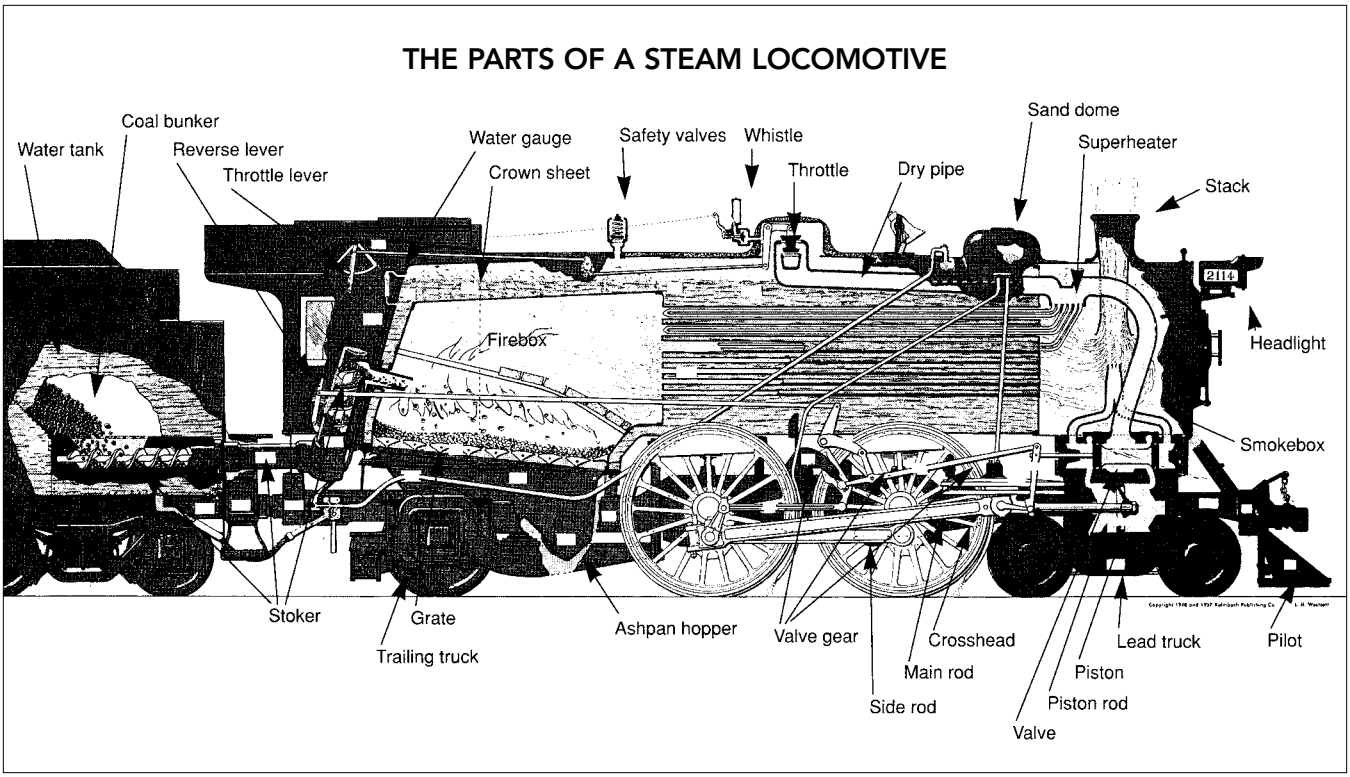
Contents

CHAPTER TWO

Prototype steam locomotives

A Pennsylvania Railroad class K4s Pacific (4-6-2) leads the *Liberty Limited* away from Inglewood Station (Chicago) in February 1940. The Pacific was the most common passenger locomotive of the 1900s, and the Pennsy's K4s (with more than 400 built from 1914 to 1928) was among the most-famous of the type. *Harold Stirton collection*

Steam locomotives ruled North American railroads from the early days of railroading through the 1940s. Even though they've been gone from revenue service for more than 60 years, steam engines remain favorites among modelers for many reasons. These powerful machines provide an impressive show while moving, with the rhythmic motion of valve gear and side rods along with visible and audible chuffs to show how hard they're working. Steam locomotives were built for specific duties and applications, meaning each railroad's engines had a distinct appearance and character.



This cutaway drawing shows the basic components of a steam locomotive. This is a coal-fired 4-4-2 with a mechanical stoker.

Models of steam engines, like their prototypes, are fascinating to watch. And, with the tremendous growth in Digital Command Control, sound effects make steam models even more appealing.

Understanding how prototype steam locomotives work, how they evolved, and knowing what kinds of locomotives were used in various types of service will help you better determine which model steam engines are appropriate for your layout. It will also help you to better model them in terms of details, operations, and weathering—all subjects we'll examine more thoroughly in Chapter 3.

