This design was also incorporated into the A.A.R.'s plan for 50-ton and 70-ton hopper cars adopted as Standard in 1936. The design to the right appears in and is described in patent no. 1,834,952, awarded to William F. Kiesel Jr., mechanical engineer for the Pennsylvania Railroad, in 1931. It was used in the Pennsy's H27 hopper car. In this design, the side rail is straight for its entire length, and it joins the end rail at a 90° angle. The crease in the top corner runs from the top of the offset to the intersection of the top rail and corner post. Although this end-side-sheet design was not a claim of the patent, the author has found no other patent in which this end-side-sheet is described. Therefore, he has used the Kiesel name to describe this design throughout this book. [Plate 1130, *American Railway Association, Supplement to the Manual*, March 1930; Courtesy: Association of American Railroads; *Car Builders' Cyclopedic*, 1937; Courtesy: Simmons-Boardman Publishing Corporation; U.S. Patent and Trademark Office]

The 50-ton design was designated 4D-HT and the 70-ton was designated 4E-HT. The number "4" stood for the number of axles the car had, and the letters "D" and "E" stood for the journal size. The letters "HT" were the A.R.A. designation for a hopper car with more than two hopper bays.

The Baltimore & Ohio Railroad was satisfied with this design and began ordering 70-ton cars of this design in that same year. Eventually, the B&O would purchase 7,000 of these cars, which became its W-2 classes.

The majority of the members of the A.R.A. were not satisfied with the design as presented. In 1927, they moved to have the height of the cars increased from 10' 6" to 10' 8".²⁶ This was the same height as the U.S.R.A. hopper designs, and it would permit the designers to shorten the cars' overall length.

By 1928, the committee had completed its design and submitted its revisions to the membership for approval. These new designs resulted in a 50-ton triple-hopper with an inside length of 34' 0¹¹/₁₆" and

a 70-ton car with an inside length of 40' 5". By letter ballot dated October 31, 1928, they were approved as Recommended Practice.²⁷ Once the drawings were completed, the Recommended-Practice cars were designated 4D-HT-2 and 4E-HT-2, and the earlier designs were designated 4D-HT-1 and 4E-HT-1.

The offset sides for these cars were based upon a proprietary design of the Enterprise Railway Equipment Company. This design can be identified by the distinctive layout of the end side sheet of the car, which is described in Figure 4.21. In 1929, the Wine Railway Appliance Company received a patent for an alternate design for the narrow end of the car, which is also discussed in Figure 4.21. In 1930, Wine waived its rights to this patent for members of the A.R.A., and in a letter ballot that same year, the A.R.A. modified its Recommended Practice for 50-ton and 70-ton hopper cars to include this design for the narrow end of the car.²⁸ When this was done, the Enterprise narrow-end design was designated as an alternate end side sheet.



FIGURE 4.22

These photos compare two methods of joining the side sheets and attaching the sides to the top rail of an offset-side hopper car. To the left, the side sheets have been joined with a butt joint, and a steel plate has been added to the outside of the car to reinforce that joint. Note the two rows of rivets corresponding to the pressed-steel shapes used for the side stakes. To the right, the side sheets have been joined in a lap joint, and a single row of rivets is used to secure the rolled-steel-angle side stake to the side. At the top of the offset-side, side stake extensions that correspond to the inside stakes continue upwards to meet the overlapping side rail, composed of bulb angle. The A.A.R. used lap joints in the construction of its standard hopper designs to minimize the number of rivets used in its construction. Note also that fewer rivets are used to secure those intermediate side stakes where a joint is not present. Similar construction techniques were also used with externally mounted side posts. [Courtesy: Bob's Photo]



FIGURE 4.23

The Enterprise Railway Equipment Company was not a car manufacturer itself. In October 1928, the company had the Standard Steel Car Company build this quadruple-hopper car to the A.R.A.'s Recommended Practice as a way of promoting the use of its design. The car had a capacity of 2,755 cubic feet. Note the distinctive Z-section top rails. [Standard Steel Car Company Photo; Courtesy: D.K. Retterer Collection]

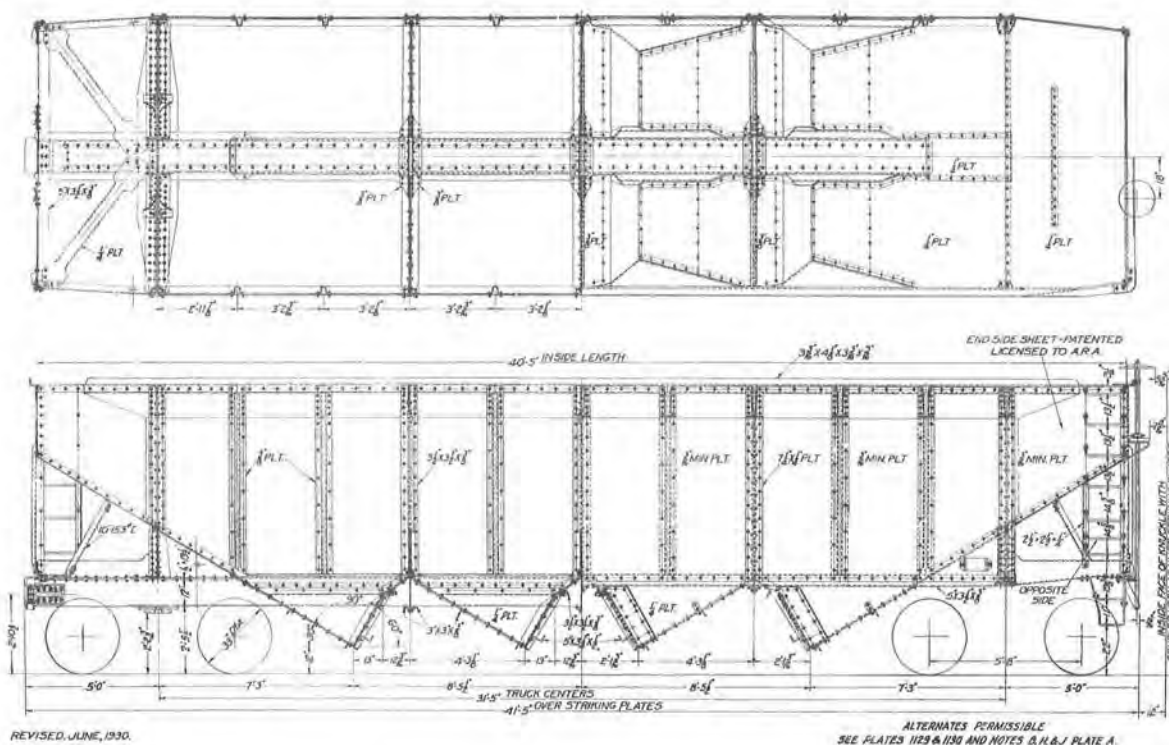


FIGURE 4.24

This drawing shows the final design of the A.R.A.'s 1928 Recommended Practice for 70-ton quadruple-hopper cars. The car had a 40' 3" inside length, 10' 0" inside width, and a height to eaves of 10' 8". This drawing was published in June 1930 and includes the Wine narrow end design. Plate 1130, which is referenced in the drawing, shows the Enterprise narrow-end design as an alternate. Note that the two center hopper sections measure 6' 4⁶/₁₆" in length. By removing one of those hopper sections, the inside length becomes 34' 0¹¹/₁₆", which is the length of the 50-ton, triple-hopper car. [Car Builders' Cyclopedia, 1931; Courtesy: Simmons-Boardman Publishing Corporation]



FIGURE 4.25

This photo of the B end of the Enterprise car shown in Figure 4.23 provides a better view of the Z-section used in the construction of the top rails. It also provides the layout of its K-brake system. [Standard Steel Car Company Photo; Courtesy: D.K. Retterer Collection]

The original design, now designated 4D-HT-1, is shown in Figure 4.18, and pictures of the B&O W-2 series, which followed the 4E-HT-1 design, are shown in Figures 4.19 and 4.20. Photos of the 4E-HT-2 are shown in Figures 4.23 and 4.25, and elevation drawings with the Wine narrow end design are shown in Figure 4.24.

The A.R.A. Recommended Practices were not well received. The 50-ton triple-hopper met with little success. Railroads preferred twin-hopper cars for their 50-ton loads. With the A.R.A.'s failure to offer a twin-hopper option, most railroads either stayed with existing twin-hopper designs or experimented with new ones. This helps explain why the U.S.R.A. 55-ton hopper design remained popular and continued to be built throughout the 1920s and into the 1930s. A few railroads built the Recommended Practice 70-ton hopper car, but more preferred to build triple-hopper cars for their 70-ton loads rather than the A.R.A.'s quad. Indeed, the U.S.R.A. style 70-ton triple-hopper car, which was not built during World War I, was produced by several railroads during the 1920s despite the availability of the Recommended Practice design.

After what amounted to a false start in developing a standard hopper car design in the 1920s, the A.R.A.'s Committee on Car Construction went back to the drawing board following its 1931 convention



FIGURE 4.26

While the A.R.A. was attempting to develop a standard hopper design, the Norfolk & Western was procuring 14,000 of these 70-ton quadruple-hopper cars. This quantity was greater than the combined total of all of the A.R.A. Recommended Practice hopper cars purchased by all other railroads. Classified as the N&W's HU and HUA series, they had an inside length of 36' 10", inside width of 9' 6", height to eaves of 11' 0", and capacity of 2,439 cubic feet. This photo shows the last car produced in the series, built in July 1927 by the Virginia Bridge & Iron Company. Beginning in 1941, these cars were rebuilt into the H3 series with one less hopper and twenty-one more cubic feet of capacity. The H3 series would survive well into the 1960s.²⁹ [Courtesy: Norfolk Southern Corporation]

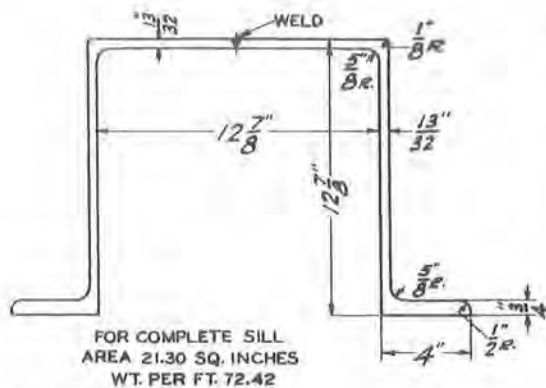


FIGURE 4.27

The A.R.A. adopted this Z-section center-sill design as Standard in 1932 for cars having a center plate height of 25 3/4". It was developed in conjunction with the design of the A.R.A. Standard box car, and, after testing proved it was strong enough, it was also adopted for use on the A.A.R. Standard hopper car. This design replaced the previous A.R.A. standard, which was developed in 1923 in conjunction with a proposed standard box car. That design was comprised of two steel beams joined by a cover plate. It had a cross-sectional area of 30.19 square inches. [Car Builders' Cyclopedic, 1940; Courtesy: Simmons-Boardman Publishing Corporation]

to explore other designs to take advantage of new, lightweight building techniques.³⁰ It was tasked with the following six conditions, which are paraphrased below:

1. Disregard existing A.R.A. guidelines when those guidelines might interfere with a more efficient design.

2. Work in conjunction with car builders and other officials in producing the design.

3. Review the design each year to insure that it's up to date.

4. Design the car so that proprietary applications (door operating mechanisms, brake gear, etc.) can be installed without major modification.

5. All A.R.A. members may use the propriety elements of the design without charge.

6. Apply lessons learned from maintenance and service of similar type cars.

In 1932, the committee presented its results to the association. They consisted of a two-bay, 50-ton hopper car and a three-bay, 70-ton hopper car.³¹ In developing these designs, the committee sought to achieve lower weight while keeping the design free of experimental

features or expensive alloys. In following these guidelines, the committee was still able to achieve 3,500 pounds in weight savings in the superstructure alone.³²

One of the issues with which the committee had to contend was the number of hoppers each car should have. The committee elected to reduce the number of hoppers for each weight class by one. By reducing the number of hoppers from four to three, the designers were able to:

- Save 800 pounds in light weight
- Lower cost by 2.3%
- Reduce operations and maintenance costs
- Reduce the number of points for moisture to collect causing corrosion
- Reduce the number of doors to operate to discharge the load

An argument was made that the additional hopper would decrease the length of the car and reduce its center of gravity. However, an analysis indicated that the extra hopper would increase the car's complexity while saving only nine inches of length and lowering the center of gravity by just 1/8".³³

Another issue of concern was the center sill. In 1932, the A.R.A. had adopted a standard "Z-section" center sill with a cross-sectional area of 21.30" for use under the A.R.A. Standard box car. Preliminary analysis indicated that the cross-sectional area of the hopper car's center sill should be increased by 20% to offset the effects of corrosion that wasn't present with the box car.³⁴ However, further testing revealed that the new standard center sill would be adequate for use under the hopper car, as well.³⁵

TABLE 4.1

Comparison of A.R.A. Standard Design Hopper Cars and 1928 Recommended Practice Hopper Cars.

	1936 A.A.R. Standard Design		1928 Recommended Practice	
Nominal Capacity, Tons	50	70	50	70
Inside Length	33' 0"	40' 8"	34' 0 3/4"	40' 5"
Inside Width	10' 4"	10' 4"	10' 0"	10' 0"
Number of Hoppers	2	3	3	4
Cu. Cpy w/10" heap	2,453	3,100	2,402	3,092
Nominal Cpy	50	70	50	70
Trucks Wt/Car	15,780	18,250	15,780	18,250
Car Body Lt Wt	25,782	30,640	28,220	34,170
Total Lt. Wt.	41,562	48,890	44,000	52,420
Total Load on Rail	169,000	210,000	169,000	210,000
Payload Ratio	.75	.77	.74	.75

Source: Report of Committee on Car Construction, Association of American Railroads Circular No. DV-836, Appendix A, *Designs of 50 and 70 Ton Nominal Capacity Hopper Cars*, June 1935

In 1935, the members of the now renamed Association of American Railroads (A.A.R.) adopted the committee's recommendations as Standard. Under its guidelines, the association identified certain items that railroads were allowed to customize as long as the basic car-body structure was not altered and other requirements were complied with. These "permissible alternates" included:

- Trucks
- Truck Brake
- Hopper Doors
- Door Mechanism
- Couplers
- Draft Attachments
- Uncoupling Arrangement
- Hand Brake
- Angle Cock Holder
- Hopper Construction, provided the same general dimensions and the same arrangement of the door openings were used
- Cast-Steel Construction, provided the same general dimensions were maintained

— Welded Construction, as long as it was of equivalent strength as riveted construction and design dimensions were maintained³⁷

The A.A.R. Standard design was an immediate success. In 1934, while the standard design was still being finalized, 8,610 of the 10,287 hopper cars built generally conformed to the draft design. In 1935, 5,591 out of 6,064 hopper cars followed the design, and through the first three months of 1936, 2,000 out of 3,050 followed the design. Of those that didn't, 1,000 still used elements of the design.³⁸

The A.A.R. Standard cars can be identified by their offset sides and Wine end-side-sheet design. Early versions had pressed-steel end posts, while later versions used rolled-steel-angle end posts. The 50-ton, twin-hopper car had irregularly spaced side posts as discussed in Figure 4.29. Other identifying features for the 50-ton and 70-ton cars are discussed in the accompanying figures.

Two railroads did not want to wait until the new standard was approved, and they ordered new cars anticipating what the final design would be. In



FIGURE 4.30

The Erie purchased 2,500 new hopper cars in 1934. In ordering these cars, the railroad sought to follow as many aspects of the proposed A.A.R. Standard as possible, even though the design had not been finalized. Despite the Erie's desire to follow the new standard, there were several differences between its cars and those that were built to the A.A.R. Standard. Some of these differences are readily apparent and others less so. Because the coal carried by the Erie weighed more than the 52 pounds per cubic foot used to design the standard car, the railroad reduced the volume of this car by lowering its height by four inches to produce a capacity of 2,053 cubic feet. At the time the railroad placed its order, the evaluation of the new standard center sill had not been completed, so it opted to use the former A.A.R. Standard, built-up center sill, which was heavier. The center sill is discussed in greater detail in Figure 4.27. Several other changes are fairly apparent. They used butt joints instead of lap joints to join the side sheets together. This caused the builders to use external plates to reinforce those joints. The use of butt joints also dictated the use of pressed-steel side stakes and side-stake extensions instead of the rolled sections used in the Standard. These side posts are evenly spaced along the side of the car as opposed to the irregular spacing of the A.A.R. Standard 50-ton car. Finally, they used the Kiesel end-side-sheet design rather than the Wine/A.A.R. design. These changes produced an alternate body arrangement that is distinctly different from the standard. The Chesapeake & Ohio also purchased 6,000 of these cars in that same year. The C&O cars differed from the Erie cars in that they were equipped with arched heap shields. [Courtesy: Bob's Photo]

1934, the Chesapeake & Ohio ordered 6,000 50-ton hopper cars, and the Erie ordered 2,500. When the railroads placed their orders, the issue of the center sill had not been settled, so both chose to use the previous standard center sill, which was heavier than the 1932 design. Additionally, since the average weight of their lading was higher than the 52 pounds per cubic foot used by the A.A.R. to compute the capacity of the standard design, they chose to procure cars of less capacity. They did this by reducing the height of the car by four inches, from 10' 8" to 10' 4". This produced a capacity of 2,053 cubic feet versus the 2,145 cubic feet of the A.A.R. Standard twin-hopper car.³⁹ This practice of lowering the height to reduce the capacity of the standard

design became common among railroads that carried heavier coal. The two railroads' designs deviated from the standard in four other ways. First, they used butt joints rather than lap joints to join the sides. Second, they used pressed-steel side posts rather than the rolled sections used in the standard. Third, the side stakes were evenly spaced along the side as opposed to the irregular spacing of the Standard's. Finally, they used the Kiesel end-side-sheet design. The result was a car with an alternate body arrangement that was distinctly different from the standard. Despite these differences, though, the A.A.R. considered the Erie and C&O cars as meeting the standard. An example is shown in Figure 4.30. Other alternate body arrangements emerged as well.

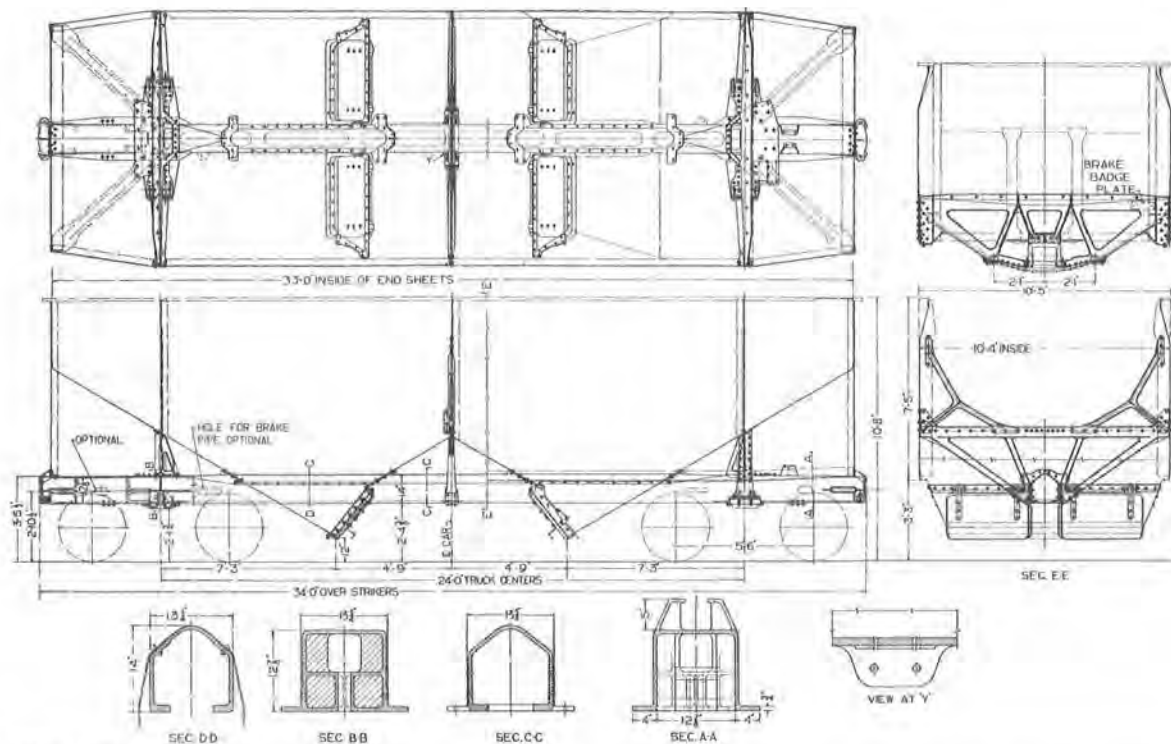


FIGURE 4.31

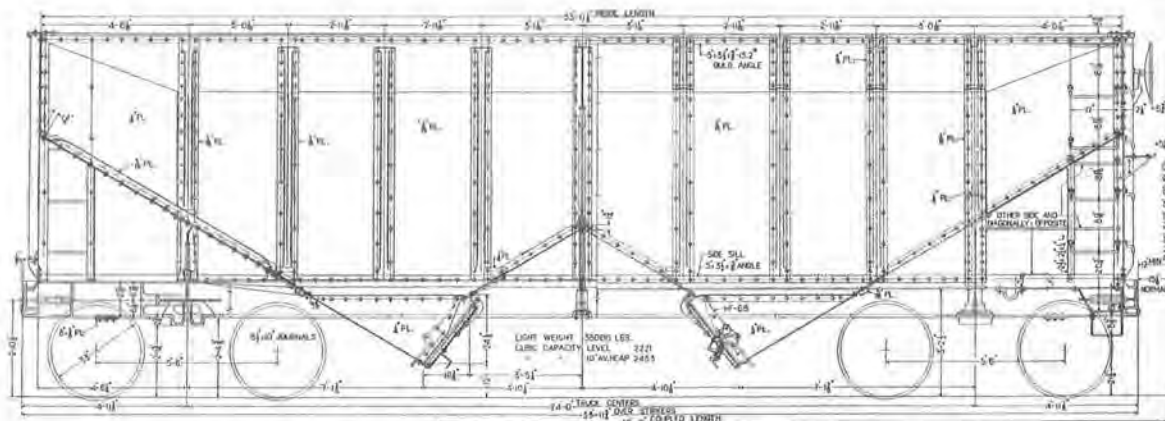
In 1936, the A.A.R. approved "alternate arrangements" for the construction of its 50-ton and 70-ton standard hopper cars. These alternates were proposed by the Unitcast Company and the General Steel Castings Corporation to take advantage of advanced building techniques using cast-steel components. The drawings shown here are the Unitcast Company's alternate arrangement for a car built using its patented designs. These drawings appeared in the trade press identified as the "Alternate Standard 50-Ton Hopper Car." The design used an integral cast-steel underframe instead of the A.A.R. Standard, twin, rolled Z-section center sill, and cast-steel bolsters, interior braces, and hopper door frames. Note that Unitcast's general assembly drawing does not provide a layout for the sides and side stakes. General Steel Castings' alternate design used the same body arrangement as the A.A.R. Standard. Unitcast did not address the body arrangement in its design, but, when it developed plans for its 60-ton car, shown in Figure 4.32, it used the same alternate body arrangement that the Erie and C&O had used in their early purchases, as shown in Figure 4.30. [Car Builders' Cyclopaedia, 1946; Courtesy: Simmons-Boardman Publishing Corporation]

TABLE 4.2

Comparison of A.A.R. Standard Base Design with Unitcast Company Alternate Cast Steel Construction.

	Weight Car Body Base Design	Weight Difference from Base	Per Cent Difference from Base
Built-up Body—A.A.R. Base Design	20,945		...
With Cast Steel Door Frames	21,061	+116	.6
With Cast Steel Bolsters	20,185	-700	3.6
With Cast Steel Center Sill	20,607	-338	1.6
With Cast Steel Bolsters and Crossbearers	19,993	-952	4.5
With Cast Steel Bolsters, Crossbearers and Door Frames	20,109	-836	4.0
With Cast Steel Bolsters, Crossbearers, Door Frames and Side Stakes	20,204	-741	3.5
With Cast Steel Center Sill, Bolsters, Crossbearer and Door Frames	19,771	-1,174	5.5
With Cast Steel Center Sill, Bolsters, Crossbearers, Door Frames, and Side Stakes	19,886	-1,079	5.1

Source: Report of Committee on Car Construction, Association of American Railroads Circular No. DV-872, Appendix A, *Designs of Cast Steel Alternate Constructions for 50 and 70 Ton Nominal Capacity Hopper Cars*, June 1936



Plan and Elevation of Unitcast Design, High-Capacity, 60-Ton Twin Hopper Car with Cast Steel Center Sill, Body Bolsters, Crossbearer, Crossbearer Arms, Hopper Frames and Hinges.

The Unitcast Company.