How steam locomotives work

The cutaway drawing above shows the basic components of a steam locomotive and illustrates how they work. Follow along with the diagram as we trace the basic construction and operation of a steam engine.

The locomotive rests on several sets of wheels, with small wheels at the front and rear (the lead and trailing trucks) and the large driving wheels ("drivers") in the middle. The number of wheels and their size varies among locomotives based on power and the type of service.

A long, horizontal boiler holds water, which is heated by a fire in a firebox. A series of flues or tubes run through the boiler between the firebox and the smokebox (at the front of the locomotive), providing more surface area for heating the water.

The drawing shows a coal-fired locomotive, the most common type. In the firebox, a brick arch extends from the bottom front above the fire itself, improving combustion and ensuring that the draft doesn't draw the fire and fuel directly out of the firebox through the flues. The burning coal rests on a grate at the base of the firebox; the ashpan or ashpan hopper below it catches ashes as the coal burns.

Coal engines can be hand-fired, meaning the fireman physically scoops coal from the tender through the firebox door into the firebox. Larger and more modern locomotives had mechanical stokers that carried coal from the tender under the cab floor or deck and up into the firebox. The drawing shows a common auger-style stoker.

Many locomotives—especially on southwestern railroads where oil refineries were nearer than coalfields—burned fuel oil instead of coal. Oil burners relied on jets to atomize the fuel into a spray for burning within the firebox. The fuel was thick—much thicker than common (no. 2) fuel oil today—typically Bunker C (or no. 6 fuel oil). It required preheating (via steam) to flow properly, and the tender tank was slightly pressurized.

The firebox on an oil burner lacked a grate and ashpan. For the fireman, maintaining the fire meant adjusting valves to control the oil flow. Other than that, the basic locomotive operations were the same.

The top surface of the firebox is called the "crown sheet." The water level in the boiler must be kept high enough to cover the crown sheet at all times, or the extreme heat of the firebox will cause the steel sheet to weaken and fail. This leads to a boiler explosion—probably the most-feared danger of steam locomotives.

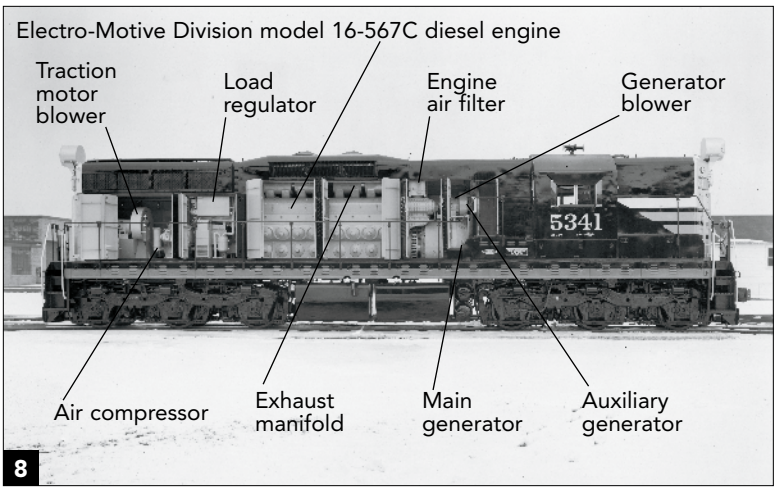
As the water boils, steam is collected at the top of the boiler in the steam dome. There, a lever from the throttle opens and closes a valve atop the dry pipe, which allows steam to pass to a valve above the cylinders on each side

6

Electro-Motive Division E units, such as Florida East Coast E3 no. 1001, had full-width carbodies. Early Es had long, slanted noses compared to F units and late Es. *William L. Wedemeyer*

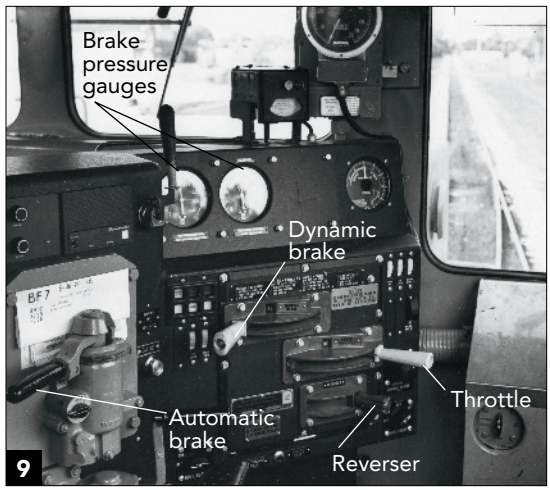
7

Independent Locomotive Service GP9 no. 1334, a General Motors Diesel Division (Canada) GP9, illustrates the road switcher body, featuring a narrow hood with side walkways.