FIGURE 4.32

In 1936, the A.A.R. approved two "Alternate Arrangements" for its 50-ton and 70-ton standard hopper cars. As noted in Figure 4.31, the General Steel Casting general arrangement employed the same car body design used in the A.A.R. Standard, but the Unitcast arrangement did not include a specific design for the body. The Unitcast Company subsequently proposed this design for a 60-ton car that employed its patented cast-steel construction. The sides consisted of four sheets joined with butt joints, reinforcing plates, and pressed-steel side stakes. The side stakes appear to be evenly spaced, the actual dimensions being shown in the drawing, and it used the Kiesel end-side-sheet design. Other than its height, it was similar in appearance to the cars produced for the Chesapeake & Ohio and the Erie in 1934. This car had a height to eaves of 10' 10", but otherwise conformed to A.A.R. Standard dimensions. The result was a car that had a capacity of 2,221 cubic feet. Because of the association between the Unitcast Company and this side arrangement, cars with this design are sometimes identified as "Alternate Standard," however, as discussed in Figures 4.30 and 4.31, the A.A.R. did not specifically approve this alternate body arrangement, and it could be found on cars of both standard and alternate-standard construction. [Car Builders' Cyclopedia, 1946; Courtesy: Simmons-Boardman Publishing Corporation]

As already noted, when the A.A.R. developed the specifications for its standard hopper cars, it made allowances for permissible alternates as long as the basic structure of the cars was not changed. The year after the committee approved the standard design, it approved two alternate arrangements that took advantage of building techniques proposed by the Unitcast Company and the General Steel Castings Corporation. These alternate designs permitted the use of integral cast-steel underframes instead of the A.A.R. Standard twin, rolled-Z-section center sill, and they allowed certain parts, such as bolsters, interior braces, and hopper-door frames to be made in cast steel.⁴⁰ The advantage of replacing built-up rolled-steel components with cast-steel components is shown in Table 4.2.

The A.A.R. approved two sets of designs for cast-steel alternate constructions for its 50-ton and 70-ton hopper cars, one from each company. Each proposed designs for cast-steel parts that could be used in lieu of the built-up parts of rolled steel used in the standard design. In addition, each company submitted an alternate general arrangement for a complete car using its building techniques. The General Steel Castings' alternate general arrange-

ment used the same side and side-stake design as shown in the A.A.R. Standard. As discussed in Figure 4.31, Unitcast did not include an alternate general arrangement for the sides of its alternate design, but it subsequently used the side arrangement seen in Figure 4.32 in its cars. This was similar to the body arrangement used by the Erie and Chesapeake & Ohio in their purchases in 1934.

Because of Unitcast's use of this side arrangement, it has come to be associated with the alternate standard, and cars employing this design are often referred to as "Alternate Standard" cars. Indeed, this has served as a convenient way to differentiate between these two sets of cars. However, not all cars with this side arrangement employ the alternate standard, and not all alternate-standard cars employ this side arrangement. Therefore, this is a less-than-accurate way to describe cars employing this side arrangement. Perhaps the best example of this situation are the sets of cars ordered by the Erie and Chesapeake & Ohio in 1934. Both sets share all the external characteristics of this design, but neither conforms to the Alternate Standard approved by the A.A.R. In fact, they predate the approval of the alternate-standard designs.



FIGURE 4.33

Illinois Central car number 86406 presents another alternate body arrangement for a hopper car that otherwise meets the criteria for an A.A.R. Standard 50-ton hopper car. The Enterprise Railway Equipment Company developed this design in the 1920s, and it modified the design in the 1930s to incorporate the dimensions of the A.A.R. Standard. The sides of these cars were made up of five sheets instead of the four used in the A.A.R. design, and the sheets were joined with butt joints with reinforcing strips. The car uses seven pressed-steel side stakes instead of the nine rolled-steel-angle stakes used in the standard design, and it uses the Enterprise narrow-end design. Despite these differences, the car's dimensions were the same as the A.A.R. Standard, providing a capacity of 2,145 cubic feet. The IC purchased over 13,000 of these cars from 1937 through 1949 from a number of different manufacturers, and it also produced a large number in its own shops. The IC was very familiar with this design. In the 1920s, it had purchased 1,450 built to the same general design but of larger dimensions. This car was built in 1949. [Courtesy: Bob's Photo]

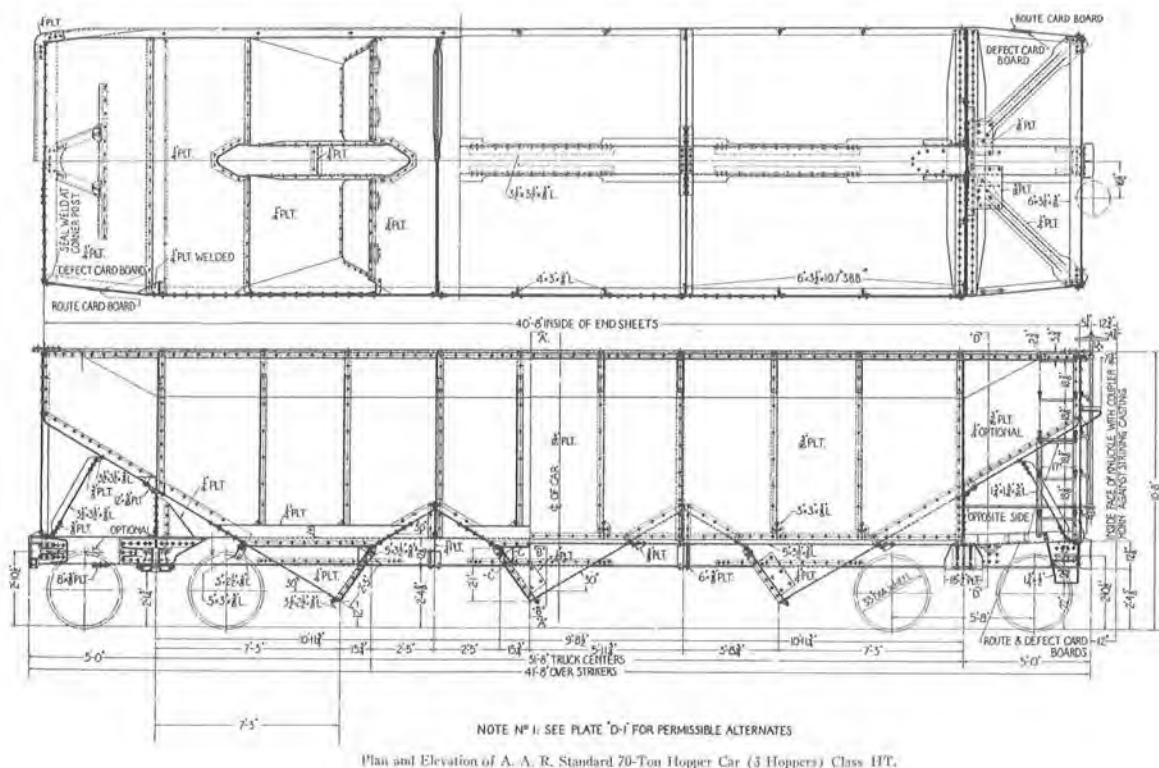


FIGURE 4.34

At the same time that the A.A.R. adopted the 50-ton hopper-car design shown in Figure 4.29, it adopted this 70-ton triple-hopper car design as standard, also. The A.A.R. Standard 70-ton triple-hopper cars can be differentiated from the A.A.R. Recommended Practice, 50-ton triple-hopper cars by their interior length, number of side posts, and construction of the end posts. The Recommended Practice, 50-ton triple-hopper cars had an interior length of 34' 0¹¹/₁₆", nine side posts, and steel-channel end posts. The A.A.R. Standard, 70-ton triple-hopper car had an interior length of 40' 8", ten side posts, and pressed-steel end posts. [Car Builders' Cyclopaedia, 1943; Courtesy: Simmons-Boardman Publishing Corporation]



FIGURE 4.35

In 1946, the B&O contracted with Bethlehem Steel to build these 70-ton hopper cars conforming to the A.A.R. Standard design. These cars had an empty weight of 49,100 pounds and a capacity of 2,773 cubic feet. By using lightweight techniques and by eliminating one of the hoppers, the A.A.R. was able to produce a car that had a cubic capacity equivalent to the Recommended Practice design while saving almost 4,000 pounds in empty weight. Elevation drawings for this car are shown above. [Courtesy: Railroad Museum of Pennsylvania Archives, PHMC]

Despite the success of the A.A.R.'s standard designs, not all railroads used them. For a variety of reasons, some railroads continued to use coal cars of their own design. Many of these railroads were those which sent few, if any, of their cars off line, and therefore they were able to tailor the design of their cars to meet their own specific needs.

Another factor was the weight of the coal the car was destined to carry. The capacity of the A.A.R. Standard hopper was calculated based upon an average weight of lading of 52 pounds per cubic foot, but some railroads were hauling coal that averaged over ten percent above that figure. Thus, railroads such as the Norfolk & Western, with its Pocahontas mine-run coal averaging over 59 pounds per cubic foot, or some of the anthracite railroads, whose coal averaged over 58 pounds per cubic foot, had little use for all of the volume that the new standard offered.

An all-steel car that has a light weight of 40,000 pounds and a total allowable weight on rail of 169,000 pounds, has 129,000 pounds of available capacity. If a railroad's lading averages 58 pounds per cubic foot, then the maximum volume it can fill without exceeding its weight on rails is 2,224 cubic feet. This is about what a car with 1,900 cubic feet of capacity can hold with a 30° heap. Therefore, there

was little need for these railroads to purchase cars with greater capacity. These railroads had several alternatives to purchasing the A.A.R. Standard.

The first was to modify the standard design to reduce the capacity consistent with the weight of the coal being carried. This is what the Erie and the Chesapeake & Ohio did in the situation previously discussed.⁴¹ Subsequent purchases by both of these railroads were for similar cars of reduced capacity.⁴² This was not an uncommon practice. From May 1939 to May 1940, 12,250 of the 17,765 50-ton hopper cars built following A.A.R. standards had been modified to reduce their capacity.⁴³

The second alternative railroads had was to repair an existing fleet or create a new one tailored to the needs of the company. Rather than invest in new cars, the Pennsylvania Railroad chose to rebuild or repair its existing fleet of over 25,000 cars in its GLA series and over 35,000 cars in its H21 family. To its south, the Norfolk & Western built almost 15,000 new hopper cars to its own specifications during the 1930s, and in the midwest, the Chicago, Burlington & Quincy turned to its own design for its HT-5, straight-sided, 50-ton hopper car. In the anthracite fields, carriers such as the Delaware & Hudson and the Lehigh Valley also turned to alternative hopper car designs.



FIGURE 4.36

Rather than procure A.A.R. Standard hopper cars, the Norfolk & Western embarked on a program of building cars of its own design that were suited to its unique needs. One of the contributing factors was the weight of the coal that it was carrying. Pocahontas Coal averaged between 52 and 59 pounds per cubic foot, and when loaded to their full cubic capacity, A.A.R. hopper cars would have greatly exceeded their allowable weight on rail. The Norfolk & Western's 50-ton twin-hopper cars were carefully sized to meet its own requirements, running between 1,800 and 2,000 cubic feet. N&W car number 22000, pictured here, was built in 1936, the same year that the A.A.R. approved its Alternate Standard. It was one of 12,500 cars produced in this series. The series had an inside length of 31' 0", inside width of 9' 9 3/4", and height from rail to eaves of 11' 0", producing a capacity of 1,998 cubic feet. With a 30° heap of 431 cubic feet, they had a total capacity of 2,429 cubic feet. Note the shape of the heap shields on the ends of this car. [Courtesy: Norfolk Southern Corporation]

A third alternative was for a railroad to extend the life of its existing fleet by rebuilding its cars. One such opportunity was presented by the Standard Railway Equipment Manufacturing Company, which introduced replacement panels for existing hopper cars in the 1930s. The side and end sheets were particularly subject to corrosion resulting in their frequent replacement. Standard introduced pressed-steel replacement panels that both strengthened the sides and increased the car's capacity. These were introduced in two versions, one in which the panels were riveted in place to traditional, external side posts, and one in which the panels were welded together at the seams, with the pressed-steel panels creating their own side posts. The company designed replacement panels to fit existing freight-car designs such as the U.S.R.A., the GLA, and the 1905 Common Design cars.⁴⁴ The way in which the panels were assembled is shown in Figure 4.37, and photographs of cars equipped with these panel sides are shown in Figures 4.39 and 4.40.

A constant concern of the railroads was the durability and life span of their coal cars, and manufacturers began introducing devices to address those concerns. In the mid-1920s, the O.C. Duryea Corporation introduced its Cushioned Underframe as a cost-effective solution to reducing the damage to draft gears and car structures from rough handling. It accomplished this by employing a floating center sill that increased the travel distance to absorb

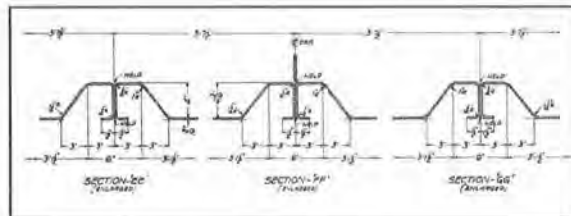


FIGURE 4.37

In the late 1930s, the Standard Railway Equipment Company introduced raised panel sides that could be used to replace flat side sheets on existing hopper cars. This diagram shows the way in which panels could be welded together at their seams to create a side post. Another design permitted the raised panels to be welded or riveted to existing side posts. Examples of both are shown in Figures 4.39 and 4.40. [Car Builders' Cyclopaedia, 1940 Edition; Courtesy: Simmons-Boardman Publishing Corporation]

impact shocks from 2¾" to 8".⁴⁵ Although damage to contents was less of a factor with coal cars, testing by Pullman-Standard on its own version of a cushioned underframe demonstrated that they could reduce the damage to a car's contents to one third that of a car equipped with conventional draft gear.⁴⁶ Several railroads took advantage of cushioned underframes in their freight cars, and the Reading and the Baltimore & Ohio Railroads made extensive use of them in their coal cars.



FIGURE 4.38

With Scranton-area anthracite weighing over 57 pounds per cubic foot, the Delaware & Hudson had little use for the 2100+ cubic feet of the A.A.R. Standard 50-ton hopper. Instead, the D&H purchased 1,400 of these "fish-belly" hopper cars in 1939 and 1940 numbered 4701 to 6100. They had an inside length of 30' 11", inside width of 9' 9", and height from top of rail to eaves of 10' 5", producing a capacity of 1,860 cubic feet. [Paul B. Dunn Photo; Courtesy: Richard J. Burg Collection]



FIGURE 4.39

C&O car number 63361 began life in 1919 as one of the Chesapeake & Ohio's 2,000 U.S.R.A. twin-hopper cars. In the early 1930s, the cars were rebuilt at Raceland with panel sides supplied by the Union Metal Products Company. The pressed-steel panels increased the strength of the sides and increased the car's capacity by 53 cubic feet. The panels were riveted in place to the existing side posts.⁴⁷ This conversion was featured in the October 1933 issue of *Railway Mechanical Engineer*. [Courtesy: Railroad Museum of Pennsylvania Archives, PHMC]



FIGURE 4.40

St. Louis & San Francisco car number 86831 was built in 1923 following the U.S.R.A. twin-hopper car design. In 1943 it was rebuilt with Standard Railway Equipment's pressed-steel, raised-panel sides. The panels were welded together as shown in Figure 4.37, creating their own side posts. The fabrication yielded a seamless internal side that resisted corrosion. The raised panels increased the capacity from 1,880 cubic feet to 1,976 cubic feet. The "T" side posts that resulted from this construction technique are clearly visible in the photo. Standard also made panels that could be riveted to side posts in the traditional manner, similar to those shown in Figure 4.39. [Paul B. Dunn Photo; Courtesy: Richard J. Burg Collection]

In addition to being subjected to rough handling in trains and beatings from workmen trying to break loose frozen coal, coal cars were constantly being subjected to the corrosive action of the atmosphere and coal leachings. Studies indicated that the corrosion of coal cars was attributable to three main causes: (1) atmospheric corrosion, (2) corrosion caused by coal leachings, and (3) abrasion. The length of time that the car remained loaded and wet aggravated the first two factors.⁴⁰ Contributing to the problem was coal-car design. Joints, bends, rivet heads, and other pockets where moisture and sulphur leachings could lodge served as points of origin for the corrosion.

During the 3rd and 4th decades of the 20th century, railroads experimented with a variety of measures to overcome the corrosion problem. The railroads most affected were those hauling wet coal, those operating in warmer climates, and those storing coal for extended periods of time in their coal cars.

The traditional approach to dealing with the issue was to use wood in those areas in contact with coal. Thus, railroads like the Delaware & Hudson, Southern, and Nickel Plate, operated composite wood-and-steel hopper cars well into the 1930s. Another option was to employ different building materials in the construction of coal cars. The first to be employed was copper-bearing steel, which reduced the affects of corrosion by about 50%.⁴¹

TABLE 4.3

In the late 1930s, a major eastern railroad compared the durability of copper-steel, the traditional steel alloy used to prevent corrosion in coal cars, to Cor-Ten steel, an advanced high-tensile-strength, low alloy steel developed by U.S. Steel, in its coke cars by comparing the weight loss due to corrosion. The railroad evaluated one hundred cars constructed of each material over specified periods of time. The results demonstrated the superior corrosion resistance of the high-tensile-strength steel alloy. The results of the test also demonstrate why coal cars needed to be reweighed periodically.

	Copper Steel	Cor-Ten
Average weight at delivery	54,390 lbs	41,978 lbs
Average weight after 39.8 mos.	53,158 lbs	
Average weight after 31.2 mos.		41,570 lbs
Average weight lost per month	30.94 lbs	13.05 lbs

Source: *Railway Mechanical Engineer*, April 1940



FIGURE 4.41

As others sought new materials and construction techniques to combat the effects of corrosion, some railroads remained steadfastly committed to composite construction. The Delaware & Hudson Railroad was building composite wood-and-steel hopper cars into the early 1930s, and many of the midwestern and western railroads continued to build composite drop-bottom gondolas to carry coal. Shown here is a composite-construction, 70-ton drop-bottom gondola built in 1929 for the Atchison, Topeka & Santa Fe. The car had an inside length of 50' 4", an inside width of 9' 1 1/2", and an inside height of 5' 9", yielding a capacity of 2,650 cubic feet. Note that the car is entirely self-clearing, and that the drop doors are corrugated to increase their strength and facilitate unloading. The car is equipped with Wine door locks, which stiffened the floor and saved as much as 1,500 pounds over the earlier, winding-chain devices.⁵⁰ This car was built by the Standard Steel Car Company in 1929. The railroad also purchased a drop-bottom, drop-end version that was dimensionally identical the following year. [Standard Steel Car Company Photo; Courtesy: D.K. Retterer Collection]



FIGURE 4.42

Corrosion from the elements and the leachings from coal were a major factor in the shortened life span of early steel cars. Shown here is a Baltimore & Ohio W-1 whose sides have been so weakened that they have peeled away from the side posts. Beginning in the 1920s, steel companies began introducing steel alloys that resisted corrosion. The process of repairing a car rusted in this manner is shown over the next two pages. [Walter A. Lucas Collection; Courtesy: Railroad Museum of Pennsylvania Archives]



FIGURE 4.43

Another Baltimore & Ohio W-1-class quadruple-hopper car awaits repairs in the railroad's Mt. Clare shops. The B&O's Public Relations department released this photo to show the effect that corrosion had upon its coal car fleet. The caption reads, "All steel car after 12 years service so weakened by corrosion that it buckled at the center." The center sills of hopper cars were particularly subject to corrosion. Corrosive elements would settle on the center sill where they would accumulate, because they were not washed away by rain. [Walter A. Lucas Collection; Courtesy: Railroad Museum of Pennsylvania Archives]



FIGURE 4.44

Figures 4.44 through 4.47 detail the process required to repair coal cars weakened by corrosion. In the picture above, an H21A has been dispatched to the Pennsylvania Railroad's Pitcairn shops for repairs. Inspectors have already identified those panels that need to be replaced. [Courtesy: Walter P. Keely Jr. Collection]

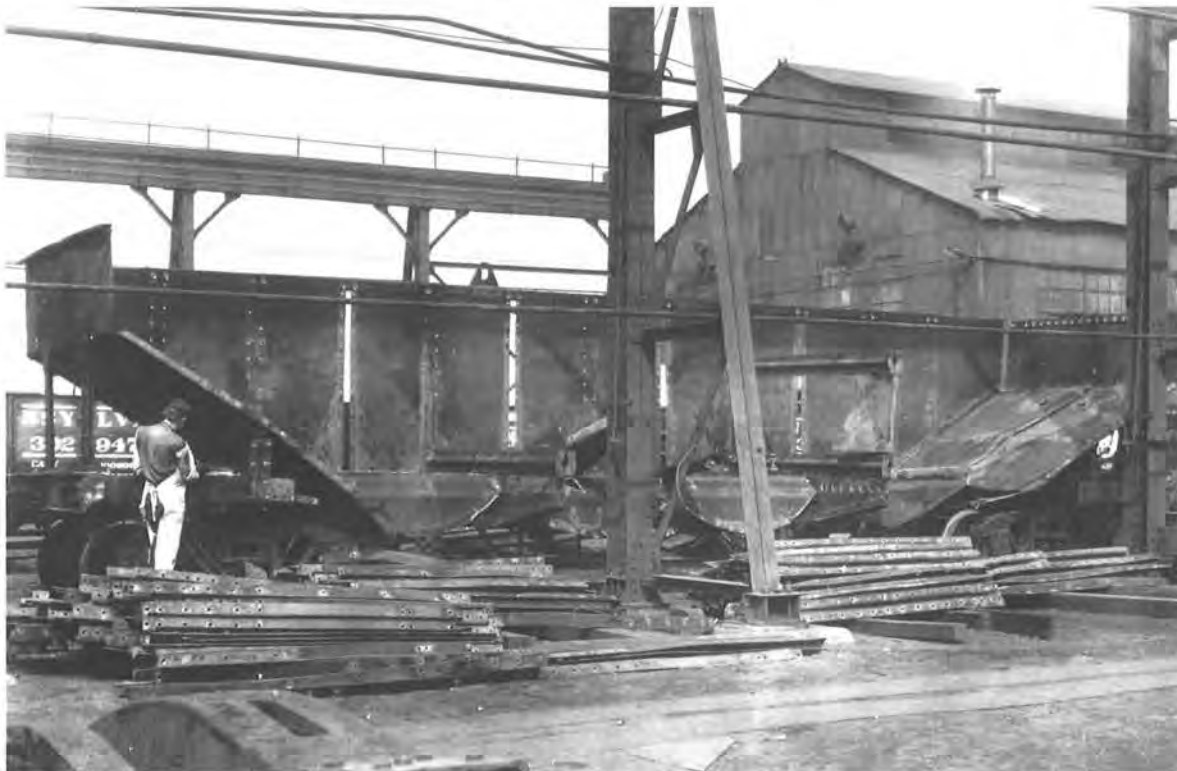


FIGURE 4.45

The car has been moved to the repair track, and workmen have begun dismantling the car by drilling out the old rivets. The old side posts are stacked in the foreground. [Courtesy: Walter P. Keely Jr. Collection]

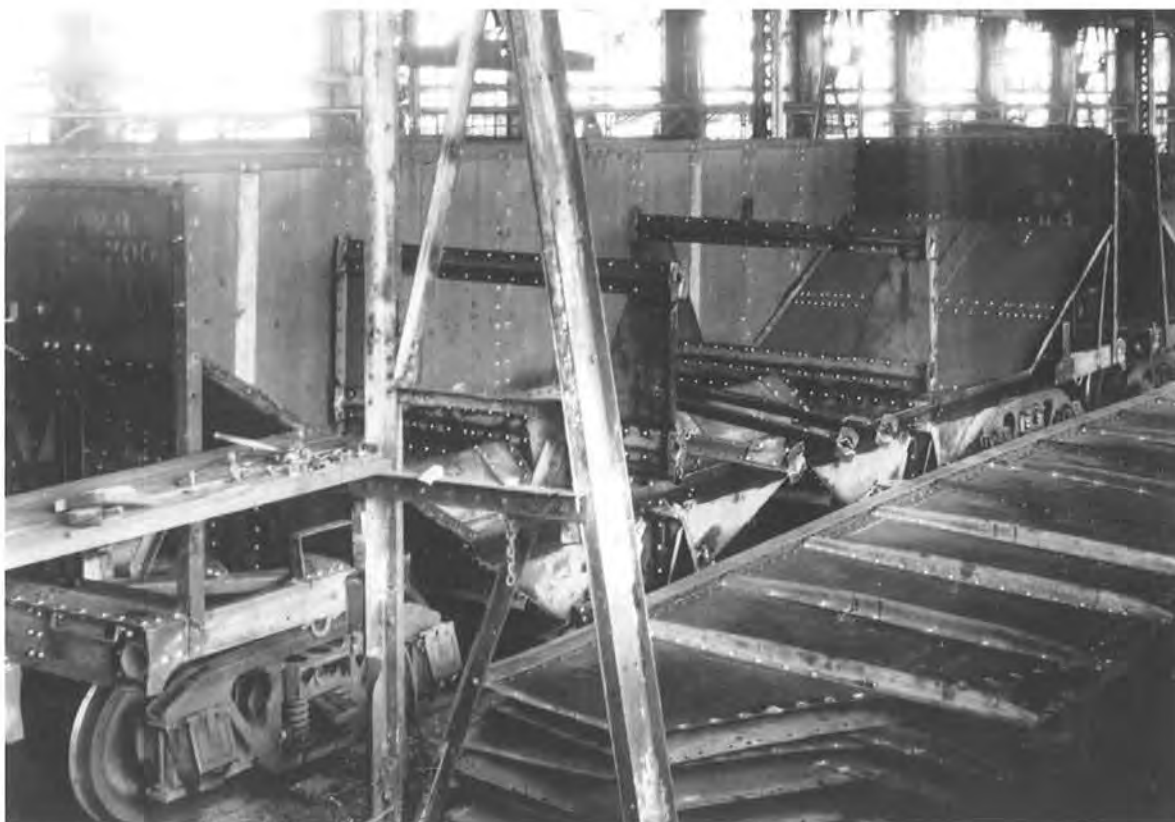


FIGURE 4.46

The dismantled car has been moved to the car shop where new sides and posts were installed. A stack of built-up sides can be seen in the foreground. [Courtesy: Walter P. Keely Jr. Collection]



FIGURE 4.47

This final frame shows the completed car awaiting its turn in the paint shop. [Courtesy: Walter P. Keely Jr. Collection]

In 1934, the Baltimore & Ohio teamed with the Aluminum Company of America to build the first aluminum hopper car. That car, shown in Figure 4.48, not only addressed the issue of corrosion but also of weight. There was a seven-ton reduction in light weight between equivalently sized aluminum and steel cars. Despite this difference and the fact that this car stayed in service for almost 19 years,⁵¹ it was another 50 years before this metal saw extensive use in coal cars.

During the 1930s, a number of steel manufacturers began introducing high-tensile-strength steel alloys that were resistant to corrosion. In 1933, the United States Steel Company introduced its Cor-Ten steel alloy with those properties. Not only could builders achieve lower weights because of the alloy's higher strength, but the alloy also had four to six times the corrosion resistance of ordinary steel. In 1934, the B&O built two experimental cars using this material. The results are discussed in Figure 4.49. The following year, the Chesapeake & Ohio built ten test cars to evaluate the durability of this new material. The results of that testing were positive and are discussed in Figure 4.50.

The A.A.R. standard hopper cars were designed to be built with standard carbon or copper-bearing steel. However, by 1940, almost 14% of all cars built following A.A.R. guidelines were being constructed of the newer, high-tensile-strength steel alloys.⁵²

The railroads also explored other techniques to eliminate corrosion. Here, two systems were employed. The first was to transition to cast-steel parts, which was a factor in producing the A.A.R. Alternate Standard hopper-car design. In addition to taking advantage of cast-steel's natural resistance to corrosion, the cast-steel parts eliminated many of the joints, bends, and seams in the hopper zone that provided pockets where concentrated sulphuric acid, resulting from the leachings from the coal, could lodge and eat away rolled-steel plate.⁵³

They also examined the use of welding to replace riveting as a way of joining parts and assemblies, since it was becoming recognized that a great deal of corrosion started at rivet heads, and rivet joints.⁵⁴ Thus, as the industry entered the 1940s, an increasing number of cars were being constructed with specialty-steel alloys, welded joints, and cast-steel parts to reduce their weight and increase their durability.

The industry's experimentation with new materials and car designs was slowed by America's entry into World War II. Steel plate was needed to meet America's war needs. In an effort to rationalize production, the War Production Board appealed to the railroad industry to limit its production of gondolas, hopper cars, and flat cars to seven freight-car designs that minimized the use of this critical commodity.⁵⁵

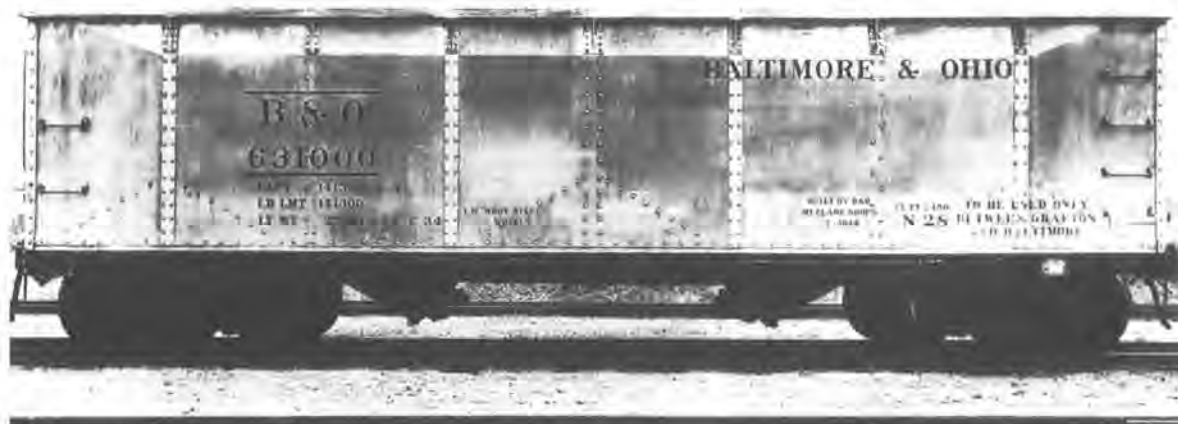


FIGURE 4.48

The Baltimore & Ohio teamed with the Aluminum Company of America to produce this 70-ton twin-hopper car at its Mt. Clare shops in 1934. Both the underframe and body were constructed of aluminum alloys. Not only was the metal expected to reduce the effects of corrosion, but it saved over seven tons in car weight. An A.A.R. Standard, all-steel twin-hopper car had a light weight of 41,500 pounds, capacity of 2,453 cubic feet and a nominal capacity of 50 tons. This car had a light weight of 27,000 pounds, a capacity of 2,450 cubic feet and a nominal capacity of 70 tons. The following is stenciled on the side of the car, "TO BE USED ONLY BETWEEN GRAFTON AND BALTIMORE."

[Walter A. Lucas Collection; Courtesy: Railroad Museum of Pennsylvania Archives]



FIGURE 4.49

In 1934, the Baltimore & Ohio Railroad built seven experimental hopper cars to evaluate various building materials and design features, including the use of Cor-Ten steel to reduce weight and corrosion. B&O car number 633001, shown here, had a capacity, level full, of 2,070 cubic feet, a light weight of 31,200 pounds, and a nominal capacity of 50 tons. Its end sheets, side sheets, slope sheets, cross-ridge sheets, and outside hopper sheets were constructed of $\frac{3}{32}$ " Cor-Ten steel. The sides and ends were corrugated to increase their strength and rigidity. The cars were periodically evaluated to determine their endurance. The $\frac{3}{32}$ " floors lasted 13 years, compared to 10 years for $\frac{1}{4}$ " carbon-steel floors and 15 years for $\frac{1}{4}$ " copper-steel floors. The sides were still in service after 19 years.³⁶ [Walter A. Lucas Collection; Courtesy: Railroad Museum of Pennsylvania Archives]



FIGURE 4.50

In 1935, the Chesapeake & Ohio built ten experimental hopper cars built with high-strength, specialty-steel alloys to test their suitability for use under actual service conditions on the railroad. The cars were built along the same lines as the A.A.R. Standard 50-ton car, except that an additional hopper was added and specialty steels used. Cor-Ten steel, a high-tensile-strength, low-corrosion steel alloy containing copper, silicon, chromium, and phosphorus, was employed in all areas that came in contact with coal. Man-Ten steel was used in all other areas. The use of these alloys enabled the railroad to save over $3\frac{1}{2}$ tons in light weight compared to the A.A.R. Standard design, yielding a revenue to gross weight ratio of 79.5%.³⁷ [Courtesy: Hagley Museum and Library]



FIGURE 4.51

In 1941 and 1942, the Reading built 1,500 welded-steel hopper cars in its company shops—one thousand for its own use and five hundred for lease to the Central of New Jersey. The design was intended to reduce the cars' life-cycle costs. Copper-bearing steel was used in all areas exposed to the lading. Interior joints of the car were welded to eliminate seams. To eliminate the seam between the end sheet and slope sheet, the two were composed of a single sheet of steel with a "generous radius" provided at the bend in the sheet. The cars were equipped with Duryea Cushioned Underframes, the costs of which the railroad expected to recover in reduced damage to draft gears. They were also equipped with friction truck springs.⁵⁸ One of the CNJ cars is shown here, relegated to ash service, in 1954. The elevation drawings for these cars are shown in Figure 4.52. [Courtesy: John C. La Rue Jr. Collection]

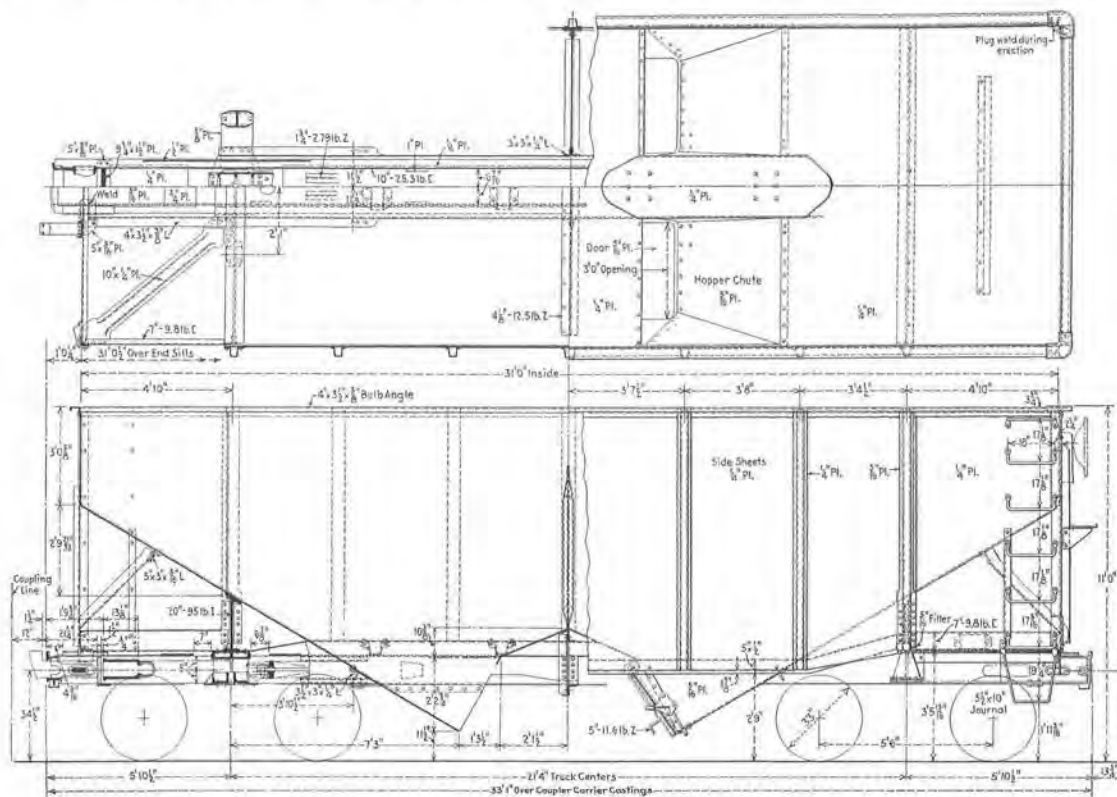


FIGURE 4.52

These are the elevation drawings for the Central of New Jersey welded-steel hopper car shown in Figure 4.51. The car was designed by the Reading to be able to carry full tonnage loads of either anthracite or bituminous. [Railway Mechanical Engineer, March 1942, p. 118; Courtesy: Simmons-Boardman Publishing Corporation]

In response to this appeal, the A.A.R. developed two composite wood-and-steel hopper-car designs, a 50-ton car with an inside length of 33 feet, and a 70-ton car with an inside length of 40' 8". The designs followed the A.A.R. standards as closely as possible to permit the use of as many common parts as possible, and were designed so that railroads could replace the wood sides with steel once that metal became available again.⁵⁹ War shortages also meant that specialty steel alloys were not available, so railroads resorted to low-carbon steel plates, shapes, and castings in the construction of these cars.⁶⁰

The use of composite construction in the 50-ton car shown in Figures 4.53 and 4.54 enabled the builders to save 2½ tons of steel per car. The use of wood for the sides and slope sheets also resulted in these cars being 5,800 pounds lighter than comparable all-steel cars, but the increased width of the lumber resulted in a 7% reduction in overall capacity.⁶¹

From May 1943 to May 1944, railroads ordered

4,520 hopper cars built to the A.A.R. composite emergency design,⁶² with the biggest purchasers being the Southern, the Chesapeake & Ohio, the Union Pacific, and the Louisville & Nashville.⁶³

By 1944, steel became available once again. As a result, the War Production Board lifted its restriction on the production of all-steel cars, and the production of these "war emergency" hopper cars was ended. Many of these cars were later retrofitted with steel sides and remained in service well into the 1960s.

In 1944, the A.A.R. announced its "Victory" freight-car designs, which was essentially the A.A.R. standard design with some detail changes, such as substituting structural-steel shapes for built-up plate construction.⁶⁴

In the twelve months following victory in Europe, railroads ordered 9,125 50-ton hopper cars. Of these, 6,775 were A.A.R. Standard or Alternate Standard. Of the remaining number, 2,000 were

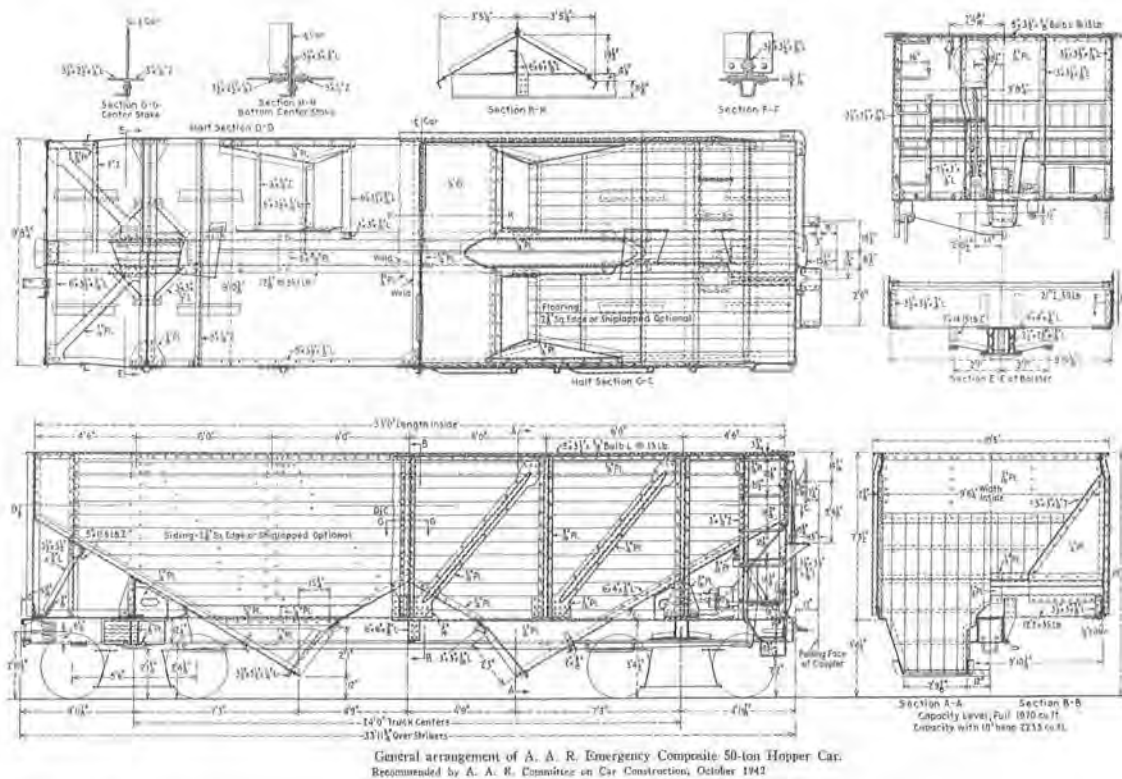


FIGURE 4.53

In November 1942, the A.A.R. developed drawings for a 50-ton and 70-ton composite hopper car in response to an appeal from the War Production Board to reduce the amount of steel plate used in freight-car construction. The original design, shown here, had wood sides and wood floors that extended down to the hopper doors. This design was later changed to incorporate steel hopper bottoms.⁶⁵ These cars have come to be known as "war emergency" hopper cars, though that term wasn't used at the time. [Car Builders' Cyclopedica, 1943; Courtesy: Simmons-Boardman Publishing Corporation]



FIGURE 4.54

ATSF 180739 was part of a 4,000-car order for 50-ton, composite wood-and-steel construction, war emergency hopper cars from Pullman-Standard from five different railroads in the summer of 1943. The order consisted of 1,450 cars for the Southern, 100 cars for the Central of Georgia, 1,250 cars for the Chesapeake & Ohio, 1,000 for the Louisville & Nashville, and 200 for the Atchison, Topeka & Santa Fe. Note the similarity of the side trusswork between these cars and the Seley cars, designed almost fifty years earlier. [Paul B. Dunn Photo; Courtesy: Richard J. Burg Collection]



FIGURE 4.55

Southern Railway's car number 104818 was part of the same order from Pullman-Standard as the Santa Fe car shown above. These cars were designed to use as many components that were common to the 1935 A.A.R. Standard hopper design as possible and to have their wood components replaced with steel plate when it became available. The car shown here has had its wood sides replaced with steel. This process added 75 cubic feet of capacity to the car, but at the expense of 5,000 pounds in light weight. [Paul B. Dunn Photo; Courtesy: Richard J. Burg Collection]

standard except that they employed floating center sills (cushion underframes). The remainder varied in size and width to accommodate differing load capacities.⁶⁶ However, the tide was beginning to turn against the offset-side A.A.R. design.

Strength and durability became the focus of post-World War II coal-car design. By this time, some of the flaws in the A.A.R. design were becoming apparent, and this era was marked by railroads paying increasing attention to reducing the overall life-cycle costs of their cars by employing advanced materials and construction techniques.

While it may have seemed like a good idea at the time, the offset sides with their internal side stakes proved problematic. The internal structural members could interfere with the loading and unloading of the car, and they were susceptible to damage from mechanical loading and unloading devices. Additionally, the structural members created pockets and ledges where moisture and fine particles of coal could collect and cause corrosion.⁶⁷

Two elements emerged as the means by which railroads would extend the lives of their coal cars—advanced steel alloys and welded car design. Along with their desire to reduce the overall life-cycle costs for their coal-car fleets, railroads would be confronted with new challenges in the post-war era that would influence their car designs. Among these were their customers' desire for larger coal cars and the impact that shake-out machines would have on the structure of their cars.

By the end of the war, railroads already had a dozen years experience with U.S. Steel's Cor-Ten

steel alloy. They had seen that this high-tensile-strength, low-alloy steel could reduce the light weight of a comparable size 50-ton car by over 3½ tons. Now, they had empirical evidence of its durability. In a series of controlled tests, Cor-Ten demonstrated that it had approximately twice the life of copper-bearing steel.⁶⁸ In other words, a Cor-Ten car could operate for 25 years before needing heavy repairs compared to the 14-15 years of expected life for cars built of copper-bearing steel.⁶⁹

These tests also revealed other life-limiting factors. Corrosion inhibits further corrosion, and one of the ways in which Cor-Ten resisted corrosion was that corrosion adhered very tightly to the alloy. However, testing revealed that stress would break the corrosive film and expose bare metal to further corrosion. This phenomenon was particularly apparent at riveted and lapped joints. Thus, if you could eliminate those joints, you could further extend the life of the car.⁷⁰

In 1947, U.S. Steel took all of these lessons learned and applied them in building a prototype, 50-ton hopper car. The car had a light weight of 33,500 pounds, which yielded a load capacity of 135,500 pounds, or 3½ tons more than the A.A.R. Standard. Especially noteworthy, however, was the way in which the car was constructed, the object being to eliminate as many joints and seams as possible. Thus, the side sheets were butt-welded together as opposed to being lapped and riveted. The rolled-steel side stakes were moved to the outside to provide a smoother interior surface that eliminated the ledges and pockets that were subject



FIGURE 4.58

U.S. Steel built this all-steel, 50-ton hopper car in 1946 based upon lessons learned to reduce the life-cycle costs of coal cars. The heavy, pressed-plate side posts were moved to the outside and the side sheets were butt-welded to create a smooth surface that eliminated places where corrosion could develop. The construction techniques saved a total of 3½ tons in light weight compared to similar-capacity cars of the period. The design pointed the way toward future car development. [Courtesy: John C. La Rue Jr. Collection]

to corrosion and enabled the lading to flow freely.⁷¹ While many of these techniques had been used individually—for example, the Reading had built 1,500 welded hopper cars with external side posts in its shops in 1942⁷²—this was the first example in which all of these elements had been brought together in a single design. The techniques used in building this car would serve as a pattern for car builders over the next twenty years.

Despite the obvious advantages of Cor-Ten, many railroads continued to build their coal cars of traditional steel alloys due to the higher cost of the specialty alloy. However, they were quick to adopt the building techniques employed in the U.S. Steel car, that is, welded construction and heavier, external side posts, choosing to favor strength and durability over empty-weight-to-loaded-weight efficiency. An example of one of these early post-war-era cars is described in Figure 4.59. However, by 1960, over 340,000 freight cars had been built of Cor-Ten,⁷³ and other steel manufacturers were introducing their own high-tensile-strength steel alloys.

As America readjusted to a peacetime environment, railroad earnings slumped and railroads suffered from the excess capacity that had developed during the war years. As a result, railroads retired many of their older cars and deferred maintenance on others. By 1950, however, conditions had changed, and the huge surplus of freight cars that

had existed in 1949, suddenly became a shortage. By mid-1950, railroads were reporting a combined shortage of 38,925 freight cars.⁷⁴

Another issue was developing during this period, and that was the desire by customers for larger coal cars. As sales of anthracite declined and the demand for bituminous increased, especially among large users, the requirement for larger coal cars emerged. Customers asked railroads to begin building more 70-ton coal cars so they could reduce the number of cars they had to handle.⁷⁵

In addition, the railroads had to contend with another technology that was affecting their coal cars, the use of car shake-out devices. Hopper cars were never completely self-clearing, and it was common practice for men to beat the sides of hopper cars to encourage the load to discharge. For this reason, many photos of early hopper cars show their sides damaged as the result of being beaten to loosen the load. To expedite unloading of their cars, many receivers installed shake-out devices at their unloading points. Car shakers were either hydraulic or pneumatic devices that were attached to the car and literally vibrated the car until the contents were discharged. Needless to say, these devices were prone to exploit any weaknesses in a car's structure and create the need for even more robust car designs.⁷⁶

Thus, the trend away from lightweight construction and toward more robust designs accelerated.