8

Ever wonder what's behind the hood doors on a diesel locomotive? This photo reveals the internal components of Southern Pacific SD9 no. 5341. *Trains magazine collection*



9

Control features vary among locomotives, but this control stand on an EMD GP40-2 is typical of most diesels. *Ernest L. Novak*

moved from left to right. Most diesels have nine notches (idle and 1 through 8); notching the control up increases engine RPMs, which increases power. If you look closely, you'll see that the throttle handle has its flat surfaces oriented horizontally. That makes it easier to distinguish by feel the throttle handle from that of the dynamic brake, which has the flat surfaces positioned vertically.

The uppermost lever is the dynamic brake, which is moved from left to right. It locks in two positions, off (as shown in the photo) and set up. It moves through the rest of its range, 1 through 8. Dynamic braking turns the traction motors into generators, providing resistance to turning that serves as braking power. Dynamic braking is primarily used for controlling train speeds on descending grades.

The reverser handle is located below the throttle and has three positions: left, center, and right. When the handle is moved right, the locomotive is set up to move forward. Moving the handle left sets the locomotive up to move in reverse. If the reverser is centered, the dynamic brake handle can't move because of a mechanical interlocking. Though the throttle will still move, power isn't sent to the traction motors.

Two additional brake systems are used. The automatic brake applies and releases the train brakes by removing air from (or adding air to) the train line, the system of pipes and air hoses that run the length of the train. This action triggers control valves on each car to apply or release the brake shoes, which apply pressure on the wheels.

The independent brake, below the automatic brake, operates the locomotive's brakes separate from the train.

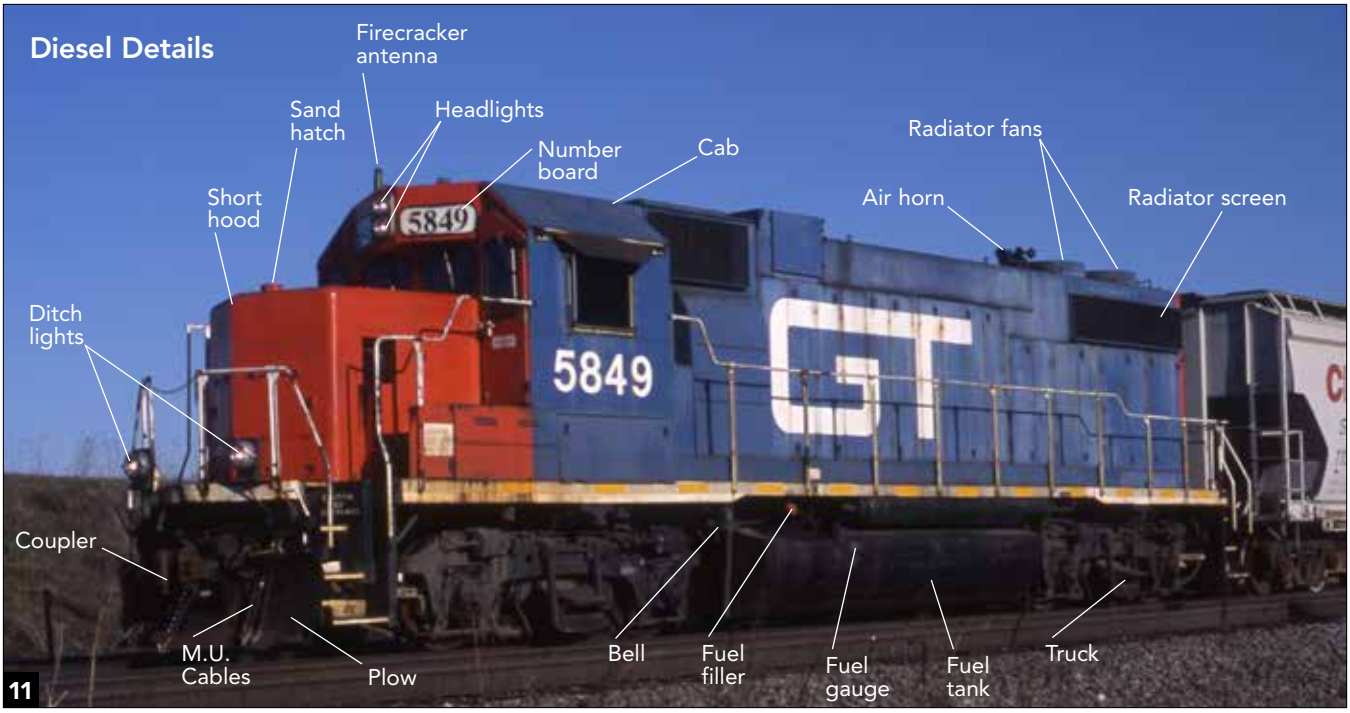
What's on the outside?

Unlike steam locomotives, diesel locomotives are fairly standardized with common parts and built in assembly-line fashion, meaning an SW1500 on the Wisconsin Central is going to look fairly similar to one on the BNSF, **10**. To further understand the external parts of a locomotive, look at the Grand Trunk Western GP38-2 in **11**.