FIGURE 4.59

Pullman-Standard built 2,000 of these welded-steel cars numbered 34000 to 35999 for the Louisville and Nashville in 1948 and 1949. They had an inside length of 34' 11", inside width of 9' 7", height to eaves of 10' 8", and capacity of 2,142 cubic feet. The cars used $\frac{5}{16}$ " pressed-plate external posts to reinforce the sides. The one-quarter side post and rivet pattern in the center indicate where the cross-ridge brace was attached. These cars were very similar to their successor, the PS-3. The Soo Line also purchased cars of this general design. [Courtesy: Bob's Photo]



FIGURE 4.60

The Delaware, Lackawanna & Western purchased 1,000 of these welded, 50-ton hopper cars numbered 85500 to 86499 in 1947. The cars had an inside length of 34' 4", inside width of 9' 8", and height from top of rails to eaves of 11' 0", producing a capacity of 2,221 cubic feet. Their lightweight construction included the use of Cor-Ten Steel.⁷⁶ [Walter A. Lucas Collection; Courtesy: Railroad Museum of Pennsylvania Archives, PHMC]



FIGURE 4.61

The Pressed Steel Car Company built 1,000 welded-steel hopper cars of 50-ton and 70-ton capacity for the Chicago & Eastern Illinois in 1952. These cars were noted for their exceptional strength, sacrificing light weight for longer service life. The cars were constructed of copper-bearing steel on all surfaces in which the load came in contact with the car. To increase the service life, these plates were made $\frac{1}{16}$ " thicker than in previous designs. The sides were increased from $\frac{3}{16}$ " to $\frac{3}{4}$ ", and the other surfaces were increased from $\frac{1}{4}$ " to $\frac{5}{16}$ ". Based upon copper-bearing steel losing about .008 inches per year, this increase in thickness was expected to extend the lives of these cars by 5 to 8 years. The car company indicated that three other roads had placed orders for these cars, bringing total production to 3,000 cars.⁷⁷ These were among the last cars produced by the Pressed Steel Company. The company closed its freight-car building plant in early 1954. [Courtesy: Bob's Photo]



FIGURE 4.62

The Pullman-Standard Car Manufacturing Company began producing these 70-ton, lightweight hopper cars for the Birmingham Southern Railroad Company in 1939. This twin-hopper car had an inside length of 30' 3", width of 9' 7", and height of 10' 8", yielding a capacity of 1,850 cubic feet. It was designed to be used in either coal or ore service. Elements of this welded-steel car design would become increasingly popular in the late 1940s and early 1950s and would be used by Pullman-Standard in its PS-3 design. [Courtesy: Bob's Photo]



FIGURE 4.63

American Car & Foundry introduced a standardized series of hopper cars in 1948. The cars were built using a welded, lightweight design. This 50-ton version, built for the Atlantic Coast Line in 1949, was photographed in Fayetteville, North Carolina, ten years later. The 50-ton cars had a capacity of 2,100 cubic feet and a light weight of 37,000 pounds. This series can be identified by the slight offset running parallel to the top rail. Note that this car is almost a full ton lighter than the welded car that the same manufacturer built for the Lackawanna, shown in Figure 4.60. The Chesapeake & Ohio purchased 70-ton cars from American Car & Foundry with a similar offset-side design. It is reported that the way in which the side posts were welded created a "hinge" effect at the seams that caused the sides and side posts to separate.⁷⁸ [Courtesy: Bob's Photo]



FIGURE 4.66

The Clinchfield was among the first railroads to purchase the 50-ton version of the PS-3 twin-hopper car. Note that the pressed-plate side posts are welded to the side sheets. The rivets down the center side post indicate where the cross-ridge brace is attached. The cross-ridge braces were first riveted in place and then welded along their seams to minimize corrosion. These cars had an inside length of 35' 0", inside width of 9' 7 $\frac{3}{4}$ ", height from rails to the top of the car body of 10' 8 $\frac{1}{16}$ ", and a capacity of 2,143 cubic feet, level full. With a 10" average heap, the capacity increased to 2,423 cubic feet. This photo was taken in Fayetteville, North Carolina, in March 1959. The Louisville & Nashville was another early and large user of the 50-ton PS3, having over 3,000 of these 50-ton cars on its roster, numbered 82200 to 85199. [Courtesy: Bob's Photo]



FIGURE 4.67

In 1951, Bethlehem Steel built 1,000 triple-hopper cars with 2,622 cubic feet of capacity for the Chesapeake & Ohio. The steel company soon marketed this hopper-car design to other railroads, including the Western Maryland, which bought the car shown here in 1955. These cars had an inside length of 40' 8", width of 9' 7 $\frac{3}{4}$ ", and height of 10' 8", with a nominal capacity of 70 tons and a design light weight of 54,800 pounds. When the Western Maryland purchased these cars, it had already begun transitioning to roller bearing trucks. Other railroads that purchased cars built to this design were the Cambria & Indiana and Reading. Note that this car is built with Mayari-R-Steel, Bethlehem Steel's high-tensile-strength, low-alloy steel, similar in nature to U.S. Steel's Cor-Ten. Note, too, that the side posts are riveted in place along their flanges. This provided increased strength along the entire width of the flange rather than just at the seam of the weld. The "R" inside the circle indicates that the car is equipped with rubber draft gear. [Courtesy: Bob's Photo]



FIGURE 4.68

The Chesapeake & Ohio purchased 6,500 of these 70-ton triple-hopper cars from American Car & Foundry in 1951. These cars employed welded interiors, riveted side posts, and Cor-Ten steel in all areas exposed to the lading. The cars had an inside length of 40' 6", height above rails of 10' 8", and capacity of 2,608 cubic feet. They had a light weight of 52,100 pounds. One is seen here in Fayetteville, North Carolina, in April 1952. [Courtesy: Bob's Photo]



FIGURE 4.69

The New York Central System was one of many users of this welded, 70-ton triple-hopper design. It had an inside length of 40' 7 3/4", inside width of 9' 7 3/4", height to eaves of 11' 0", and capacity of 2,700 cubic feet. Other railroads employing variants of this design included the Delaware & Hudson, Seaboard Air Line, and Western Maryland. This car was built by the Greenville Steel Car Company, but others were built by American Car & Foundry, Bethlehem Steel, General American Transportation Company, and Pullman-Standard. Note the heavy side rail and fifteen, pressed-plate side posts. The side posts opposite the cross ridges show where the cross-ridge braces are riveted in place. A close examination will reveal shadows where the cross-ridge sheets are welded to the sides. This photo was taken in Niagara Falls, Ontario, in July 1957. [Courtesy: Bob's Photo]



FIGURE 4.70

Bethlehem Steel built 500 of these 70-ton triple-hopper cars designed by the Virginian in 1956. Based upon its satisfaction with the design, the company built another 3,300 cars in its own shops. The goal of the design effort was to minimize the effect of corrosion. This was accomplished by using high-tensile-strength, low-alloy steel plate in all areas exposed to the lading, and by eliminating as many holes and lapped joints as possible. However, the side posts were riveted, not welded to the side sheets to reduce the rigidity of the structure and minimize the effects of shake-out devices. The side posts were rolled-steel channels that were folded back on themselves to provide a riveting flange. The cars had a capacity of 2,573 cubic feet, level full.⁸⁰ [Courtesy: Bob's Photo]



FIGURE 4.71

The Norfolk & Western developed its H-10-series, 70-ton triple-hopper car in 1956 and produced 5,500 of them before the close of the following year. The car employed a two-angle slope sheet. The floor sheet sloped at an angle of 45° from the end sheet to the body bolster, and at 30° from the body bolster to the hopper bottom. The higher angle for the floor slope sheet reinforced the end sheet, which had been susceptible to damage in other cars. The lower angle in the hopper slope sheets accommodated standard hopper components. The cars were increased in height by 4" so as to have the same interior capacity as the N&W's earlier, H-2-series of hopper cars.⁸¹ [Norfolk Southern Collection, Digital Library and Archives, University Libraries, Virginia Polytechnic Institute and State University; Courtesy: Norfolk Southern Corporation]

Each of the major car designers developed its own design that capitalized on these new building trends. These designs become readily apparent from the heavier, flat sides to the more robust pressed-plate side posts. In doing this, car builders sacrificed efficiency and light weight to obtain capacity and reliability.

By the mid-1950s, twenty years had elapsed since the A.A.R. had established its standard hopper-car designs, and for the preceding ten years, car builders had been moving away from those standards. Car builders and railroads, both individually and collectively, began producing their own standard designs, some of which are displayed in Figures 4.59 through 4.71. In addition, some railroads, including the Chesapeake & Ohio and Louisville & Nashville, began rebuilding their fleets of A.A.R. Standard cars, eliminating the offset sides.

In the late 1950s, the three largest users of coal cars, the Chesapeake & Ohio, the Norfolk & Western, and the Pennsylvania Railroad began collaborating to develop a common hopper-car design. Industry applauded this effort, since the three roads owned 31% of all coal cars in use. A standard design would mean reduced manufacturing costs, because steel mills would no longer have to change mill schedules to fill orders for individual railroads. Additionally, even though the cars were designed



FIGURE 4.72
This is an interior view of a Norfolk & Western H-11-series hopper car, the railroad's 85-ton companion to the 70-ton "Committee Design" car. [Norfolk Southern Collection, Digital Library and Archives, University Libraries, Virginia Polytechnic Institute and State University; Courtesy: Norfolk Southern Corporation]

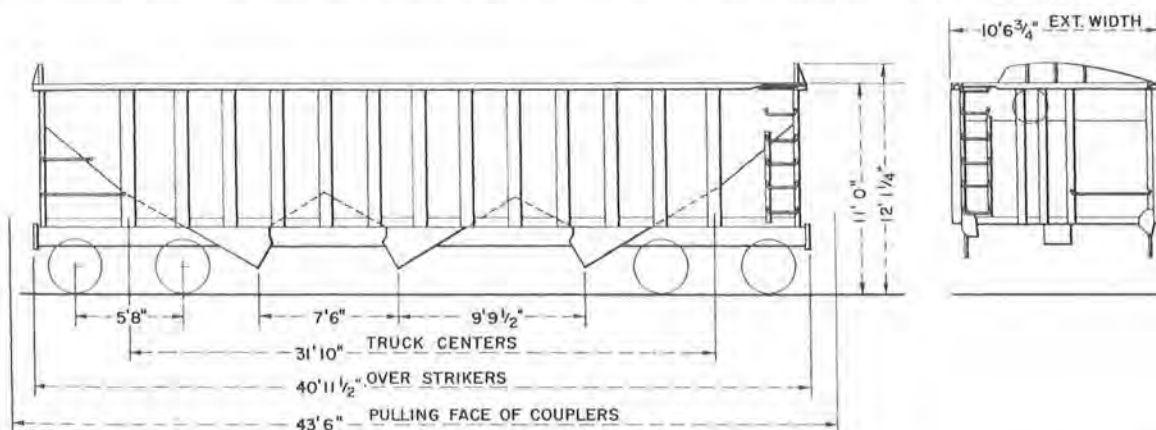


FIGURE 4.73

In 1957, the Norfolk & Western, and the Chesapeake & Ohio and the Pennsylvania Railroad collaborated to produce a standard, 70-ton triple-hopper car with an internal length of 39' 10", inside width of 9' 9 1/2", and capacity of 2,603 cubic feet. Borrowing from the N&W's H-10 series, the car had a dual-angle slope sheet. From the end sheet to the body bolster, the floor sloped at an angle of 42°. From the bolster to the base of the hopper, it sloped at an angle of 30°. The higher angle facilitated the discharge of the load and reinforced the end sheet. The lower angle in the hopper enabled the builders to employ standard hopper components. The car employed a combination welded-and-riveted design. The side posts were riveted to the side sheets to enable the car to better withstand the rigors of shake-out devices.³³ This design was accepted as an Alternate Standard by the A.A.R. in 1960. It is sometimes referred to as the "Committee Design." The N&W adapted this design in 1960 to produce its 85-ton H-11 series. [Railway Locomotives and Cars, April 1960, p. 37; Courtesy: Simmons-Boardman Publishing Corporation]

to be constructed of either high-tensile or copper-bearing steel, those parts were designed to be interchangeable regardless of which was used.⁸⁴

The three railroads introduced their cars in October 1958. An interesting aspect of the design was the dual angles of the floor slope sheet. The Norfolk & Western had used a similar technique in its H-10 series to reinforce the end sheet and speed the discharge of the car's contents. The car featured welded construction, with the exception of side posts, top and bottom chords, center fillers, strikers, and safety appliances. During the test program, it was demonstrated that riveting the sides helped combat the damaging effects of car shakers.⁸⁵

Despite its participation in the project, the N&W did not produce any of these cars. The Pennsy designated the design as its H-39 class and produced over 16,000 of them. In addition to its prototype, C&O 300006, the Chessie produced 500 of these cars numbered 151500 to 151999 in its Raceland shops in 1963.⁸⁶ The A.A.R. designated the design as Alternate Standard in 1960.⁸⁷

Although the N&W did not produce any more of these cars, its prototype, N&W number 59000, remained in its fleet for many years. The Norfolk & Western's participation, however, did not go for naught. It employed the lessons learned from this experience in the design of its 85-ton, H-11 Series.⁸⁸ Likewise, the C&O employed the lessons learned from this test in its 85000 to 86999 series of 85-ton triple-hopper cars.

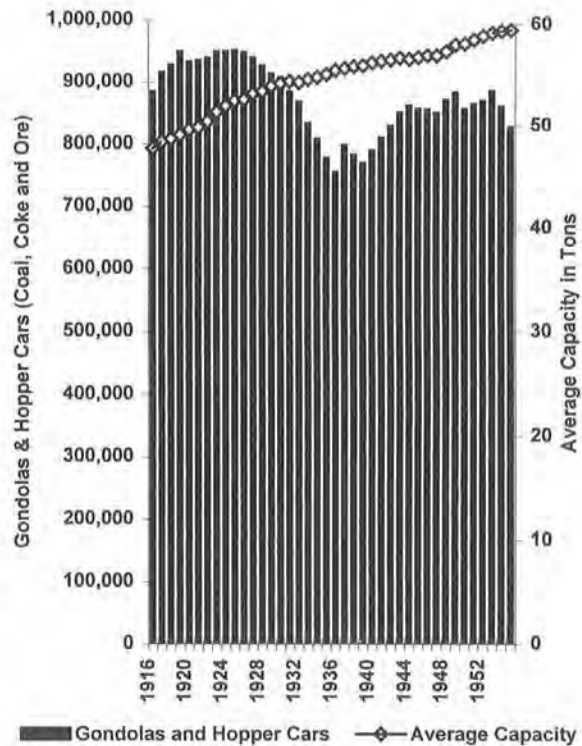


FIGURE 4.74
Coal Car Inventory, 1916-1955. [Source: *Railroad Car Facts*; American Railway Car Institute; 1955]



FIGURE 4.75
The H-39 class was the Pennsylvania Railroad's version of the "Committee Design" 70-ton hopper car, which was designed jointly by the Chesapeake & Ohio, Norfolk & Western, and Pennsylvania Railroads. The car had an internal capacity of 2,603 cubic feet. The Pennsy had over 16,000 hopper cars built in this series by a number of car builders. This car was built by American Car & Foundry in July 1959 and was seen here in Alexandria, Virginia, in December 1974. These cars can be identified by the thirteen riveted side posts. Note that the Pennsylvania design lacked the heap shields that are shown in the Norfolk & Western design in Figure 4.73. The Pennsy design employed Cor-Ten steel in all areas exposed to the lading in its cars of this series. [Courtesy: Bob's Photo]



Braking in Hard Weather.

FIGURE 5.1

This 19th century engraving dramatizes the hazards of braking in inclement weather before the advent of the automatic brake. The brakeman might also have used a hickory club to gain additional leverage in turning the brake wheel. [*The American Railway*, 1889]

Automatic Brakes

The power brake did not begin with George Westinghouse's patent in 1869. Robert Stephenson patented a steam-powered brake for locomotives in 1833.³⁹ Indeed, George Westinghouse didn't even invent the air brake; it was patented by an Englishman named Crawford in 1845.⁴⁰ What set Westinghouse's invention apart was the continuous nature of his invention, that is, the ability to control the brakes throughout an entire train.

Westinghouse's patent of 1869 was for a straight air brake, that is, as air was applied through the train lines to the brake cylinders under each car, the brakes were applied. This system worked reasonably well as long as air pressure could be supplied to the brake cylinders to apply the brakes. However, in the event that there was a loss of air pressure, for example if the train broke in two, the train was left without brakes.⁴¹ Westinghouse solved this problem in 1872 with his invention of the triple valve, which made the automatic brake possible.⁴²

"Westinghouse Air Brake engineers developed an automatic device called a 'triple valve,' and they located one of these and an air reservoir on each car in addition to the main one on the locomotive. All the while a train was in motion, the pipe line and the car reservoirs were charged with compressed air. When the engineer wanted to stop the train, instead of letting air into the pipe line as before, he let the air out. The reduced pressure activated the triple valve which automatically turned the air from the car reservoir into the braking cylinder. The ingenious part of this arrangement was that, when a train broke in two, the automatic feature caused both parted sections to stop promptly. This safety feature is still acclaimed as one of the great inventions of all time."⁴³

The improved comfort, reliability, and safety provided by the automatic brake gained it widespread acceptance for passenger service, and by the late 1870s, most passenger trains were equipped with Westinghouse brakes.⁴⁴ However, as effective as the air brake was on short passenger trains, it did not work well on long freight trains. The problem involved the time required for the "message" to be transmitted from the locomotive to the rear of the train. This was observed in the first Burlington trials conducted by the Master Car Builders' Association in 1886. On a fifty-car train operating at twenty miles an hour, it took a full eighteen seconds for the brakes to be applied to the last car in the train. Considering that it only took fifteen seconds for the air brake to bring a twenty-mile-an-hour locomotive to a complete stop, with eight inches of slack



FIGURE 5.24

This engraving shows a lever brake installed on an early coal car. This type of system was used on the first cars that ran on the Delaware & Hudson gravity railroad. [*The Science of Railways*, 1902]

between every car with the link-and-pin coupler, it was possible that the front of the train could be stopped while the rear of the train was still moving at twenty miles an hour. The results were obvious and disastrous—a series of collisions between every car in the train.⁴⁵

In the absence of a clear choice for an automatic brake, a number of alternatives, both credible and not-so-credible, emerged. The vacuum brake, which was widely used in Europe in passenger service, operated on the principle of using a vacuum to release the brakes. As air was let into the system, the brakes were applied. This offered the same fail-safe properties as the Westinghouse brake, but it also suffered from the same shortcomings, as well as being too weak for freight use.⁴⁶ There were a variety of momentum brakes, which used the momentum of the train to apply the brakes to each car, and there were wind-up brakes, which applied the brakes by winding a chain around an axle.⁴⁷ There were also contenders that used electricity in combination with some of these other systems to solve the problem of the transmission time for the braking signal from the front to the rear of the train. Even though these fared well in the trials, the use of electricity was still in its infancy, and many were concerned about its reliability. However, if George Westinghouse had not acted quickly to fix the problems with his automatic brake after the Burlington trials, it's quite possible that railroads might be using an electro-pneumatic braking system today.

The growing desire by the railroads for an automatic braking system caused the M.C.B.A. to form a committee in 1885 to determine if any were capable

of controlling a 50 car train.⁴⁸ This led to the Burlington trials conducted in July 1886 and May 1887. None of the five contenders emerged a clear winner at either of these trials, but it began to appear as if the electric brake held the greatest promise for the future.

However, George Westinghouse attended the second of these trials, and after identifying the problems with his air brake in freight use, increased the diameter of his brake pipe from 1 inch to 1 1/4 inches and redesigned the triple valve to accelerate the communication between the cars.⁴⁹ Westinghouse returned to the trials with his new Quick-Action Brake in the summer of 1887 and demonstrated the ability to apply the brakes throughout the entire train in two seconds and stop the train in less than one-third its length.⁵⁰

Westinghouse immediately took the train on a tour throughout the country. Table 4.2 shows the average stopping distances demonstrated during this tour. Experts within the community termed the performance "remarkable" and estimated that automatic brakes, which cost no more than \$55 per car to install, would pay for themselves in reduced accident costs.⁵¹ In 1889, the Master Car Builders' Association adopted the quick-action automatic brake as standard.⁵²

The Quick Action Brake, which became the Type H series, came in several forms. The "HC" (combined) arrangement had the brake cylinder mounted directly on the auxiliary reservoir, as shown in Figure 5.27. This was the most common arrangement for freight cars. The "HD" (detached) arrangement separated the brake cylinder from the reservoir for those installations in which the use combined arrangement could not be used. This is shown in Figure 5.28. The only differ-

TABLE 4.2
Stopping distances for trains using hand-brakes and trains using Westinghouse Quick-Action Brake following the Burlington trials in 1887.⁵³

	Feet
Hand-brakes, 50 cars, 20 miles an hour	794
Hand-brakes, 50 cars, 40 miles an hour	2,500
Air-brakes, 50 cars, 20 miles an hour	166
Air-brakes, 50 cars, 40 miles an hour	581
Air-brakes, 20 cars, 20 miles an hour	99

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A. P. MASSEY, Mechanical Eng'r.

WORKS, WATERTOWN, N. Y.

The **EAMES AUTOMATIC VACUUM FREIGHT BRAKE** was the **ONLY** brake exhibited at the competitive brake trials at Burlington, Iowa, in May, 1887, which, without the aid of electricity, was able to handle fifty-car trains, light or loaded. The Carpenter brake was inoperative without electricity, and three stops which were made by the Westinghouse brake with fifty empty cars produced such excessive and dangerous shocks that all further attempts to operate it as an air brake were **ABANDONED**. The **MAXIMUM** shock in the emergency stops of the Eames Brake, with fifty cars, two-thirds loaded and one-third empty, was **LESS THAN EIGHT INCHES**. The **MINIMUM** shock with the Westinghouse brake with fifty cars, all empty, was **OVER SEVENTY INCHES**.

In the drifting tests, where trains were brought to the top of a grade at a speed of twenty miles an hour, which was to be reduced to fifteen miles an hour, and maintained at that rate to the foot of the grade, the maximum variation from fifteen miles with the Eames Brake was **ONLY TWO MILES**, while the Westinghouse speeds ranged from **NINE** to **THIRTY MILES**.

The superiority of the **EAMES DRIVER BRAKE** is shown by the following record of stops:

Engine and Dynamometer Car. Speed, forty miles an hour on down grade of fifty-three feet.			Engine, Dynamometer Car, and fifty-one empty cars. Speed, twenty miles an hour, on level. Stops made with driver and tender brakes only.		
	Speed.	Length of Stop.		Speed.	Length of Stop.
EAMES, . . .	40 miles.	899 feet.	EAMES, . . .	20 miles.	1,625 feet.
WESTINGHOUSE, 40 "	"	1,010 "	WESTINGHOUSE, 20 "	"	2,589 "
CARPENTER, . 40 "	"	931 "	CARPENTER, . 20 "	"	1,956 "
AMERICAN, . . 40 "	"	961 "			

FIGURE 5.25

This 1887 advertisement for the Eames vacuum brake points out the shortcomings of the early Westinghouse brake and demonstrates that the acceptance of the Westinghouse brake was by no means a foregone conclusion. [Poor's Manual of Railroads, 1887]

ence between the "HC" and "HD" arrangements was that the auxiliary reservoir and the brake cylinder were combined in the former and detached in the latter. Hopper cars commonly use the "HD" arrangement, because of the lack of contiguous space beneath the car. Diagrams from the period indicate that hopper-bottom and drop-bottom gondolas also used the "HD" arrangement. When detached, the distance between the brake cylinder and auxiliary reservoir could not exceed 8-10 feet without impairing the braking in the car. The triple valve also came in two configurations, H-1 and H-2. The H-1 configuration was used on 8" x 12" brake cylinders; the H-2, on 10" x 12" cylinders. The

Geo. Westinghouse, Jr., President. John Caldwell, Treasurer.
T. W. Welsh, Superintendent. W. W. Card, Secretary.
H. H. Westinghouse, General Agent.

The Westinghouse Air Brake Co.,

PITTSBURGH, PA., U. S. A.,

MANUFACTURERS OF THE

WESTINGHOUSE AUTOMATIC BRAKE.

The WESTINGHOUSE AUTOMATIC BRAKE is now in use on 20,000 engines and 125,000 cars in all parts of the world. This includes 60,000 freight cars.

The WESTINGHOUSE AUTOMATIC BRAKE is the only continuous brake that has been successfully used on freight trains.

THE AUTOMATIC BRAKE will, in consequence of its quick application, stop a train in the least possible distance.

THE AUTOMATIC BRAKE on freight trains, as in passenger service, applies itself instantly to all parts of the train in the event of the train breaking into two or more parts, a feature of great importance in view of the statistics published in the *Railroad Gazette*, which show conclusively that a majority of the collisions are caused by the breaking in two of trains. (See *Railroad Gazette*, Feb. 12, 1896, page 113.)

THE AUTOMATIC BRAKE also applies itself to every car in the train, in the event of any accident to the brake apparatus of such a nature that it would render any non-automatic continuous brake inoperative.

THE AUTOMATIC BRAKE can be applied from the rear or from any portion of the train, if desired.

THE AUTOMATIC BRAKE will effect an increase of at least twenty-five per cent. in the efficient value of freight rolling stock, owing to the quicker time that can be made on the road, and the avoiding of delay at stations and sidings. Freight trains carrying perishable goods are being daily run on passenger schedules.

THE AUTOMATIC BRAKE, applied to freight cars, avoids the flattening of wheels and effects a yearly saving, in this item alone, nearly equal to the first cost of the apparatus.

THE AUTOMATIC BRAKE will prevent a greater part of the accidents to freight trains which form so large an item of expense in railway management.

THE AUTOMATIC BRAKE will save employees from the danger and exposure to which they are now subjected, having to ride on the tops of cars in cold and stormy weather, and often sacrificing their lives in the discharge of their duties.

THE AUTOMATIC BRAKE is simple in construction and operation, and cheaply maintained, the working parts being combined in one piece of mechanism.

THE AUTOMATIC BRAKE is not an experiment, but is the result of many years of practical experience, and its capabilities are well known to all railway managers.

FIGURE 5.26

This advertisement for Westinghouse's Automatic Brake appeared opposite the Eames advertisement in Figure 5.25, showing two different interpretations of the same test results. [*Poor's Manual of Railroads*, 1887]

smaller brake cylinder was used on freight cars with a light weight greater than 22,000 pounds but less than 37,000 pounds; the larger cylinder was used on cars with a light weight greater than 37,000 pounds.⁵⁴

The installation of air brakes by railroads was neither instant nor universal. The Railway Safety Appliance Act of 1893, as amended in 1896, only required that "a sufficient number of cars in it be so equipped with power or train brakes that the engineer on the locomotive drawing such train can control its speed without requiring brakemen to use the common hand brake for that purpose." As a consequence, it remained a matter of judgment for the

railroads as to how many cars in a train would be required to have air brakes for the engineer to control the train. It was common practice to group the cars with air brakes at the front of the train, and engineers developed the skill of controlling the slack in the entire train with the "braked" cars in the front of the train.⁵⁵ In fact, railroads even modified some of their cars with train lines running through them so that these non air-braked cars could be placed between other cars with air brakes.⁵⁶

In 1903, Congress again intervened and directed that "not less than fifty percentum of the cars in such train shall have their brakes used and operated by the engineer of the locomotive drawing such train."⁵⁷

Then, in 1910, the Interstate Commerce Commission directed that "not less than 85 per cent of the cars of such train shall have their brakes used and operated by the engineer."⁵⁸ However, by this time, the railroads themselves, through the M.C.B.A., had required that quick-action brakes be installed in all cars in interchange traffic.

The Type H, quick-action brake was designed for trains of 50 cars or fewer. By the early 1900s, railroads were already running trains with more than 50 cars, and an improved system capable of handling trains of increased length was required. The Type H brake presented three problems with long trains—there was such a delay between the application of the brakes in the front and rear of the train that a buffeting action resulted which could damage the cars and break the train; there was such a delay between the release of the brakes in the front and rear of the train that the slack could run in or out without the engineer's ability to control it; and the difference in

brake-pipe pressures between the front and rear of the train could affect the ability of the auxiliary reservoirs to recharge. The Type K triple valve, introduced in 1908, addressed these problems.⁵⁹ The Type K triple valve mounted on the existing auxiliary reservoir and came in the same configurations as the Type H triple valve, that is, K-1, K-2, KC, and KD.

By the 1920s, freight trains had grown even longer and heavier, and the demand for greater braking power increased. In response to this demand, the American Railway Association, in cooperation with the Interstate Commerce Commission, conducted a series of brake trials at

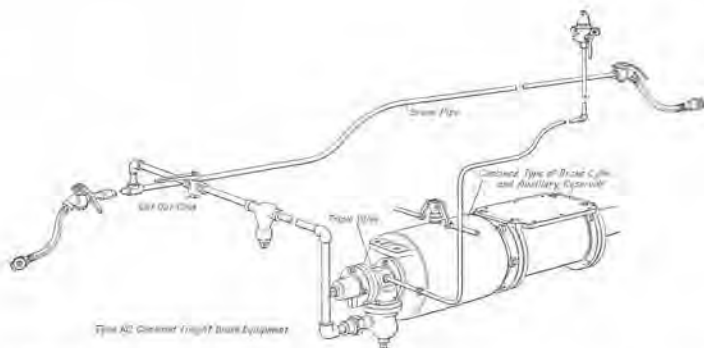


FIGURE 5.27
Components of KC (Brake Cylinder and Reservoir Combined) arrangement of quick-action brake for freight car use. [Reproduced from *Freight Car Brake Equipment*, copyright Education Direct, Inc. Used with permission.]

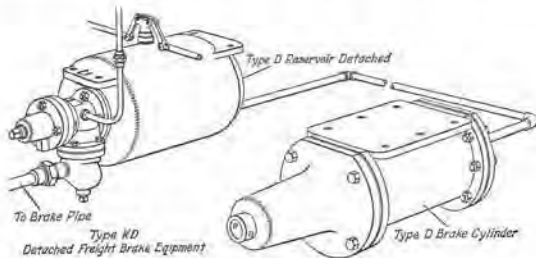


FIGURE 5.28
Components of KD (Brake Cylinder and Reservoir Detached) arrangement of quick-action brake for freight car use. Hopper cars and hopper-bottom gondolas typically used this arrangement because they lacked the room beneath the car for the combined configuration. [Reproduced from *Freight Car Brake Equipment*, copyright Education Direct, Inc. Used with permission.]

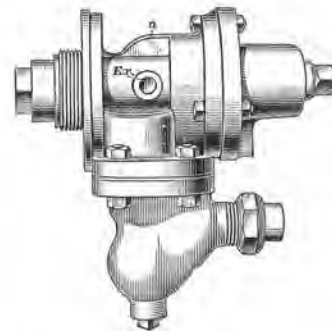


FIGURE 5.29
As freight cars increased in weight and trains increased in length, Westinghouse found it necessary to improve his original automatic braking system. Shown here is the K-2 Triple Valve, which was used with 10" x 12" brake cylinders for freight cars with light weights of 37,000 pounds or more. The K-1 was used with 8" brake cylinders. The K-series was made Recommended Practice in 1913 and advanced to Standard in 1917.⁶⁰ [Reproduced from *Freight Car Brake Equipment*, copyright Education Direct, Inc. Used with permission.]

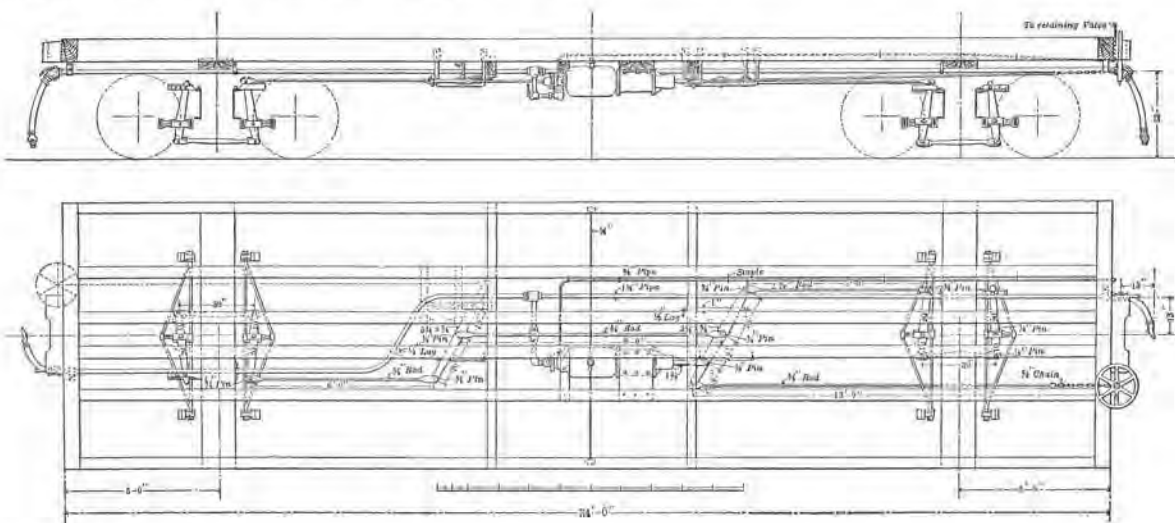


FIGURE 5.30
1892 drawing showing installation of Westinghouse Quick-Action Brake on an open-bottom freight car. [Railway Car Construction, 1892]

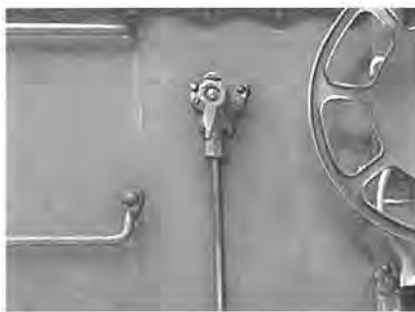


FIGURE 5.31

The pressure-retaining valve is used to help the engineman maintain control of the train when operating on grades. Under normal conditions, the auxiliary reservoir can only be recharged when the triple valve is in the release position. When the pressure-retaining valve is cut in and the engineman releases the brake valve, the pressure in the brake cylinder is slowly released down to a predetermined level and held there. This enables the engineman to retain some braking power on the grade while still recharging the auxiliary reservoirs.⁶¹ [Photographed at the Strasburg Railroad, Strasburg, Pennsylvania]



FIGURE 5.32

This 1898 all-steel hopper car shows the installation of the "HD" Series of the Westinghouse Quick-Action Air Brake. Note that the brake cylinder and brake wheel are located on the right side of this early Pennsylvania Railroad hopper car. [Photographed at the Railroad Museum of Pennsylvania, Strasburg, Pennsylvania]



FIGURE 5.33

This all-steel hopper car built in 1915 shows the general arrangement of the "KD" series air brake. The picture shows the brake-release levers running from the brake-release valve on top of the auxiliary reservoir to the side-post gussets. The brake-release lever was used by trainmen to release stored air pressure in the brake cylinder so they could move the car after it had been spotted. Also visible is the location of the pipe running from the top of the triple valve up the end post to the pressure-retaining valve. [Photographed at the Baltimore & Ohio Railroad Museum, Baltimore, Maryland]

Purdue University in 1926. The result of these tests was the development of a new brake system for freight-car brakes, commonly referred to as the AB brake.

The A.R.A. established new specifications for air brakes in 1933, which the AB brake system met.⁶² The AB brake system was designed for trains of 120 or more cars,⁶³ providing improved quick service, improved release, and improved emergency application.⁶⁴ It replaced the triple valve with an AB valve, and the single reservoir with two reservoirs bolted together. In 1933, the A.R.A. established rules that required that brakes meeting the 1933 specifications (AB brakes) be installed on all cars built new after September 1, 1933 or rebuilt after August 1, 1937. It also required that those brakes be installed on all cars in interchange service after January 1, 1945. As with most of its deadlines, the A.A.R. extended the deadline for having all cars in interchange service equipped with the newer brake system several times, but the deadline became final on July 1, 1953. (The deadline was October 1, 1953 for tank cars).⁶⁵

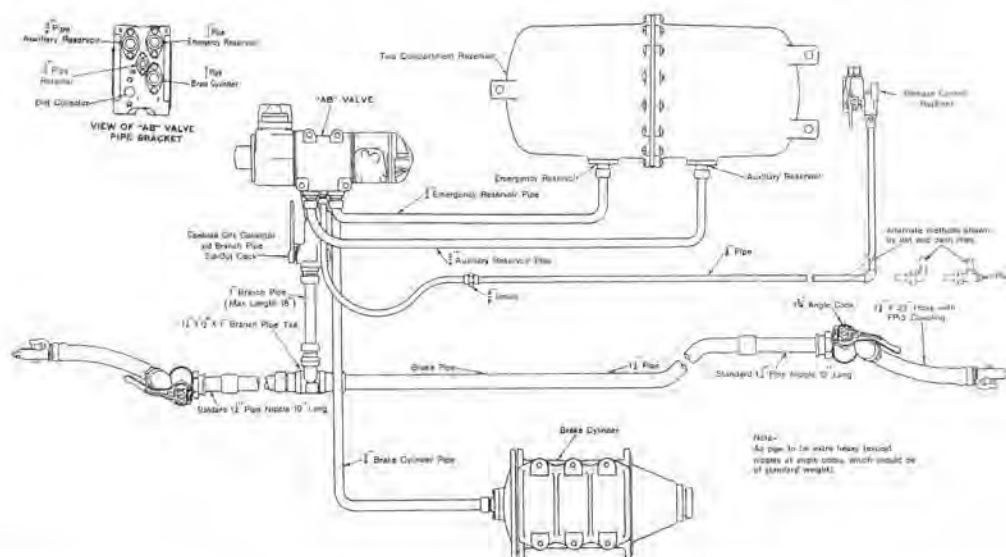
Consistent with the introduction of AB brakes, the A.R.A. also took action to specify the minimum power applied by the brakes under a normal service application. In 1919, the A.R.A. had issued a circu-

lar that stated that brake gear should be laid out to provide braking power of 60% of the empty weight of the car.⁶⁶

In 1935, the A.A.R. adopted a formal standard for the minimum braking power for freight cars offered in interchange service. It stated that "On or after January 1, 1938, all freight cars offered in interchange having single-capacity brakes shall have a nominal braking ratio of not less than 60% nor more than 75% of the empty car weight . . ."⁶⁷ After being modified in 1946 to reduce the minimum braking ratio from 60% of the empty car weight to 50% of the empty weight,⁶⁸ this rule was finally adopted as standard in 1955.⁶⁹

From the early 1900s, concerns had been expressed about the difference in braking power between empty and loaded cars. In 1906, the M.C.B.A.'s proceedings contained a discussion of the utility of being able to adjust the power of brakes based upon a car's weight on rail, and by the second decade of the 20th century, Westinghouse was offering "empty and load brakes" as an option. This system had an extra brake cylinder and an extra reservoir to increase the braking power when the system was manually set to "load."⁷⁰

In 1935, Westinghouse introduced an automatic



Piping Diagram of the Complete "AB" Freight Car Brake Equipment

FIGURE 5.34

The distinguishing features of the AB brake system are the two reservoirs bolted together and the larger AB valve, which replaced the triple valve. The two reservoirs, an auxiliary for normal service application and an emergency reservoir for quick-service application, offered several advantages over the "K-series" brake system. They provided for a 40% improvement in quick-service applications, and they allowed for a more rapid recharge of the auxiliary reservoir during normal service applications.⁷¹ [Reproduced from *Freight Car Brake Equipment*, copyright Education Direct, Inc. Used with permission.]

empty-and-load brake for its AB brake system. This system worked by having a piston attached to the truck bolster that sensed when the car was empty or loaded. When empty, air was directed through a changeover valve to one brake cylinder. When the car was loaded, air pressure was directed to both brake cylinders for additional braking power.⁷²

In 1936, the A.A.R.'s Brake Committee proposed that automatic empty-and-load brakes be installed on all freight cars in which the marked capacity was more than three times its empty weight, exactly the situation found on many coal cars.⁷³ Installing the empty-and-load brakes would cost \$208 and add 250 pounds to the car's weight. As a result, because the proposal was based upon the car's marked capacity, many railroads chose to simply restencil their cars' nominal capacity rather than to bear this additional expense. Thus, cars that had been marked at 115,000 pounds capacity found themselves being re-marked to 100,000 pounds capacity.⁷⁴

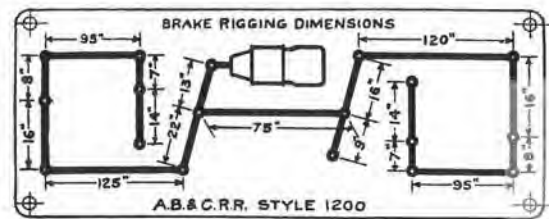


FIGURE 5.35

Proper braking power was applied equally to all wheels by the careful sizing of brake levers. In order to insure that these ratios were not changed during servicing, after 1929, the A.R.A. required that all new cars be equipped with a brake lever badge plate to identify the appropriate sizes and distances for each brake lever. [Car Builders' Cyclopedia, 1937; Courtesy: Simmons-Boardman Publishing Corporation]

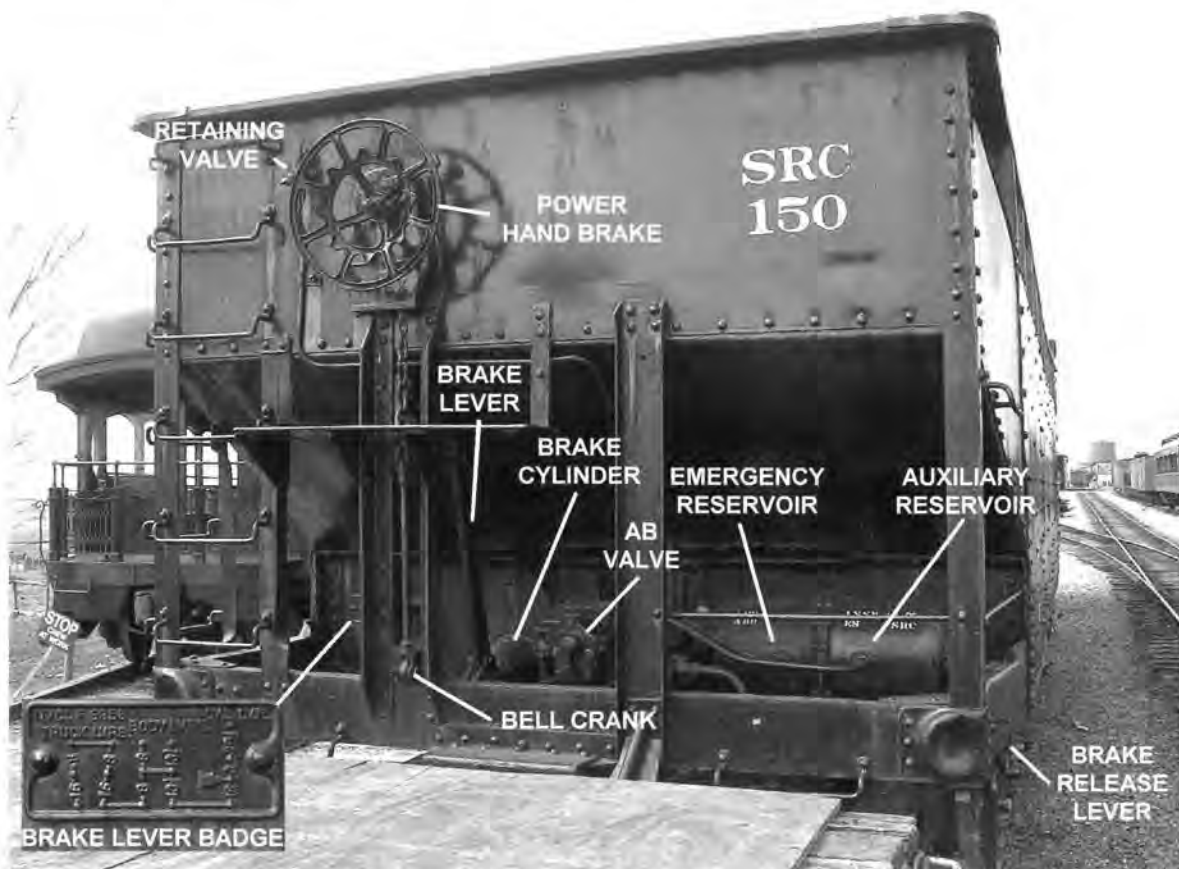


FIGURE 5.36

This view of the "B" end of a hopper shows the components of a power hand brake and AB brake system. [Photographed at the Strasburg Railroad, Strasburg, Pennsylvania]

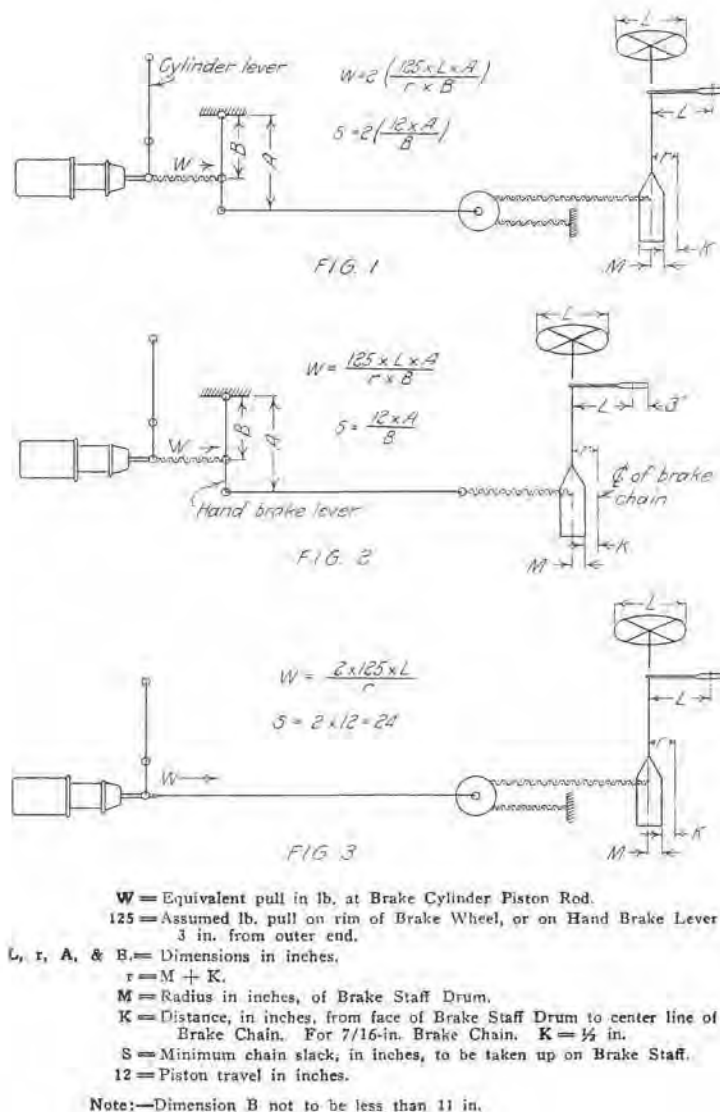


FIGURE 5.37

In 1924, the A.R.A. established hand-brake requirements for all cars built new or rebuilt after January 1, 1925, "Based upon the formulae and diagrams shown herein, the hand-brake wheel or hand-brake ratchet lever, brake staff at chain, and the hand-brake leverage between brake staff and cylinder, shall be so proportioned that a force of 125 lb. at the rim of the brake wheel or three inches from outer end of hand brake ratchet lever will develop an equivalent load " W " at the brake cylinder piston of not less than 2,500 lb. and 3,950 lb. respectively for cars having 8-in. and 10-in. cylinders."¹⁷⁵ [Proceedings of the American Railway Association, 1924]

HAND BRAKES

For over two hundred years, hand brakes were the primary means of stopping coal cars in motion. With the introduction of air brakes, the hand brake assumed a secondary role. When the United States established its safety appliance standards in 1911, it specified only that cars have an "efficient" hand brake which operated in harmony with the power brake and complied with specified minimum standards. Those standards are displayed in Plate A shown to the right.

In 1924, the American Railway Association adopted minimum standards for the force required to set the hand brakes on freight cars.⁷⁶ This standard, shown in Figure 5.37, required that no more than 125 pounds of force be needed at the rim of the brake wheel or three inches from the outer end of a hand brake ratchet lever to apply a minimum hand brake power at the shoes of 60% of the empty weight of the car.⁷⁷

In 1935, the Association of American Railroads established requirements for geared handbrakes and required that all cars built new or rebuilt on or after January 1, 1937, be so equipped.⁷⁸ In 1941, after conducting extensive testing of existing handbrakes at Purdue University, the A.A.R. realized that the requirements had to be revised. One of the issues identified was the fact that horizontal brake wheels could not be measured using the same standards as those set for vertical brake-wheel systems. Vertical brake wheels are typically 22" in diameter and designed for one hand operation, that is, one hand on a grab iron and one-hand on the brake wheel. Horizontal brake wheels are designed for two-hand operation and are typically 16 inches in diameter. The testing revealed that using two hands on a horizontal brake wheel, a man exerts about 28% as much braking force as a man exerts using one hand on a vertical wheel. As the result of this discovery, the guidelines were changed such that the "hand brake leverage ratio must provide braking power of not less than 20% of the total weight of the car plus its nominal capacity based upon a force of 220 pounds at the rim of a 16-inch-diameter wheel or equivalent lading." The previous force required was 125 pounds at the rim of the wheel.⁷⁹

In 1942, the A.A.R.'s Committee on Hand Brakes issued revised guidance for both vertical and horizontal brake-wheel systems. The A.A.R. then established a testing program and required that hand brakes be tested and receive a certificate of approval before being approved for use.

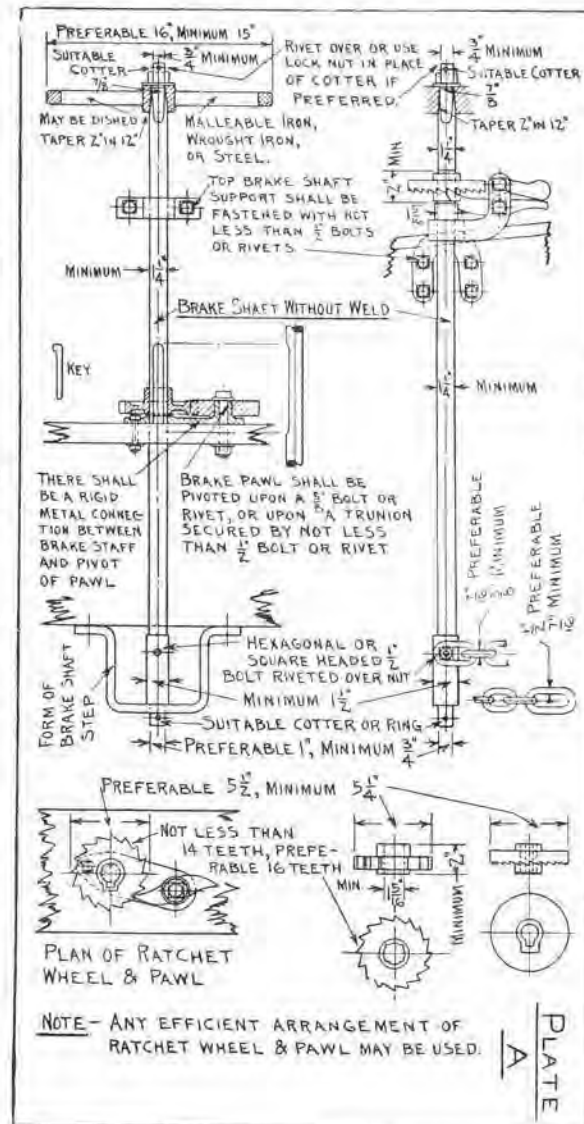


FIGURE 5.38

United States Safety Appliance Standards only specified that cars had to have an "efficient" hand brake which operated in harmony with the power brake and complied with the minimum standards displayed in Plate A above. In 1924, the American Railway Association adopted minimum standards for the force required to set the hand brakes on freight cars.⁸⁰ In 1936, the Association of American Railroads established requirements for geared handbrakes and required that all cars built new or rebuilt after January 1, 1937, be so equipped.⁸¹ In 1942, the A.A.R. revised its specifications for hand brakes and, in 1944, required that all cars built new or rebuilt after January 1, 1945 [extended until January 1, 1946], be equipped with hand brakes that met this new standard.⁸² [Courtesy: Association of American Railroads]

After January 1, 1946, all cars built new or rebuilt were required to be equipped with hand brakes that met these new standards.⁸³

By 1950, the A.A.R. had qualified 13 vertical wheel, 8 horizontal wheel, and 3 lever types of geared hand brakes.⁸⁴ Unfortunately, this diversity of hand-brake systems created operator confusion, and as a result, the manufacturers, at the insistence of the A.A.R., formed an engineering committee to standardize the functions of their various systems. By the mid-to-late 1950s, this had largely been accomplished. Among the items ultimately stan-

dardized by the A.A.R. was the brake wheel. Up until the mid-1950s, the brake wheel had been the manufacturer's signature or trademark. By the end of the 1950s, a standard brake wheel had been adopted, and operators could no longer count on identifying the hand-brake manufacturer by the wheel design. In 1959, the A.A.R. identified two designs of pressed-steel brake wheels as acceptable and designated them Standard and Alternate Standard.⁸⁵

A collection of popular brake wheels is shown in Figure 5.43.