Where the variations come into play is on the small details. For example, railroads use headlights in varying styles from multiple manufacturers; some railroads prefer mounting headlights above the cab windows between the number boards, while others like them on the nose. The bell can be under the walkway, on the hood, or on the nose. Air horn styles vary widely from railroad to railroad. Some railroads opt for cab air conditioners or pilot-mounted plows; others do not.

10

These locomotives are both EMD SW1500 switchers. At first glance, other than paint, the two locomotives look the same. However, look closely and you'll see they have different trucks, air horns, and exhaust stack spark arrestors.



11

Grand Trunk Western GP38-2 no. 5849 is a fairly typical example of the more than 2,200 of the four-axle road units that were built by Electro-Motive Division between 1972 and 1986.

Types of locomotives

In the 75-plus years of diesel locomotives, there have been a handful of major manufacturers and a wide variety of locomotives. The major manufacturers include General Motors Electro-Motive Division (and General Motors Diesel Division in Canada), General Electric, Alco, Baldwin Locomotive Works, Lima-Hamilton, and Fairbanks-Morse.

The last Baldwin diesel was built in 1956, and the final Fairbanks-Morse locomotive for the domestic market rolled off the assembly line two years later. Alco quit making locomotives in 1969. General Motors sold EMD to a firm called Electro-Motive Diesel in 2005; five years later, Caterpillar-owned Progress Rail Services purchased Electro-Motive Diesel. Today, GE and EMD are the big two of diesel locomotive manufacturing.

Although there are many subcategories and crossovers, diesel locomotives can be broadly categorized into three basic types: switchers, road freight locomotives, and passenger engines. You'll find each builder's locomotives has a distinctive appearance, and with some practice, you'll be better able to identify them by things such as cab style and shape, hood shape, location and style of details (fans, exhaust stacks, number boards, etc.), and type of trucks.

A note on model designations: Most manufacturers used basic letter designations to indicate a series or type, with numbers indicating either horsepower or successive (newer) models. Some used additional numbers to indicate the number of axles and/or powered axles. A full explanation of the many variations, with photos, can be found in *The Model Railroader's Guide to Diesel Locomotives* (Kalmbach, 2009).

Switchers

Switching locomotives were among the first successful diesels, gaining

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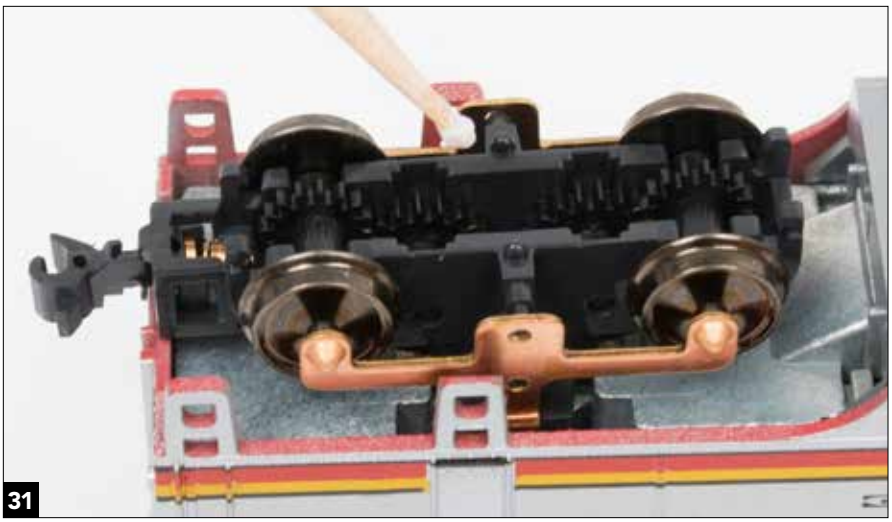
Most manufacturers specify where to apply oil and grease to a locomotive, and how often. Make sure the lubricants you use are plastic compatible.