FIGURE 5.39

This photo shows the arrangement for the winding chain and brake lever for a hopper car built for the Baltimore & Ohio in 1915. Note that the winding chain is connected directly to the brake lever. [Photographed at the Baltimore & Ohio Railroad Museum, Baltimore, Maryland]



FIGURE 5.40

This photo shows the arrangement for the winding chain and brake lever for an East Broad Top Railroad hopper car. Note the installation of a pulley. See Figure 5.37 for the details of this installation. [Photographed at the East Broad Top Railroad, Orbisonia, Pennsylvania]

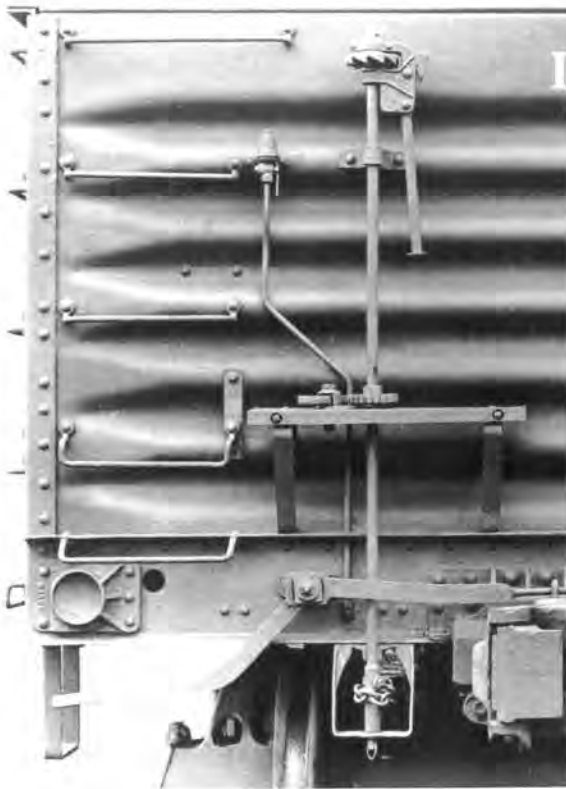
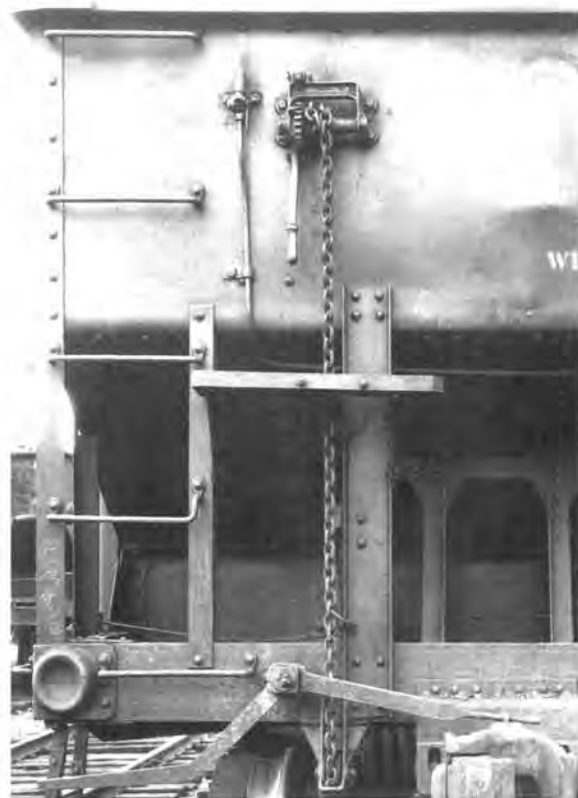


FIGURE 5.41

Lever-action hand brakes were introduced in the second decade of the 20th century. They were intended to enable a brakeman to apply the brakes with one hand while holding on to the ladder with the other. The system shown here replicates the motion of a horizontal brake wheel with a winding chain connected to the brake lever. [Standard Steel Car Company Photo; Courtesy: D.K. Retterer Collection]

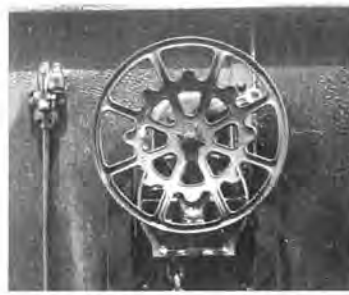
FIGURE 5.42

The ratcheted action shown here used a lifting motion to apply the brakes. Note how the winding chain is taken up on the horizontal shaft and the motion applied through a bell crank to the brake levers. This brake was installed on a Delaware, Lackawanna & Western hopper car. [Thomas T. Taber Collection; Courtesy: Railroad Museum of Pennsylvania Archives]





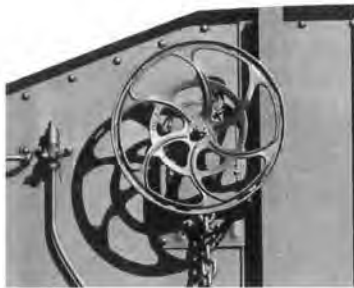
Ajax, pre mid-1930s^a



Ajax, post mid-1930s^a



Champion^a



Equipco^a



Klasing^b



Miner^a



Peacock, early 1920s^a



Peacock, post mid-1930s^b



Superior^d



Ureco, circa 1930s^c



Universal, circa 1940s^d



A.A.R. Standard/Universal^e

FIGURE 5.43

With the introduction of power hand brakes, each manufacturer sought to distinguish itself with a unique brake wheel. Some of the more common varieties are shown here. Ultimately, railroads became disenchanted with the variety of brake wheels and different methods of operations, and the A.A.R. adopted standards for both. [^aCourtesy: Norfolk Southern Corporation; ^bCar Builders' Cyclopedic, 1937; Courtesy: Simmons-Boardman Publishing Corporation; ^cPhotographed at the Baltimore & Ohio Railroad Museum; ^dPhotographed at the Railroad Museum of Pennsylvania; ^ePhotographed at the Strasburg Railroad; Courtesy: Railroad Museum of Pennsylvania Archives]

DRAFT GEAR

The draft gear is the component that connects the draw bar or coupler with the body of the car. The first draft gear was nothing more than a hook to which the chain connecting the cars was attached. With the introduction of link-and-pin couplers, railroads replaced their rigidly mounted hooks with spring draft gears, such as that shown in Figure 5.44, that absorbed the shock of compression and tension as the train's slack ran in and out. In 1879, the M.C.B.A. recommended a draft spring with a 13,000-pound capacity. However, as the weights of freight cars and the lengths of trains grew, increasing demands were placed upon the draft gear. Within five years, the M.C.B.A. increased that capacity to 18,000 pounds. In 1893, after the automatic coupler had been adopted, it further increased the capacity to 22,000 pounds. It also set the travel limits at $2\frac{1}{8}$ inches free motion.⁶⁶

In 1887, the M.C.B.A.'s committee on draft gear recommended that two springs be used instead of one. Although this recommendation was not approved, many railroads adopted this two-spring design.⁶⁷ The springs were mounted either concentrically, that is, one within the other, or in tandem, as shown in the Miner draft gears pictured in Figure 5.44.

A freight car is like a system, and anyone who has worked with systems knows that if you tinker with one part of a system, it's certain to affect another. Such is the case with a car's draft gear. The key shortcoming of spring draft gear is that after it stretches or compresses, it springs back. This

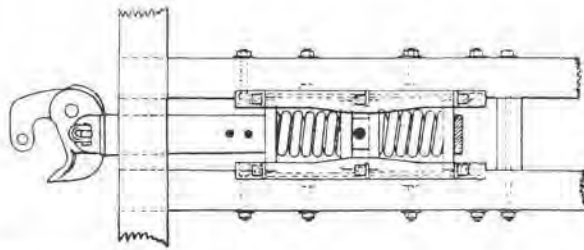


FIGURE 5.44

This drawing shows a Miner tandem-mounted, two-spring draft gear designed for 60,000-pound and 80,000 pound cars with wooden sills. [*Railroad Digest*, July 1901]

"ricochet effect" did not create much of a problem during the era of short trains and manual brakes. However, as trains became longer, the railroads experienced an increasing problem with trains breaking in two, with the culprit being the draft gear, which was acknowledged as being the weakest part of the freight car.⁶⁸

One of the first to recognize this problem was George Westinghouse. The problem was that air brakes apply serially, that is, as the engineer makes a reduction, the brakes in the first car apply a split second before the brakes in the next car, and so on throughout the train. The result is that the slack between the first and second car runs in, the second car bounces back and collides with the third car whose slack has just run in. The result is a series of minor collisions running the length of the train. These "collisions" are not only hard on the cars but their contents as well. Westinghouse first became aware of this problem when a train in England on

THE WESTINGHOUSE FRICTION BUFFER,

MANUFACTURED BY
THE UNION SWITCH AND SIGNAL CO.,
SWISSVALE, PA.,

Is in fact a form of Draft-Gear with a Buffering Resistance ten times greater than in Draft-Gear as usually made and applied. It can be used with any form of Coupler, and on Old or New Cars.

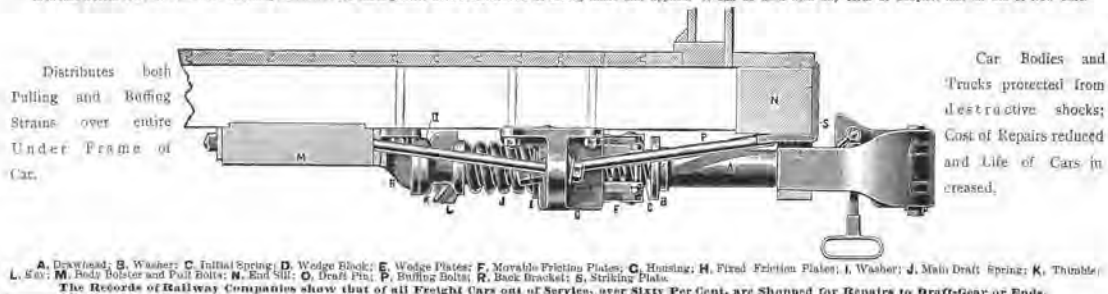


FIGURE 5.45

Westinghouse developed his "Buffering Apparatus" in response to the extreme buffeting caused by the train's slack action during the application of his air brakes. This 1889 advertisement describes the problem confronting the railroads with their draft mechanisms. [*National Car and Locomotive Builder*, August 1889]



FIGURE 5.46

The Harvey friction draft spring was developed by the Frost Railway Supply Company to dampen spring motion in traditional spring draft gears. Rather than invest in new friction draft gear, railroads could replace the springs in their existing draft gear with these friction springs. [Car Builders' Dictionary, 1912; Courtesy: Simmons-Boardman Publishing Corporation]

which he was demonstrating his air brakes broke in two during a rapid brake application. It was reinforced during the Burlington trials when he observed severe slack action throughout a train during a rapid brake application. This problem could have adversely affected the acceptance of his air brake, and therefore, Westinghouse developed and patented the first friction draft gear, which dampened the spring action much as a shock absorber dampens the spring action in a modern automobile. Although friction draft gears were slow to be

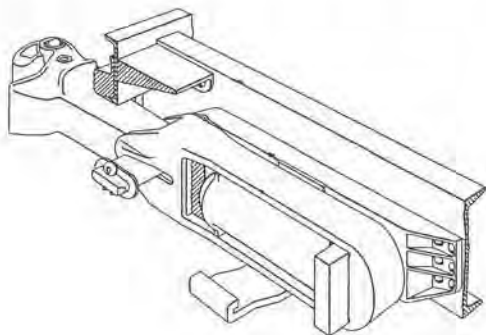


FIGURE 5.47

This drawing shows the Miner A-24-A friction draft gear with cast-steel yoke. [Car Builders' Dictionary, 1912; Courtesy: Simmons-Boardman Publishing Corporation]

accepted, they were fairly well established by the first decade of the 20th century.³⁹ For those railroads that wanted to forestall an investment in friction draft gear, the Frost Railway Supply Company offered Harvey Friction Springs, which could be installed in a conventional spring draft gear to buffer the action.

The railroad associations did not attempt to standardize draft gears until the late 1920s, but it did begin standardizing some of their components in 1905, including setting a standard distance between the draft sills of 12⁷/₈ inches. In the late 1920s, the American Railway Association conducted a series of trials on draft gears and developed specifications for such attributes as capacity, endurance, sturdiness, uniformity of action, freedom from sticking, dimensions, and travel. Using these specifications, it developed an approved list of draft gears for use in interchange service and required that all cars built after January 1, 1934, or rebuilt after August 1, 1937, be equipped with draft gears meeting those specifications.⁴⁰ Cars built before that date were granted a reprieve when the association grandfathered existing draft gears, allowing them to be used until they wore out or became unserviceable.⁴¹

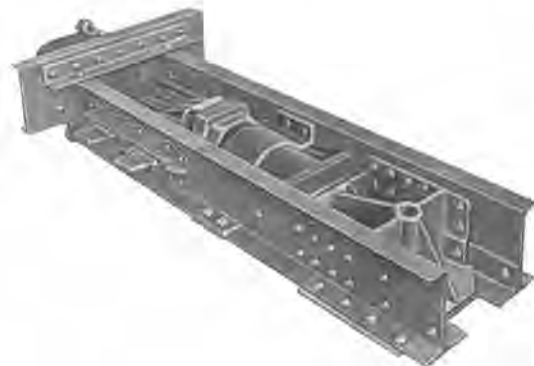


FIGURE 5.48

Symington offered the Farlow Two-Key draft attachment for friction draft gears. It is shown here with a Sessions friction draft gear. [Car Builders' Dictionary and Cyclopedia, 1919; Courtesy: Simmons-Boardman Publishing Corporation]

Despite technical advances in draft gear, railroad cars and their lading continued to suffer damage from rough handling in yards and trains. While the lading in coal cars was not often subject to damage, the fact that coal cars were usually loaded to their full capacity meant that the cars themselves were prone to damage in rough handling.

In the mid-1920s, the O.C. Duryea Corporation introduced its Cushioned Underframe as a way to protect cars and their lading from such damage. The cushioned underframe was designed with a floating center sill that was allowed to travel within limits imposed by cushion gear located at each end of the car. By floating the center sill, Duryea's engineers were able to increase the travel distance available to absorb impacts, thus decreasing damage to the car and its contents.⁹²

A number of railroads installed cushioned underframes under their coal cars from the mid-1920s through the late 1940s. As cushioned underframes became popular, an increasing number of manufacturers introduced versions of their own. However, as coal cars became more durable, fewer railroads installed cushioned underframes under them, though the cushioned underframe remained a popular item under cars with more expensive lading and in cabooses.⁹³

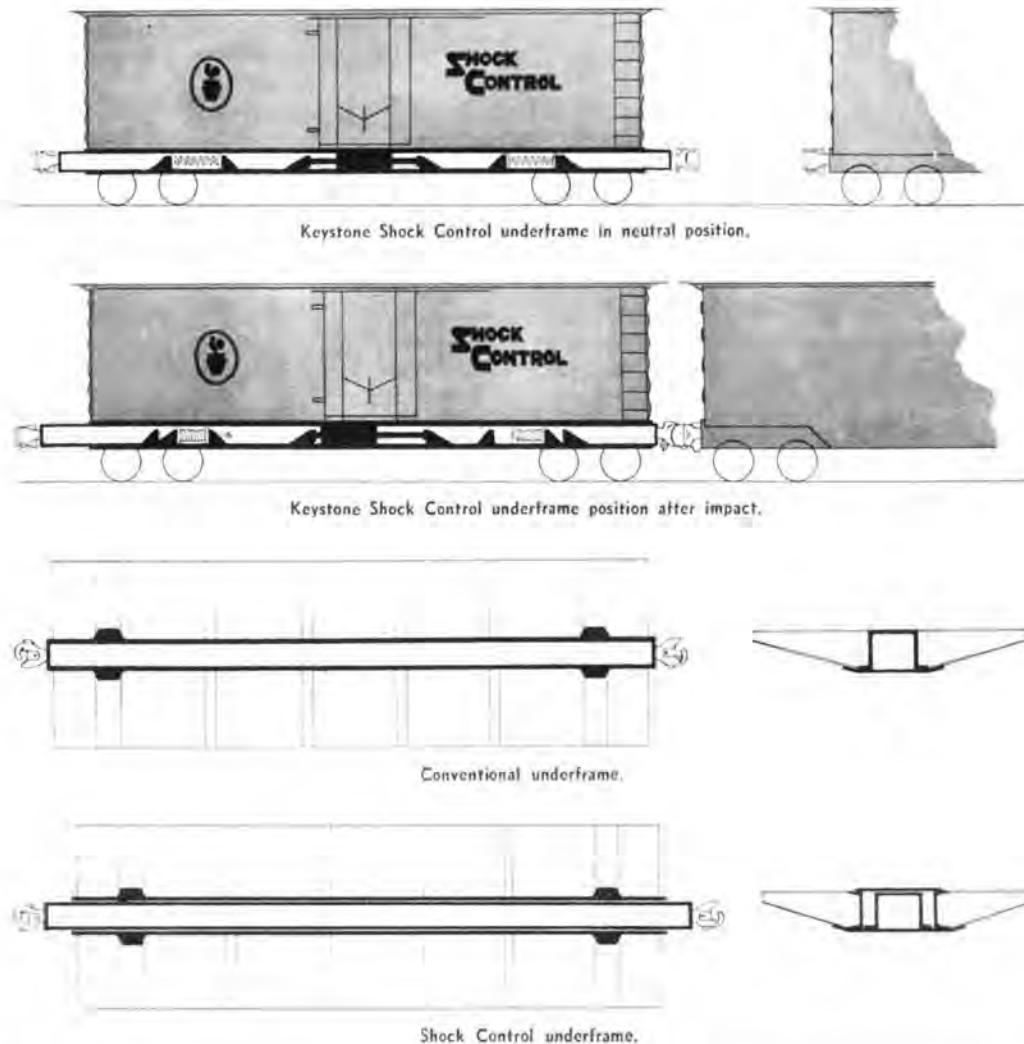


FIGURE 5.49

The concept of the cushioned underframe is shown here in this 1960 drawing from the Keystone Railway Equipment Company. The center sill is not rigidly attached to the car frame but is allowed to travel longitudinally within limits provided by cushion gear located at each end of the car. By allowing the center sill to travel, the designers were able to increase the distance over which buffing action occurred during impact. The cushioned underframe thus provided greater cushioning to the lading and car structure during rough handling.⁹⁴ An end view of a Baltimore & Ohio hopper equipped with a Duryea Cushioned Underframe can be seen in Figures 4.19 and 4.20. [Car Builders' Cyclopaedia, 1961; Courtesy: Simmons-Boardman Publishing Corporation]



FIGURE 8.127

RDG 87994 was one of 4,000 hopper cars in Reading's 86000 to 89999 series. This car was built in May 1913 and was seen here in May 1944. The car had an inside length of 32' 10", inside width of 9' 6", height to eaves of 10' 3⁷/₈", and capacity of 1,843 cubic feet. The series was rated at a capacity of 110,000 pounds. The noticeable feature of this car is the rolled-steel-channel side sill used to help support the extra length of the car. The side construction duplicates that used on the early Standard Steel cars. Another picture of a car in this series is shown Figure 8.1 next to a 19th century jimmy. There were over 3,950 of these cars still in service in 1938. [Paul B. Dunn Photo, Courtesy: John C. LaRue Jr. Collection]

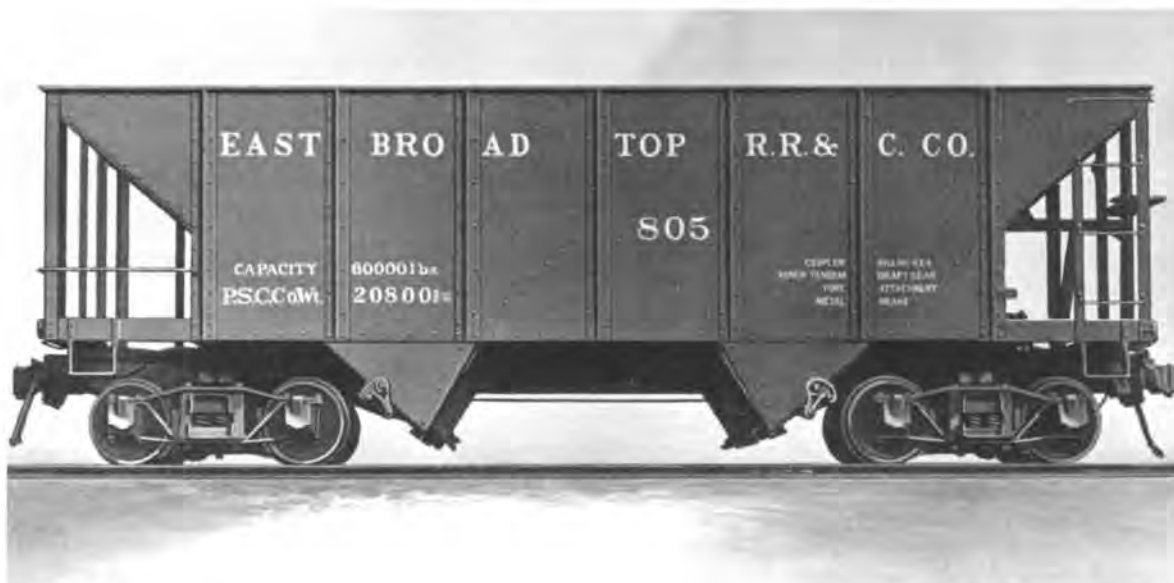


FIGURE 8.128

The East Broad Top was the first narrow gauge railroad to purchase all-steel hopper cars. In 1912, the railroad ordered ten all-steel hopper cars from the Pressed Steel Car Company. They had an inside length of 25' 7", inside width of 7' 6", and height to eaves of 8' 6". The cars had a capacity of 848 cubic feet, level full, and 1,008 cubic feet, heaped. They were equipped with Lind door-operating gear, as shown here. [Pressed Steel Car Company Photo; Courtesy: D.K. Retterer Collection]



FIGURE 8.129

In 1913, the East Broad Top ordered another thirty twin-hopper cars from the Pressed Steel Car Company. These cars were built somewhat longer than the car shown in Figure 8.128 in order to lower the center of gravity, which had been somewhat problematic in the first design. From 1914 through 1919, the railroad built 210 cars based upon the revised design in its Orbisonia shops. The next 180 cars, built from 1915 through 1919, had three hoppers. Those hoppers bays were initially equipped with twin, horizontally-mounted drop doors, but they were ultimately converted to a sawtooth design with vertically-suspended doors. The cars had a capacity of 70,000 pounds.¹⁴ They are shown here equipped with K-series brakes and Wine door locks. This car is riding on Vulcan T-section trucks with 4 1/4" x 8" journals. [Photographed at the East Broad Top Railroad, Orbisonia, Pennsylvania]



FIGURE 8.130

In order to increase their capacity, the railroad added extensions to the sides and ends of some of its cars, as shown in this photograph. With this addition, the nominal capacity was increased to 80,000 pounds. [Photographed at the East Broad Top Railroad, Orbisonia, Pennsylvania]



FIGURE 8.217

The Nashville, Chicago & St. Louis had four series of A.A.R. Standard 50-ton cars—HM17, numbered 47500 to 47999; HM14, numbered 48100 to 48299; HM15, numbered 48300 to 48499; and HM16, numbered 48500 to 48799. All were built by the Pressed Steel Car Company. This is the builder's photo for the last series. The cars were of standard design with a height to eaves of 10' 8" and a capacity of 2,145 cubic feet. Note the Wine door locks and Universal power hand brake. The car is also equipped with rolled-steel-angle end posts that extend all the way up the end sheet to the end rail. [Courtesy: Jay Williams Collection]



FIGURE 8.218

NC&StL 47917 was built in May 1949 as part of that railroad's HM17 series. This series was equipped with Enterprise door locks instead of the Wine door locks seen in the H16 series above. This photo was taken in 1961. [Paul B. Dunn Photo; Courtesy: Richard J. Burg Collection]



FIGURE 8.238

P&LE 4133 was one of 1,000 cars in Pittsburgh & Lake Erie's 4000 to 4999 series. Like the New York Central car in Figure 8.237, it had an inside length of 31' 6", inside width of 10' 4" and height to eaves of 11' 0". However, this car was listed as having a capacity of 2,210 cubic feet. Note how the side stakes in this car are more evenly spaced than in the New York Central car. This car was built in September 1948. This photograph was taken in the early 1960s. [Paul B. Dunn Photo; Courtesy: Richard J. Burg Collection]



FIGURE 8.239

The New York Central was among the first railroads to begin removing the offset sides from its cars during heavy repairs. NYC 86654 began life in 1940 as an offset-side car of the same design as the P&LE car in Figure 8.238. Beginning in the early 1950s, the railroad began removing the offset sides on its oldest cars and replacing them with this lightweight, flat-sided design with external, riveted side posts. This changed the inside length from 31' 6" to 31' 5", and it changed the inside width from 10' 4" to 10' 0". The result was a car with a capacity of 2,160 cubic feet, fifty cubic feet less than the offset-side design. By the mid-1960s, all but a few thousand of its offset-side cars had either been retired or converted to cars of this design. The railroad also purchased 2,500 of these cars new in 1953. [Courtesy: Jay Williams Collection]



FIGURE 8.242

Delaware, Lackawanna & Western car number 85177 was one of 500 cars in the series numbered 85000 to 85499 that was featured in an article in the April 4, 1940 issue of *Railway Age*. These cars were built to a lightweight design by American Car & Foundry employing Cor-Ten steel. The result of the use of this high-tensile-strength, low-alloy steel was a car with a light weight of 38,400 pounds and a revenue load ratio of 77.34%. The cars had an inside length of 34' 0", inside width of 10' 1", height to eaves of 10' 8", and capacity of 2,151 cubic feet. The cars must not have stood up well on the railroad. By 1954, 55 cars were already out of service. As presented in the *Railway Age* article, the car had five side sheets butt-jointed together with Enterprise end side sheets. As seen here in 1959, the car had four side sheets with lap joints and Wine end side sheets. [Courtesy: Bob's Photo]



FIGURE 8.243

Central of Georgia car number 21660 was built in October 1936. It had an inside length of 34' 0", inside width of 10' 1", and height to eaves of 10' 8", producing a capacity of 2,180 cubic feet. It was one of 200 cars in this series, numbered 21500 to 21699. [Paul B. Dunn Photo; Courtesy: Richard J. Burg Collection]

con, nickel, and phosphorus.

Buffer: An elastic apparatus or cushion attached to the end of a car to receive and absorb the shocks caused by other cars running against it.

Buffer Beam: A short timber bolted to the face of the end sill, usually protected with a striking plate against which the shoulder on the head of the drawbar strikes when the draft gear springs are closed solid. Its function is to protect the end sill from damage and to act as a distance block to keep the cars a sufficient distance apart to allow a man to step between them. Frequently called a deadwood or dead block.

Buffer Blocks: Two blocks of wood or iron attached to the end sill or buffer beam of a freight car, in contradistinction to buffer beam, which is a single block in the middle of the end sill, although the latter is sometimes designated as a single dead block. Buffer blocks are sometime called Deadwood or Dead Blocks.

Bulb Angle: A structural form with a cross section in the shape of a right angle with one end enlarged to reinforce the structure. 

Capacity: The nominal load in pounds or gallons which the car is designed to carry.

Carline: Framing members which extend across the top of a car from one side to the other and support the roof.

Center Bearing: The place in the center of a truck where the weight of the body rests. A body center plate attached to the car body rests on a truck center plate attached to the truck. The general term center bearing is used to designate the whole arrangement and the functions it performs.

Center Pin: A large bolt which passes through the center plates on the body bolster and truck bolster. The truck turns about the bolt but the stress is taken up by the center plates. Sometimes referred to as the "king bolt."

Center Plate: One of a pair of plates made of cast or malleable iron or pressed or cast steel which fit one onto the other and which support the car body on the trucks, allowing them to turn freely under the car. The center pin or king bolt passes through both, but does not really serve as a pivot.

Center Sill: The central longitudinal member of the underframe of a car, which forms, as it were, the backbone of the underframe and transmits most of the buffing shocks from one end of the car to the other.

Center Sill Top Cover Plate: The peaked portion of a hopper car floor running longitudinally that covers the center sill. Also **Longitudinal Cover**.

Channel or Channel Bar: An iron or steel form with a cross-section taking the shape of a channel or the letter U. Also "U-Section." 

Chord: The long horizontal members of the top and bottom of a truss. The side sills and plates of a car body

are top and bottom chords of the side trusses.

Colliery: The entire mining operation including all the buildings, the rail plant, and the loading equipment.

Corner Brace or Corner Plate: A pressed-steel angle plate or knee on the outside corner to strengthen and protect the frame. There are three types of corner plates—upper, lower, and middle. A push pole pocket was commonly combined with lower corner plate.

Corner Post: The vertical member which forms the corner of the frame of a car body.

Coupler: The device by which the connection of one car to another is maintained and conversely by which cars can be disconnected.

Coupler Horn: The projecting lug cast on top of the coupler head which bears on the striker plate when the draft gear is fully compressed.

Coupler Shank: That part of a coupler behind the head which connects to the yoke and draft system.

Cross Beam: A transverse floor member placed upon the sills to support the inclined floor of a coal or ore car.

Cross Bearer: A transverse member of the underframe placed between the bolsters acting as a tie between the various sills and helping to distribute the weight of the car.

Cross Ridge: The lateral peaked portion of a hopper car floor that separates one hopper from another.

Cross Ridge Brace: A brace that extends from the peak of the cross ridge to the side of the car to prevent the sides from bulging and to support the cross-ridge. Also referred to as a Diagonal Brace. Replaces the term Hopper Support.

Culm: The waste product from anthracite mining including slate, shale, low-grade coal, and unmarketable sizes of coal.

Dead Block: A single wooden block or stick of timber attached to the end sill of freight cars to protect persons between the cars from injury, by preventing the cars from coming together in case the drawbar or its attachment should give way.

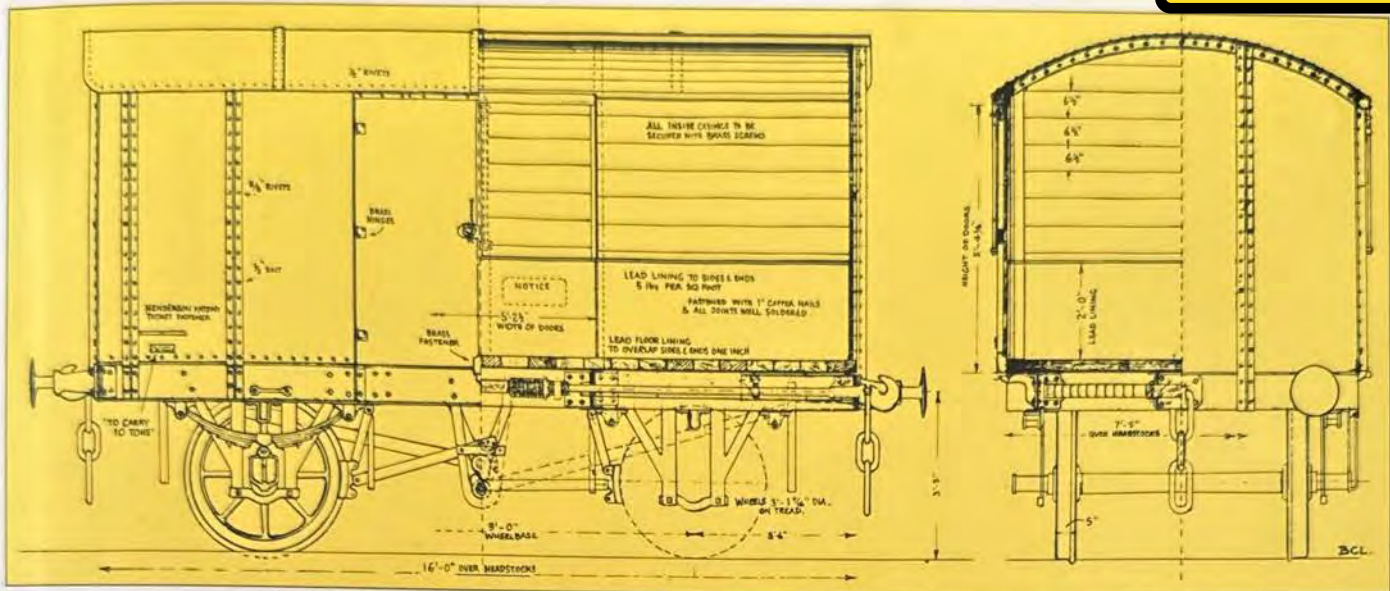
Diamond Arch Bar Truck: The type of freight car truck which was in practically universal use from the time of the first attempts at standardization until the end of the 19th century. Known first as the Diamond Truck, then the Diamond Arch Bar Truck, and finally the Arch Bar Truck.

Draft Gear: The mechanism that connects the coupler with the car sills. The energy absorbing component of the draft system.

Draft Gear Pocket: The space in the draft sill that contains the energy absorbing components of the draft system.

Draft System: The term used to describe the arrangement on a car for transmitting coupler forces to the center sill. On standard cars, the draft system includes the

Exhibit 8



LANCASHIRE & YORKSHIRE WAGONS

VOLUME TWO



NOEL COATES

LANCASHIRE & YORKSHIRE WAGONS

VOLUME TWO

BY
NOEL COATES



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Plate 157. The vast majority of merchandise went by open wagon (often sheeted over to keep out the elements) and this view of a Dia. 1 single planker is typical, except that the wagon looks so clean. The paint date on the solebar says 2/16 and the photograph is dated 16th March 1916 which explains why; this older style narrow side rail vehicle had received new headstocks (and oil axleboxes probably) during the recent general repair, some 20 years after building. The wagon also features in the bottom right-hand corner of Vol. 1, Plate 112.

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PREFACE

A large number of people were kind enough to express their thoughts and pleasantries with regard to Volume 1 of the goods wagons of the L&Y, and it became clear that the format used in that work had gained the approval of many. This has actually made the job of completing Volume 2 that bit harder, for the remainder of the stock to be dealt with was of such varied character that the length of explanation required was far greater, and so has taken more time. One decision which has had to be made is the numbering of the

plates and figures. In the end, I have opted for a consecutive system so that there is no confusion between volumes; thus, the photograph adjacent to this Preface is *Plate 157*, and the next figure is *Fig. 85*. I hope this is clear for all, and will make the volumes easier to use together. Some changes to placing wagon diagrams in the various sections have been adopted in the light of discoveries made, but in all other instances the objectives of the work remain the same.

IMPORTANT DATES & KEY TO FLOW DIAGRAMS

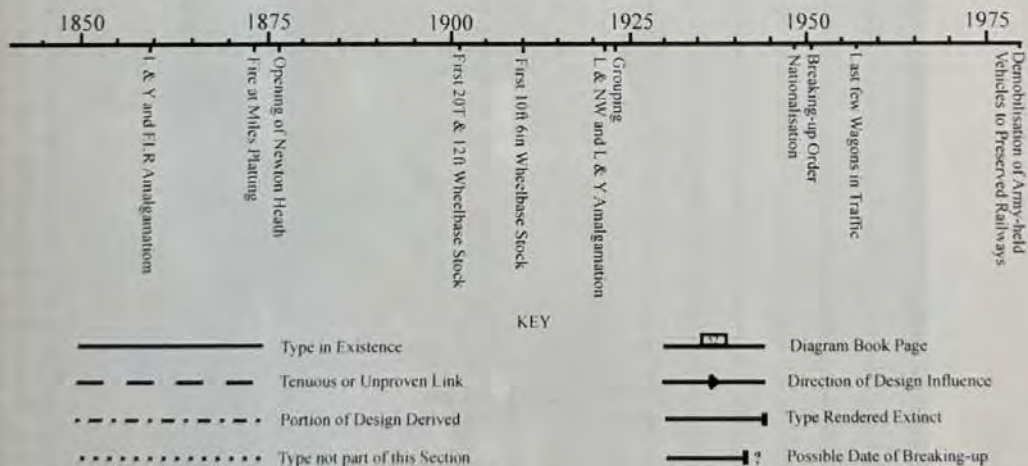


Fig. 85. Explanation of the Flow Diagram (see also Vol. 1, p. 103).

HOPPER WAGONS

The reintroduction of hopper wagons came about owing to the development of electric train services, commencing with the Liverpool & Southport line, introduced in 1904. The L & Y had to generate the required electricity supply itself, and to do this there had to be a constant supply of coal. When the first power station was planned at Formby, the question of how best to handle the coal was answered in the form of gravity feed.

When plans were taken a stage further, there may well have been a few of the old 1880s hopper wagons still in service to aid the design process, though of course they were far too small to be used themselves. From the beginning, the new standard wagon size of 21ft by 8ft was considered, both in traditional wood and all-metal (bodies and underframes). Going purely off the drawing numbers, it seems that the design of an all-steel hopper wagon had already been created, but the first order (S35) was placed a year before the vehicles came out in mid-1904, and it may be that the design was still being developed long after having been assigned a drawing number.

Formby Power Station was in use by the end of 1903, and it is likely that the first coal was supplied using the 20T vehicles from Order Y34 (the large order for Horwich-based vehicles fitted with bottom doors, but no top doors). Someone must have wondered whether a wooden hopper wagon was feasible (it would probably have been cheaper), and Drawing No. 5240 (Fig. 123), shows clearly that the 1902 design of nine planks with one central drop flap was the basis, even though the side door was largely superfluous on a hopper wagon; Drawing 5240, completed around September 1903, is effectively Drawing 616 (Fig. 110) extended in all directions. Other features proposed included two brake shoes per wheel, and a vacuum cylinder shoe-

horned between the bottom doors and a stub brake lever. There certainly wasn't as much space for coal as a standard 20T wagon, and the drawing is strangely silent about intended capacity (which calculates to about 550 cubic feet), but unloading would have been easier. The design was so inferior to what was required that the all-steel vehicle, which matched the standard dimensions and carried 20T, was the one built.

There was already some experience within Britain of steel-sided vehicles: the North Eastern had its ironstone wagons, the L & NWR its West Cumberland hoppers, whilst the L & SWR had bought some 12T ballast wagons from Hurst Nelson (Motherwell) in 1898, whose general style fitted the L & Y needs quite well. Within the company itself, there were the skills gained by the use of metal in the construction of rectangular tank wagons, well wagons and tramcar trolleys (see Sections G or I, Part (i)), and there was also the experience gained from the trips to America by up-and-coming managers and designers. Aspinall had also been involved in some experiments in Ireland in 1883.

Drawing No. 5123 was the basis for the first order of 45 wagons, S35 (details in Table 37), and again nothing quite like it had been seen on the L & Y before. The body was constructed of ¼in steel plate, shoehorned into a frame comprising 9in by 3½in by ½in channel solebars and cross members, the latter set 2ft 9in in from the headstocks. The body braced the underframe (and vice versa), whilst the wheels and brake gear were squeezed within the remaining space around the hopper doors; these were in pairs, set in a 'V' shape, and formed an opening 4ft 9½in long by 2ft 9in wide. Such was the premium on space that the vacuum cylinder and reservoir had to be mounted on the end of one platform, and the pipe ran along the top of the solebar on the

TABLE 37: STEEL HOPPER WAGONS

Dia Book Page	Order Book Description	Date Ordered	Order No.	Qty	Drwg No.	Account Charge	Cost £ s d	Delivery	Capacity cu ft	Tare T C Q	Notes
54	Steel Hopper Coal Wagons	25 Jun 03	S35	45	5123†	Capital	121 9 7	1904	684	8 11 3	Known numbers 30785 - 30813.
"	Steel Hopper Wagons 20T	Late 1904	F37	40	5783	"	117 10 5	1906	Some 809	various	16 wagons of this order 8ft 6in high, rest 9ft 3in high ‡
"	Steel Hopper Wagons 20T. Steel Frames. Vacuum Brake: 21ft x 8ft 9ft 3in high	27 Oct 06	G40	5	5783	Renew.	120 5 0	1907	809	8 14 0	
"	20T Steel Hopper Coal Wagons. 9ft 3in high from rails	23 Oct 07	N42	20	5783	Renew.	104 1 9	1908	"	"	
"	Steel Hopper Coal Wagons. 20T. 9ft 3in high above rail. 21ft long x 8ft wide	7 Aug 16	O54	22	5783	Renew.	294 13 5	1918/19	"	"	11 wagons built in each year

Notes

† The other drawings listed are: 5212 Ironwork, 5213 Cast Iron work, 5214 Brake, 5216 Buffer cases, 5272 Chains for doors, 5278 Scheme for doors.

5279 Protecting cross shaft (which takes them well past the Wooden Hopper wagon GA No. 5240).

‡ The distribution of vehicles is given as: Horwich 6 at 9ft 3in high and 10 at 8ft 6in high; Newton Heath 18 at 9ft 3in high; and Formby 6 at 8ft 6in high.

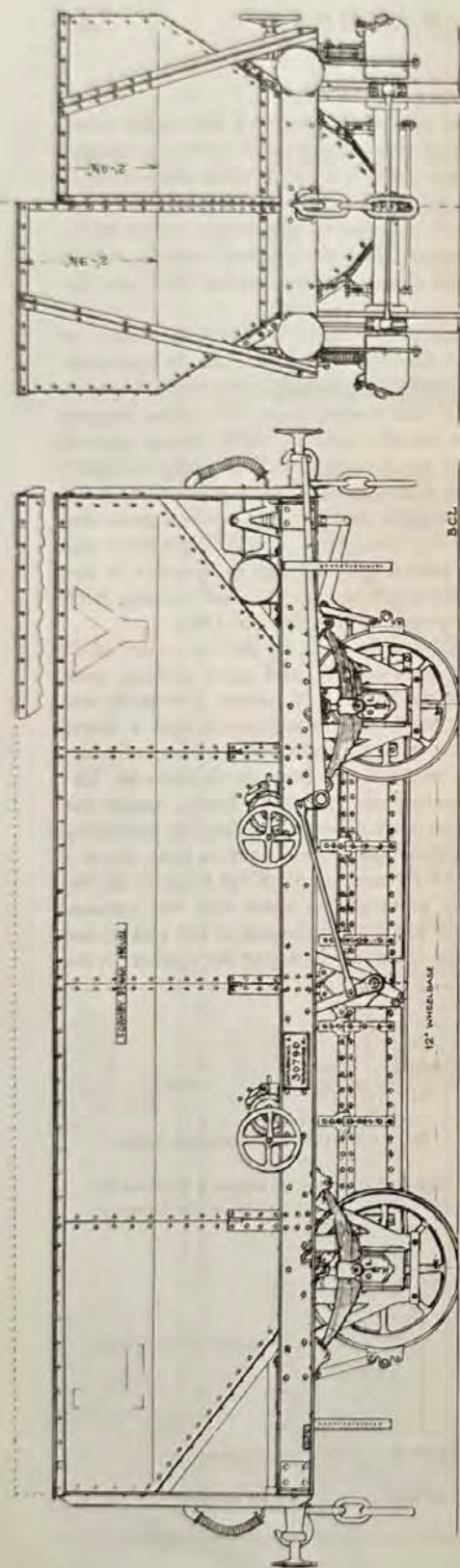


Fig. 124: The Dia. 54 all-steel Hopper wagon redrawn from Drawing No. 5123 as originally built with sides ending 8ft 6in above the rail and vacuum pipes supported by standards with vacuum reservoir and diaphragm on the right-hand end. Hand wheels are for operation of the hopper doors. The 9ft 3in high sides (from Drawing 5783) are shown dotted above and in full as the left part of the end view. Drawn by B. C. Lane.

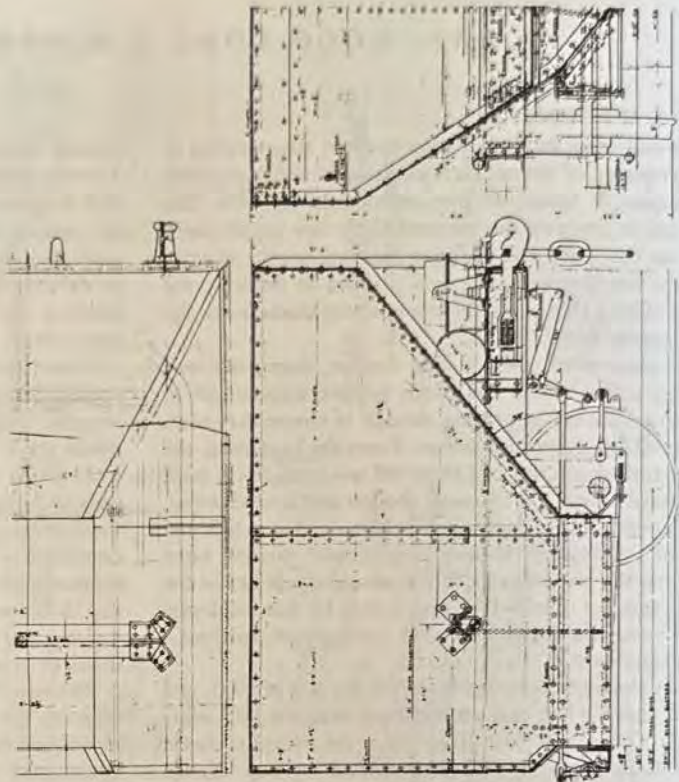


Fig. 125: The internal arrangements culled from Drawing 5123, dated 17th September 1903.



Plate 205. The official photograph of wagon No. 30813 as built and painted in June 1904. The undergear had been left grey for photographic purposes. The triangular fillets supporting the angled sides show up well.

opposite side of the wagon to the hand-wheels which controlled the opening of the bottom doors. The vertical sides were only 2ft 0¾in high, and the capacity came to 684 cubic feet (cf. that of an early 20T coal wagon at 780 cubic feet), and the designers were perhaps a little optimistic about the expected 20-ton carrying capacity. The drawing is very difficult to follow, so Fig. 124 is a tidied up composite of the two general arrangement drawings showing the two different heights and is, hopefully, much easier to follow. Plates 205 & 206 show the wagons as built, and illustrate just how complex the steelwork was, especially when viewed from inside (Fig. 125). A new Diagram Book page, No. 54, was

created for these vehicles, which received the standard livery and lettering from the very start. One idea borrowed from the brake vans and the new loco coal wagons was an allocation plate, which is further evidence that the L & Y kept these vehicles away from general revenue service, and dedicated to particular tasks.