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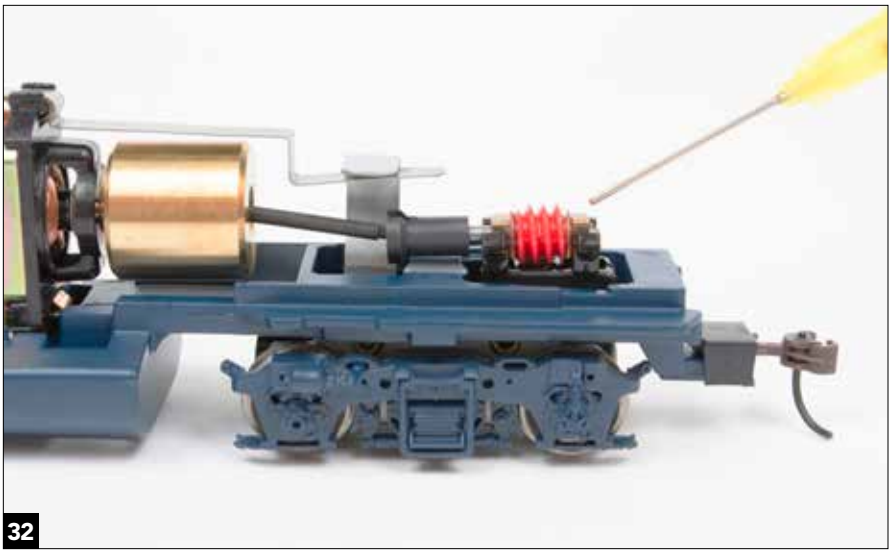
A dot of LaBelle no. 106 light grease is all that's needed to lubricate plastic gears. Regular operating will evenly distribute the grease.



32

Metal bearings on the motor, worms, and axles should be lubricated with light oil. LaBelle no. 108 is a popular brand.

require some patience and care. An advantage is that it gives you flexibility in choosing the specific decoder and features that you want.

Several firms offer decoders for HO and N scales, including Digitrax, ESU, Model Rectifier Corp., NCE, QSI Solutions, SoundTraxx, and Train Control Systems. To learn more about DCC, read Larry Puckett's monthly DCC Corner column in *Model Railroader* magazine and books such as *The DCC Guide, 2nd Edition,* by Don Fiehmann (Kalmbach, 2014).

Keeping locomotives running

Today's locomotives are well built and require little maintenance except for lubrication. But there may be occasions where maintenance or a repair require going under the shell.

Manufacturers use a variety of techniques to hold the shell to the mechanism. If possible, check the manufacturer's instructions (most include an exploded diagram). A tip: Keep all the instruction sheets for your locomotives in a common place (folder or three-ring binder) in your workshop or layout room. Many are also available online. These can be quite complex, especially for sound-equipped models.

In HO scale, you often have to remove the coupler (draft-gear) boxes, **24**. Once that's done, the shell may simply lift off, or you may have to remove a few more screws. The screws are typically located near the trucks, **25**. If the shell doesn't lift off that way, check for tabs on the shell that lock on metal lips or slots on the chassis, **26**.

One word of caution with HO models: Headlight wires attached to the PC board may be secured to the shell, and/or the headlights themselves may be secured to the shell behind clear headlight lenses. To avoid breaking the wires or connections, lift the shell off slowly. In N scale, most shells are a press fit and often can be removed without taking off the couplers, **27**. Be sure not to break or bend any details on the shell when doing this.

With the shell removed, you might need to take one more step, and that's removing the weight, **28**.

This will provide access to the motor, truck towers, and other parts that may require maintenance.

Many new locomotives come from the factory with too much lubrication, **29**. If you encounter this, wipe off the excess oil or grease or oil with a soft cloth. Too much lube will attract dust and dirt, actually causing the locomotive to run poorly.

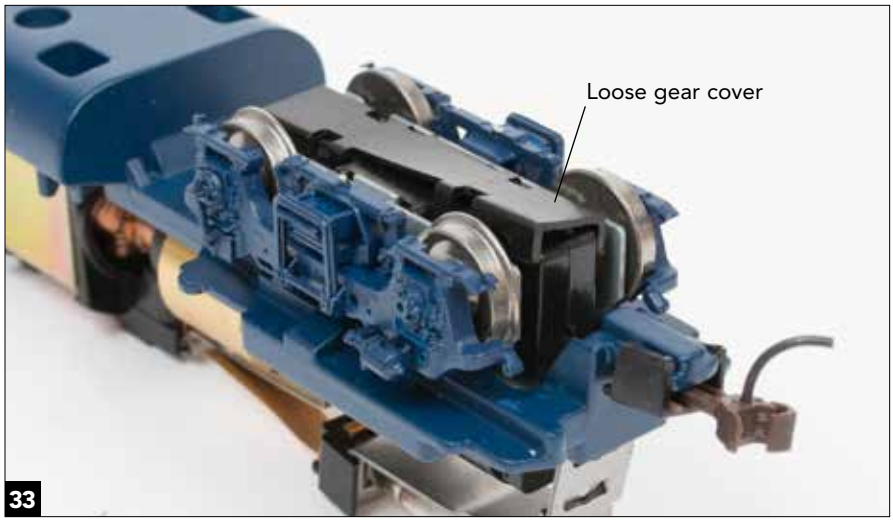
So what areas require oil and grease? That's usually recommended in the paperwork included with the model, **30**. Be sure the oil and grease you apply is plastic compatible. LaBelle no. 106 light grease works well for truck gears, **31**. The same company's no. 108 light oil is suitable for bearings on the motor, worms, and axles, **32**. Remember, a little lubricant goes a long way. A single drop of oil or dot of grease on one gear is all that's necessary. Normal operation will distribute the lubricant evenly.