The usefulness of these new wagons was soon realised, and a second order contained two extra allocations, Horwich and Newton Heath. A further development was the increase in height, so the wagon then stood 9ft 3in above rail level. The extra nine inches added to the side raised the capacity to 809 cu ft, and was done to prevent spillage of the load, as the

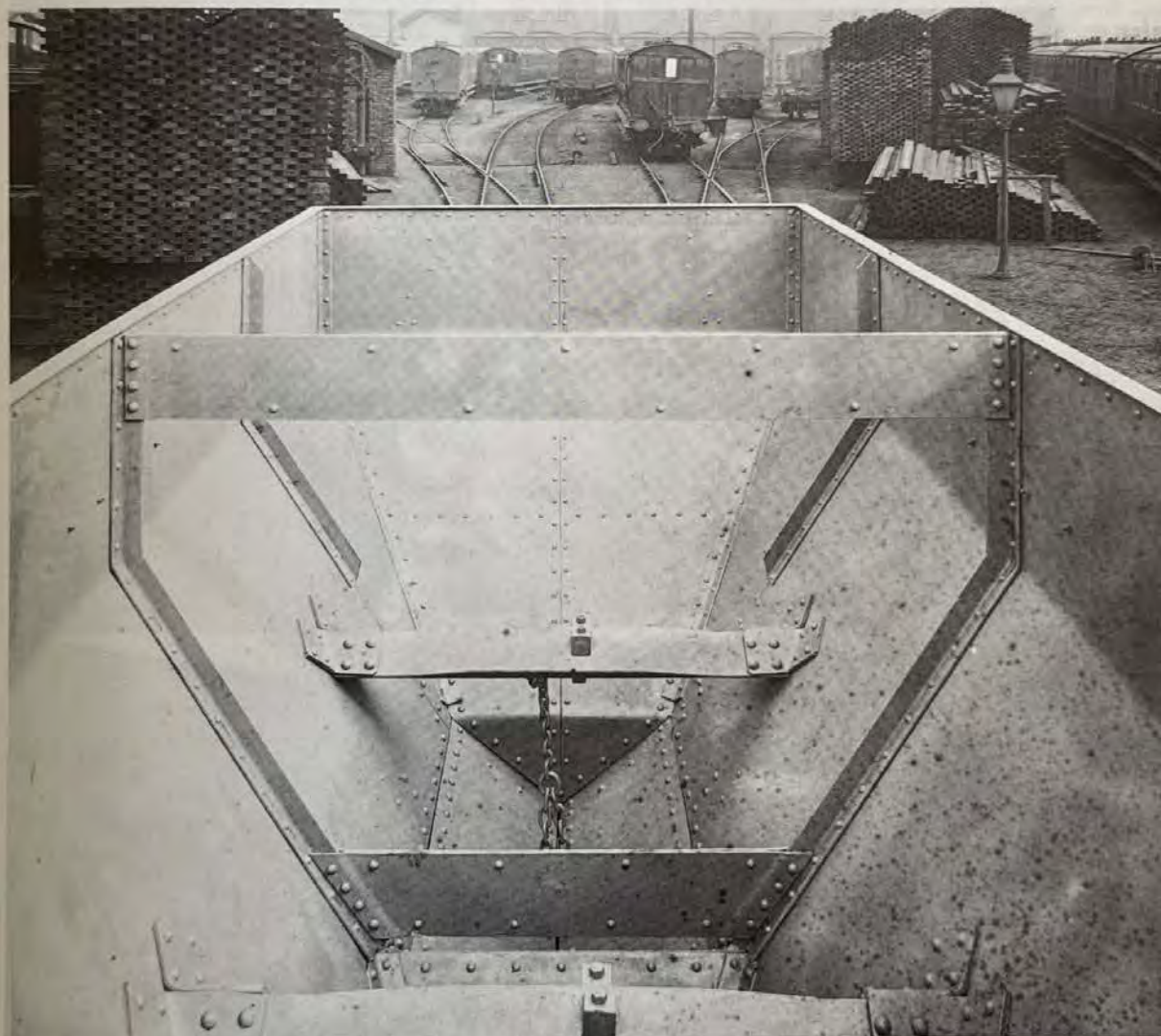


Plate 206. Thankfully, the L&Y saw fit to have the inside of one of the steel hopper wagons photographed when new. The complex system of bracing and covers for the hand-wheel rods controlling the bottom doors show up well. One presumes the poor photographer was balancing his half-plate camera atop a ladder propped against the end of the wagon and probably didn't notice the delights in the background!

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20T rating was retained. The next two orders, G40 and N42, possibly cover the replacement of the old 10T wooden hopper wagons of the 1880s, whilst the final 22 would seem to have been for the forthcoming Manchester & Bury electrification, though they didn't make it in time and some 'Formby' wagons were re-designated 'Clifton Power Station' (Plate 207).

Modifications at Formby increased the height available for wagons, and this made it possible to standardise on the higher size of side. Some wagons were definitely rebuilt (Plate 208), and there is evidence for the interim measure of adding plating to increase the height of the side (Plate 209). Nos. 30785, 30794 and a wagon from the 3080x group were all 9ft 3in in later life, but come from the first order; it is quite likely that the entire fleet of 132 wagons finished up at the full height (Plate 210).

The subsequent history of the wagons is very difficult to follow. Clifton Power Station was closed in 1933, which

probably meant that some of the oldest were broken up soon afterwards. Formby Power House ceased operation in 1946, so more wagons should have been scrapped, yet the Diagram Book has the familiar note 'Breaking up 1951', which suggests that some wagons were still around then (some only 30 years old). One guess is that they could have been diverted to ballast train duty; whilst they weren't absolutely perfect, they would have done the job (some of the expertise developed whilst building these wagons definitely went into permanent way vehicles, as the centre- and side-dumping wagons of Diagrams 78 & 79 show – see Section H). The only post-grouping photograph known shows part of one of the Horwich wagons around 1937 in wagon grey, with the 18in letters 'L M S', a rusting panel where the allocation plate had been, and that legend written in white above (Plate 212); perhaps these wagons were too modern for most photographers, and ended their days virtually unnoticed.



Plate 207. A posed shot at Clifton Junction Power Station in September 1919 with S35 Order wagon No. 30790 still lower height but redesigned for 'Clifton Power Station'. The wagon tared at only 7.19.1 and had a lovely repair on the nearest corner. Fully laden, its buffers seem dangerously lower than those of battery electric loco No. 2.
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Plate 208. The low light against Dia. 54 rebuild No. 30794 shows up the bottom doors and how the vacuum pipe ran along the top of the solebar. Strangely, the first allocation was always termed 'Formby Power House'.

COLLECTION
R. J. ESSERY





Left: Plate 209. Inside the unloading bay at Clifton in early 1915 with the far wagon showing the evidence of additional plating to raise the height of the side. Discharge was direct into the 50T capacity bunkers for each engine eliminating coal handling. Right: Plate 210. Ultimately all the Dia. 54 steel hopper wagons appeared like this. A May 1921 picture of revamped wagon No. 30785 with higher sides, vacuum standard turned down below the headstock, heavier duty buffers and flat-face axlebox covers. The loops attached to the solebar for rope/capstan haulage show up well.

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Plate 211. Early LMS days and 0-8-0 No. 12719 waits for a road with a load of coal for Formby. The neat heaps seem to have been of quite low-grade 'slack'.

AUTHOR'S COLLECTION

Plate 212. The only known post-grouping photograph of a Dia. 54 wagon taken at Horwich in May 1938. The sides of the vehicle were rusting and the only portion of the legend which can be deciphered reads 'TO LOAD TO LMS HORWICH WORKS' above the standard 18in letter 'M'. The wagon number plate reveals only '16080x' but the tare was '8 16 2'.

AUTHOR'S COLLECTION

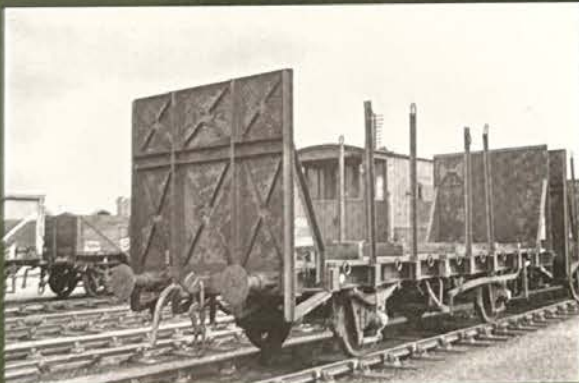
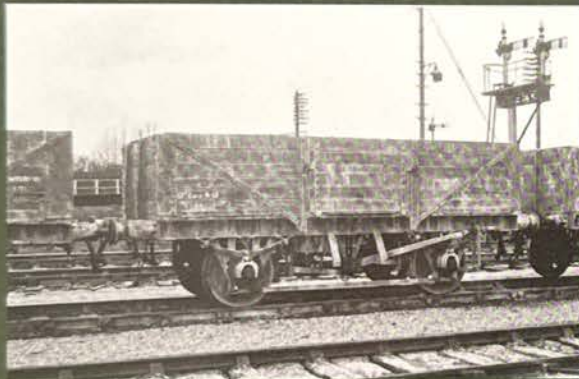


Exhibit 9

WAGONS OF THE FINAL YEARS OF BRITISH RAILWAYS

£10

A Pictorial Study of the 1962-1968 Period



David Larkin

WAGONS OF THE FINAL BRITISH RAILWAYS ERA

A Pictorial Study of the 1962 to 1968 Period

David Larkin

WAGONS OF THE FINAL BRITISH RAILWAYS ERA

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Front cover (top left): China clay Highfit number W144021 at Par Docks in May 1970. (Author's Ref No W2554/DL)

Front cover (top right): An official view of SEAG van number B730476. (Author's Ref No W50111/BR)

Front cover (bottom left): 15T timber number B455555 at Lowestoft in September 1969. (Author's Ref No W1671/DL)

Front cover (bottom right): An official view of Shochood B wagon number B726266. (Author's Ref No W50095/BR)

Back cover (top left): An official view of Conflat ISO wagon number B511000. (Author's Ref No W50195/BR)

Back cover (top right): Calcium carbide wagon number B870616. (Eric Gent)

Back cover (bottom left): 16T Mineral VB number B582417 in stone traffic, at Peak Forest in August 1973. (Author's Ref No W4395/DL)

Back cover (bottom right): B923325 at Scunthorpe in August 1969. (Author's Ref No W1695/DL)

Wagon and Diagram Number Series

Wagon Number Series (Traditional Fleet)

Most trends have been recorded in the first two volumes in this series. What remains to be noted are the final additions to what will be referred to as the "traditional fleet", by which is meant the non-air-braked fleet (to be covered in detail in the next volume). Traditional fleet numbers were issued well into the 1970s for rebuilt vehicles (beyond the period of this volume) and are recorded here.

B596000 to B596393	16T mineral wagons, rebodied vehicles on 10ft 0in wheelbase with vacuum-braked chassis
B310000 to B314999	21T mineral VB wagons.
B315000 to B317599	21T mineral NF wagons, rebodied vehicles on various chassis.
B290000 to B290485	25 tonne mineral wagons, rebodied vehicles on various chassis (not all built).
B340000 to B340924	25 tonne hopper VB wagons, rebodied vehicles on various chassis (not all built).
B345000 to B346468	25 tonne hopper NF wagons, rebodied vehicles on various chassis (not all built).
B350000 to B355796	26T/32T hopper AB wagons, "merry-go-round" wagons, B-prefix dropped after this and continued in "air-braked" series.
B455500 to B455579	15T timber wagons.
B510000 to B510049,	Container wagons.
B511000 to B511023	
B601000 to B601493,	Container wagons, Freightliner flat wagons, B-prefix dropped after this, and continued in
B601999 to B602947	"air-braked" series.
B710250 to B710255,	Experimental wagons.
B738489	
B745000 to B745999	Car-carrying wagons, used for Soda Ash, production ceasing after B745986.
(with gaps) and B745500	
to B745579	
B748000 to B748799	Car-carrying wagons, production ceasing after B748793.
(with gaps)	
B870500 to B871999	Covered hopper wagons, production ceasing at B870879.
B873000 to B874999	Covered hopper wagons, production ceasing at B874186.
B885000 to B885999	Bulk grain hopper wagons, production ceasing at B885709.
B886000 to B886999	Covered hopper wagons, virtually completed.
B922000 to B926999	30T bogie bolster wagons, production ceasing after B924899.
B927000 to B929999	42T bogie bolster wagons, production ceasing after B928199.
B946000 to B946999	50T bogie bolster wagons, production ceasing after B946229.
B947000 to B948999	Bogie plate wagons, production ceasing after B948409.
B949000 to B949999	Steel coil wagons, many gaps, production ceasing after B949608.
B950000 to B959999	Brake vans, production ceasing after B955247.
B960000 to B964999	Miscellaneous types, only use B960000 to B960023 (Coil X conversions) and B964000 to B964121 (diesel brake tenders)
DB965000 to DB999999	Non-revenue-earning stock (to be covered in full in later books in this series).

WAGONS OF THE FINAL BRITISH RAILWAYS ERA

24½T Mineral and Coal Hopper Wagons

The 24½T Mineral wagons continued to be built until late 1962. All were accredited diagram 1/118 vehicles and had 1ft 8½in Oleo hydraulic buffers and roller bearings.

The 24½T Hopper wagons were built in larger numbers, until early 1965, and there were far more variations. Lots 3315 and 3425 were to diagram 1/153 with clasp-type disc vacuum-brakes, Oleo hydraulic buffers and roller bearings; bauxite livery was applied to these. Lots 3426 and 3437 were unfitted. Self-contained buffers were originally fitted to lot 3426 (diagram 1/154) and Oleo hydraulic buffers were originally fitted to lot 3437 (diagram 1/148); all had roller bearings. Lots 3466, 3525 and 3526 (diagram 1/155) were also unfitted, with Oleo hydraulic buffers and roller bearings. Lot 3466 were grey livery; lot 3525 were delivered in freight brown with post-1964 lettering; lot 3526 had freight brown lettering panels, but were given a quick Rail Grey overpaint, which faded badly.

B282995 – B283129	24½T MIN (Diagram 1/118)	7/1962 – 9/1962	3388	BR Shildon
B283130 – B283394	24½T MIN (Diagram 1/118)	1/1962 – 4/1962	3427	BR Ashford
B335595 – B335694	24½T HOP (Diagram 1/153)	7/1961 – 5/1962	3315	BR Shildon
B336235 – B336384	24½T HOP (Diagram 1/153)	7/1962 – 9/1962	3425	BR Shildon
B336385 – B336932	24½T HOP (Diagram 1/154)	2/1962 – 6/1962	3426	BR Shildon
B336933 – B337175	24½T HOP (Diagram 1/148)	9/1962 – 11/1962	3437	BR Shildon
B337176 – B337753	24½T HOP (Diagram 1/155)	3/1963 – 7/1963	3466	BR Shildon
B337754 – B338162	24½T HOP (Diagram 1/155)	11/1964 – 2/1965	3525	Pressed Steel Ltd
B338163 – B338262	24½T HOP (Diagram 1/155)	10/1964 – 12/1964	3526	BR Shildon

Allocation details for the Minerals, as far as is known, was as follows:

B282995 to B283129 LOAD ONLY TO SHEEPBRIDGE IRON & STEEL WORKS
 B283296 to B283298, B283303-47/52/5 LOAD ONLY TO JOHN SUMMERS & SONS, Ltd., HAWARDEN BRIDGE, SHOTWICK SIDING, LMR (GC)
 B283130-5/7-52/4/6-61/6-77/80-5/7/9/90 EMPTY TO BANNOCKBURN COLLIERY ScR. LOAD ONLY TO S.S.E.B. POWER STATIONS
 B283136/53/5/63-5/78/9/86/96/8, B283200/2/3/5/11/2/6-23/5/8/31 EMPTY TO WESTFIELD OPENCASE CENTRE ScR. LOAD ONLY TO S.S.E.B. POWER STATIONS
 B283162/88/91-5/7/9, B283201/4/6-10/3/24/6/30 EMPTY TO DALKEITH PREPARATION PLANT ScR. LOAD ONLY TO S.S.E.B. POWER STATIONS
 B283227/9/32-47/9-76/8-81 EMPTY TO NEW MONCKTON COLLIERY NER. LOAD ONLY TO SKELTON GRANGE POWER STATION POWER STATION
 B283248/77/82-95/9, B283300-2 EMPTY TO SOUTH KIRKBY COLLIERY NER. LOAD ONLY TO SKELTON GRANGE POWER STATION POWER STATION
 B283348-51/3/4/6-94 EMPTY TO BANNOCKBURN, WESTFIELD OR DALKEITH SCOTTISH REGION. TO BE LOADED ONLY TO S.S.E.B. POWER STATIONS

Allocation details for the Hoppers, as far as is known, was as follows:

B336385 – B337175 LOAD ONLY TO THORPE MARSH POWER STATION (YORKS.) N.E.R.
 B335595 – B335694, B336235 – B336384 SOUTHERN REGION FOR RICHBOROUGH POWER STATION TRAFFIC

There were no conversions on these vehicles, but both types featured in the rebodging programme and will be dealt with again in the next volume.

THE 1962-1968 PERIOD

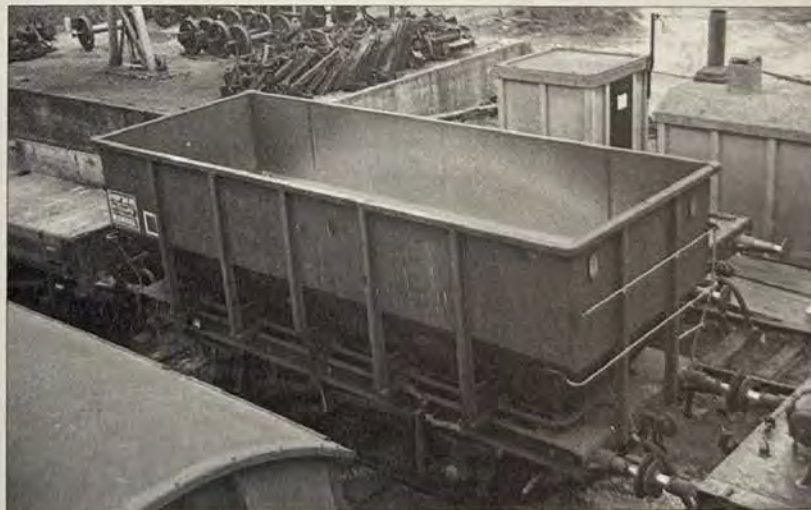
B283063 at Westhouses, Derbyshire in March 1972. This diagram 1/118 wagon has been reallocated, and is now lettered LOAD ONLY TO C.E.G.B. KEADBY POWER STN. G. C. Unusually, it has none of the capacity identification aids mentioned on page 4. Tare weight: 10ton 6cwt. (Author's Ref No W4043/DL)



B283370N at Brynnliw Colliery, South Wales in February 1972. This diagram 1/118 wagon has received the post-1964 lettering style, and has both the capacity identification aids mentioned on page 4. The tare weight seems incorrect if it is 18ton 1cwt or 8ton 1cwt, so actual tare weight is uncertain. (Author's Ref No W3224/DL)



B336320L at Tonbridge, Kent in February 1974. The vacuum pipe of the diagram 1/153 variant can be seen in this high-angle view. The livery is freight brown with correct codes and capacity identification "L" number suffix. It is not known whether there was a yellow triangle. Tare weight: 10ton 6cwt. (Author's Ref No W4460/DL)



WAGONS OF THE FINAL BRITISH RAILWAYS ERA



B336756N at Alloa, Scotland in November 1976. This lot 3426 wagon is in virtually original condition, albeit very weathered. It carries the original lettering panel for THORPE MARSH, and has received an "N" number suffix and the yellow triangle. Tare weight: 10ton 12cwt. (Author's Ref No W5997/DL)



B337235 at Hoo Junction, Rochester in December 1968. This lot 3466 wagon is in such a rusty condition it is difficult to work out the livery. It should be grey and does not appear to have ever been repainted. Tare weight: 10ton 14cwt. (Author's Ref No W1081/DL)



B338121 at Mansfield, Notts in 1970. This lot 3525 wagon is in original condition, including the yellow triangle. Although unfitted, freight brown livery was applied as per the specification when the wagons were ordered from Pressed Steel Ltd. Tare weight: 10ton 15cwt. (Courtesy Eric Gent)

THE 1962-1968 PERIOD

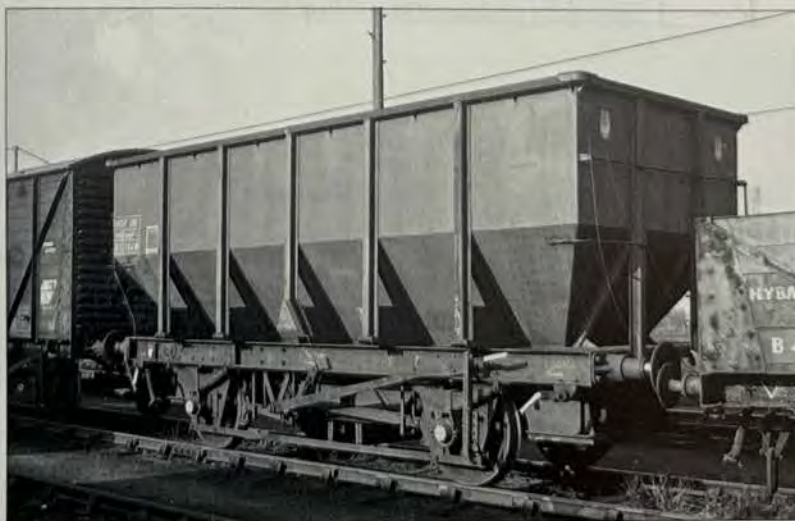
*B337542 at Rochester, Kent in March 1975. This lot 3466 wagon is in rusty grey livery. The capacity identification symbols have now been dropped, due to the introduction of TOPS, and the tare is metric (not legible). Unusually, the lettering is not boxed.
(Author's Ref No W5115/DL)*



*B337640N at Alloa, Scotland in August 1970. This lot 3466 wagon appears to have been repainted freight brown, although it is unfitted. The "N" capacity identification has been added as has the yellow triangle. The number 5 in the box is believed to be some sort of block train identity. Tare weight: 10ton 12cwt.
(Author's Ref No W2921/DL)*



*B337849N at Hoo Junction, Rochester in March 1969. This is another lot 3525 vehicle in as-delivered freight brown condition, but this one has the "N" suffix as well as the yellow triangle. Tare weight: 10ton 10cwt.
(Author's Ref No W2236/DL)*



WAGONS OF THE FINAL BRITISH RAILWAYS ERA

Air-braked Coal Hopper Wagons (Merry-go-round)

British Railways had stuck rigidly to using the vacuum-brake in preference to the Westinghouse-pattern air-brake from 1948. The only vehicles not to have it were those few intended for use on the Dover and Harwich train ferries to Europe, and even these were generally through-piped only.

This changed forever in 1964 with the introduction of air-braked coal hopper wagons. These were actually designed for the National Coal Board by French designers, and were insisted upon over any objections by BR. In this volume, only the batches built during the review period will be noted, together with one early variation, as this class will feature prominently in future volumes.

The basic vehicle was rated at 26T capacity. The second prototype, and others listed below, had what were termed top canopies, and were rated at 32T. During the review period, individual wagons could be seen in use as oil train barrier wagons, and photographs exist of steam locomotives hauling them in coal traffic in the North East and Scotland. The batches built were as follows:

B350000 – B350001	26T AB HOP (Diagram 1/156)	4/1946 – 12/1964	3495	BR Darlington
B350002 – B351681	26T AB HOP (Diagram 1/156)	3/1965 – 6/1966	3528	BR Shildon
B351682 – B351841	26T AB HOP (Diagram 1/156)	9/1965 – 3/1966	3558	BR Ashford
B351842 – B351880	26T AB HOP (Diagram 1/156)	6/1966 – 10/1966	3528	BR Shildon
B351881 – B352693	26T AB HOP (Diagram 1/156)	10/1966 – 7/1967	3574	BR Shildon
B352694 – B352740	26T AB HOP (Diagram 1/156)	8/1967 – 11/1967	3575	BR Shildon
B352741 – B352746	32T AB HOP (Diagram 1/157)	1/1968 – 2/1968	3645	BR Shildon
B352747 – B354246	26T AB HOP (Diagram 1/156)	9/1967 – 11/1968	3646	BR Shildon
B354247 – B354296	26T AB HOP (Diagram 1/156)	10/1968 – 11/1968	3647	BR Shildon
B354297 – B355044	26T AB HOP (Diagram 1/156)	11/1968 – 8/1969	3670	BR Shildon
B355045 – B355344	36T AB HOP (Diagram 1/156)	8/1969 – 12/1969	3688	BR Shildon
B355345 – B355396	26T AB HOP (Diagram 1/156)	7/1969 – 8/1969	3670	BR Shildon
B355397 – B355796	26T AB HOP (Diagram 1/156)	12/1969 – 8/1970	3699	BR Shildon

The above list has gone into 1970; after this, wagons were given numbers without prefixes under the air-braked scheme. In addition to the 32T capacity lot 3645 batch, the following were also of this variation:

B350001, B350941/63/87, B351010/56/63/77/9/94/6, B351112/3/5/7-9/21/3/4/7/8/31/43/7/56/67/8/71/5/83/5/90/6, B351217/24/5/8/35/9, B351509/32/40/50/6/60/2-4/83/93, B351601/17/38/63/8/78, B351848/56/7/67/70, B352330, B352694/6/8, B352702-12/5/6/8/23-5/7/8/30-3/6-8/40, B353518, B354124, B354247/8/50/4/5/8/9/62-7/9/71/4/5/7/8/80-3/5-7/9/92/4-6, B354420/82, B355144/55



An official view of B350001. This is the second prototype, built to diagram 1/157 and coded HOP 32 AB. Tare weight: 11ton 4cwt. (Author's Ref No W50069/BR)

THE 1962-1968 PERIOD

B350693 at Hoo Junction, Rochester in March 1969. Because railtanks with air brakes were being delivered from 1996, many of these vehicles were seconded to other duties. This example is lettered OIL TRAIN BARRIER WAGON RETURN TO THAMESHAVEN/GRAYS E. R., but in fact it is in use with BP Isle of Grain traffic. Tare weight: 13ton 8cwt. (Author's Ref No W1048/DL)



B351678 at Aylesbury, Bucks in March 1970. This HOP 32 AB also appears to be in oil train barrier traffic, although not especially lettered. It is not known where this variant operated in the review period, but they could subsequently be found in Scotland. The tare weight is not legible. (Author's Ref No W2315/DL)



B354050 at Hoo Junction, Rochester in October 1969. This HOP AB was about a year old when photographed. The side panels were unpainted, and the framing was freight brown. All lettering was black, as was the underframe. Tare weight: 13ton 7cwt. (Author's Ref No W1863/DL)