If you have a locomotive that runs jerkily or makes a lot of noise, check the worm and truck gear covers to make sure they're secured properly, **33**. Also check plastic parts, like truck gears and universal joints, for bits of stray flash (excess plastic from the molding process). Also make sure nothing has gotten in the truck gear housing, like a stray piece of ballast, dirt, or ground foam.

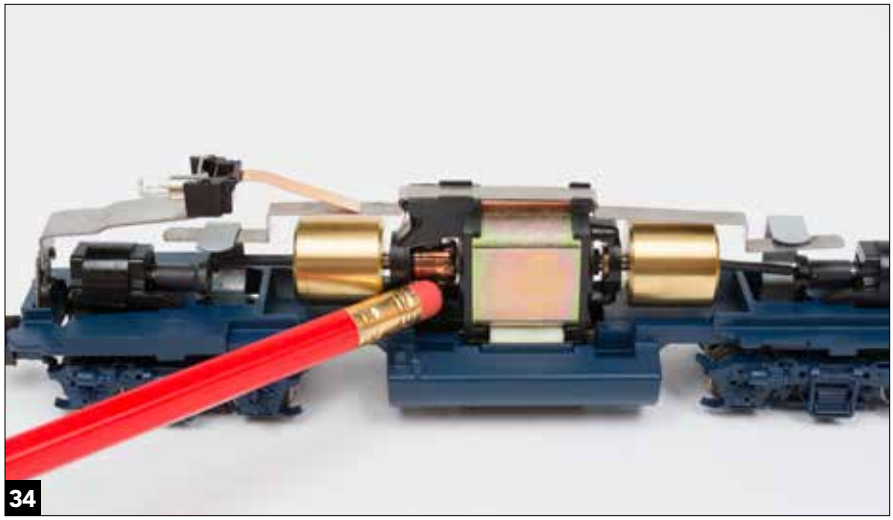
On older models, make sure the commutator and motor brushes are clean. An easy way to clean the commutator is to spin the flywheels by hand and use a pencil eraser to polish the area, **34**. Make sure no residue (rubber bits from the eraser) remains after you do this.

Cleaning wheels

Quite often, a locomotive's poor performance can be chalked up to dirty wheels (and/or dirty track). A quick fix for this is to soak a paper towel with 70 percent isopropyl alcohol and drape it over the rails. Put one truck on the towel, hold the other, and let the locomotive build up some speed. You'll see the grime come off the wheels onto the towel in a few seconds, **35**. Turn the locomotive around and repeat the process. This will work in any scale.



If a locomotive runs erratically, make sure the truck and worm gear covers are securely attached. Also check any plastic parts for flash.

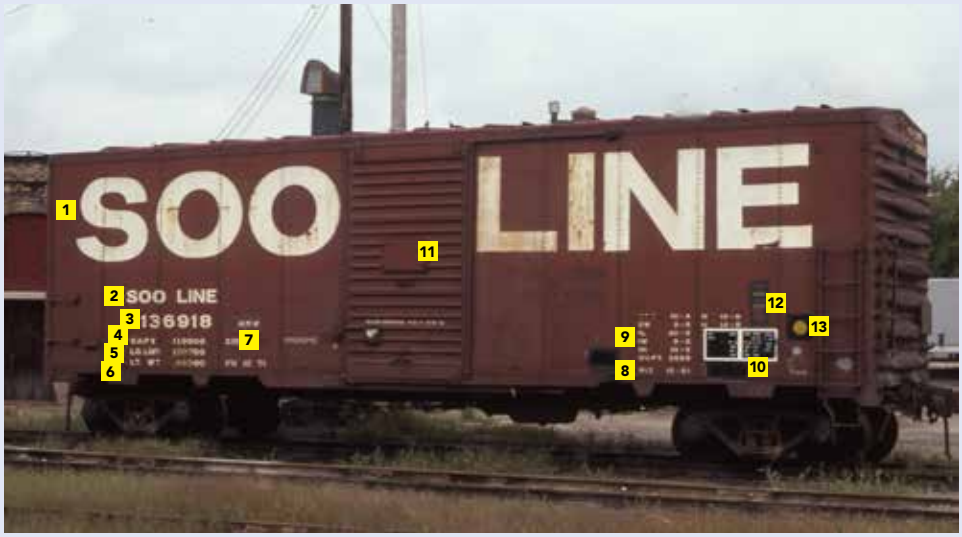


A pencil eraser does a fine job of polishing the commutator on older Athearn diesels. Keep eraser bits from getting in the motor.

Running a locomotive over a paper towel soaked in 70 percent isopropyl alcohol will remove dirt and gunk from the wheels.

Freight car lettering

Freight cars have a variety of lettering. Here is what all of the lettering means on this Soo Line car in 1980.
Jim Hediger



1) Road name and/or herald or slogan. This isn't required.
2) Reporting marks. These are required on all cars. Every owner is assigned its own set of initials (some large railroads have multiple marks, including those of predecessor lines). An "X" at the end means the car is privately owned.
3) Road number. This is also required. Only one car can have this number per reporting mark.
4) Capacity. The car's capacity in pounds. This hasn't been required on new cars since 1985. This line is often painted out on older cars.
5) Load limit. The maximum weight of the load itself.
6) Light weight. The weight of the car when empty.
7) AAR mechanical designation. This car's designation is XM, which indicates a general-service boxcar
8) Built date. The data is now in the consolidated panel.
9) Dimensional data. For boxcars and refrigerator cars, the internal and external dimensions of the car.
10) Consolidated stencil. These date to 1972. The panels document axle and brake maintenance.
11) Tack boards. On some modern cars, they're only on the ends. Some cars have them on the sides, either on the body or the doors. Smaller boards are route boards.
12) Automatic Car Identification (ACI) label. This barcode-style system, used from 1967 to 1977, proved unreliable as grime made labels unreadable. Newer cars (since 1994) have an Automatic Equipment Identification tag, a small box located at the bottom of each car side. Trackside scanners read these non-optical tags.
13) U1 inspection label. In March 1978, all cars were to be inspected for a specific manufacturer's wheel that was linked to several derailments. Cars without the wheels received a 6" yellow dot in a 9" black square. Cars with the wheels in question received white dots.

The USRA 50-ton two-bay hopper was among the earliest mass-produced hoppers, with more than 25,000 constructed. By the late 1920s, hoppers evolved to an offset-side design, with the side steel sheathing outside of vertical posts, with sheathing slanting inward at the top of the sides.

Offset-side hoppers were common from the 1920s to the 1950s, **21**. Two-bay versions of the car had 50- and 55-ton capacities. The three- and four-bay versions were rated at 70 tons.

The shift from loose-car customers, like small-town fuel dealers, local municipal power plants, and small businesses and industries, to large coal-powered electrical utilities during the 1960s and 1970s, had an impact on hopper design. During this time, more than a half dozen car builders were manufacturing 100-ton capacity hoppers, **22**. Many of these cars were used in unit trains (a solid train bound for a single destination).

Widespread use of aluminum-body coal hoppers started in the 1980s and continues today. These cars are owned by major railroads and electric utilities. Although many unit trains have shifted to large gondolas, many hoppers can still be found in coal service.

Gondolas

Gondolas were often used to haul coal in the steam era. Over the years, they've also been called on to haul rock, scrap metal, finished metal products, coil steel, wood chips, and bulky items that don't fit in boxcars.

The two most common categories of gondolas during the steam and early diesel eras were mill and general service. Mill gondolas are at least 50 feet long, with low sides, and they often have drop ends (end doors that fold down into the car), **23**. These cars mainly served steel mills.

General service (GS) cars were shorter and had higher sides, **24**. Many general-service gondolas had drop bottoms to facilitate unloading. They could haul bulky objects or bulk commodities like coal, coke, and sand.

Like boxcars, pre-World War I gondolas featured wood sides and steel bracing. After the war, all-steel gondolas became more common. Following World War II and into the 1950s, typical car lengths were 53 to 65 feet.

Welded gondolas have been around since the 1960s. The design has evolved over the years, with today's straight side-sill 100-ton cars being the most common, **25**.

38

Athearn's HO scale Ready-to-Roll line is an example of a mid-level factory-assembled car. This FMC 4,700-cubic-foot-capacity covered hopper features separately applied details, metal wheelsets, metal running boards, and plastic knuckle couplers.

39

Molco's HO scale Atchison, Topeka & Santa Fe class Bx-94 boxcar has many separately applied detail parts, metal wheelsets, and Kadee knuckle couplers.

40

Some resin kits, such as this Rail Yard Models (now out of production) HO scale Pullman-Standard covered hopper, include plastic and etched-brass detail parts. *Jim Forbes*

41

This Winston-Salem Southbound caboose was built from an American Model Builders HO scale wood kit. Most wood kits don't include trucks or couplers.

42

Using Microscale's Micro Sol and Scotch Magic tape, I was able to remove factory lettering from an Athearn car. This trick may not work on cars from other manufacturers.

43

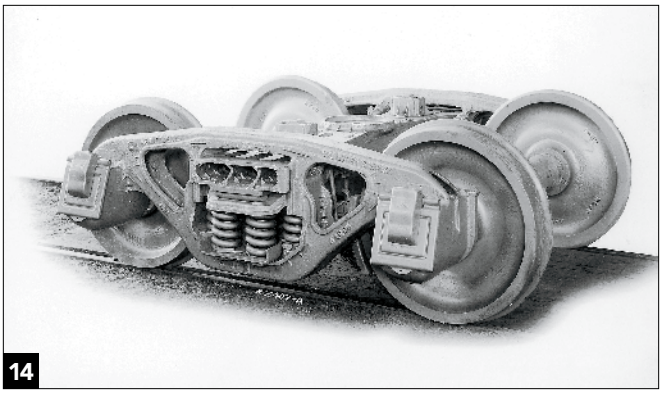
I was able to reletter the reporting marks and number on this covered hopper for the Dakota, Minnesota & Eastern without having to repaint the car.

In a case of what's old is new again, gondolas became the car of choice for coal hauling from the 1980s onward. Rotary dumpers at power plants—together with rotary couplers on coal cars—made it possible to quickly and easily unload gondolas. Like hoppers, most early 100-ton cars featured steel construction, while new cars commonly have aluminum bodies, **26**.

Intermodal equipment

Intermodal means traffic that moves by more than one type of transportation. For railroads, this means truck trailers that also ride on flatcars and containers that can be moved among railcars, truck chassis, and ships. While we often think of intermodal as a modern aspect of railroading, extensive use of trailer-on-flatcar (TOFC) dates back to the 1930s. In early days, most TOFC (piggyback) traffic was handled on existing 40- and 50-foot flatcars, **27**.

As longer trailers were built, longer flatcars were required to accommodate two trailers per flatcar. By 1960, the 89-foot flatcar was standard for this, built by Bethlehem, American Car & Foundry, and Pullman-Standard, **28**. Intermodal containers began appearing



14

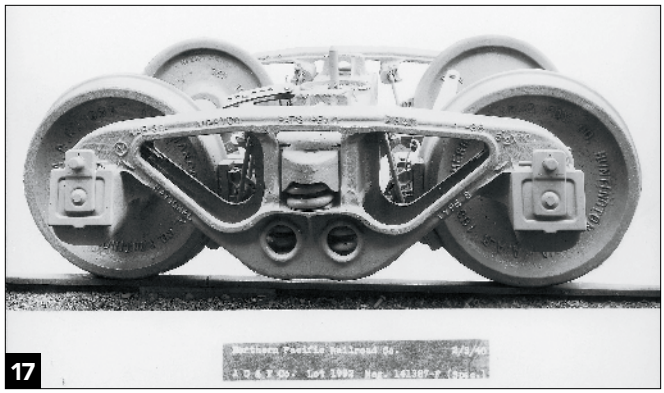
The Dalman truck stood out amongst its contemporaries because it had eight springs (on different levels) instead of the typical five. *Trains magazine collection*

15

The Barber S-2 was a common solid-bearing truck of the late steam and early diesel era. This one was built for the Chicago, Burlington & Quincy.

16

Another product from the World War II era was the American Steel Foundries A-3 Ride Control truck. This was the most popular truck from the end of the war until the end of the solid-bearing era.



17

The National B-1 is a stabilized truck that first appeared in the early 1930s. Two circles at the bottom of the sideframe and stabilizing wedges in the spring package make the truck easy to identify. *Northern Pacific*

was a must, otherwise the bearing would become dry, resulting in a journal-box fire (hence the term "hot box") or a broken axle. Solid-bearing trucks were no longer used on new cars built after 1966; they were banned from interchange in the 1990s.

Roller-bearing trucks

Though we think of roller-bearing trucks in terms of newer cars, they date back to the turn of the 20th century. In the 1930s, roller-bearing trucks were used on passenger cars. However, they were cost-prohibitive to use in large numbers on freight equipment. That started to change in the 1950s and 1960s, when roller-bearing trucks came into widespread use.

Some solid-bearing trucks were converted to roller-bearing trucks, **18**.

Roller-bearing trucks can easily be identified by looking at the end caps on the axle ends, which rotate when the car is in motion. The two leading roller-bearing trucks are the Barber S-2, **19**, and the ASF Ride Control, **20**. The trucks are produced by Standard Car Truck Co. and ASF-Keystone, respectively. If these trucks and manufacturers sound familiar, they should, as both produced trucks during the solid-bearing era.

Other modern trucks not shown here are the National C-1 and ASF Ridemaster. All modern trucks are offered in versions between 70 and 125 tons with an assortment of spring packages.

Caboose trucks

To help provide a smooth ride for crew members, cabooses were equipped with trucks that featured different springing than their freight car counterparts. A typical caboose weighs about half of what a similarly sized freight car does, so elliptical leaf springs could be used in place of coil springs. As with freight car trucks, there were many variations. A few examples include the Barber S-2 with solid bearings, **21**, and the Barber-Bettendorf with roller bearings, **22**. Some railroads, such as the Milwaukee Road, used GSC trucks based on passenger-car designs, **23**.

HO and N scale wheels

The greatest variety of wheelsets is found in HO scale. One-piece plastic castings and plastic or metal wheels on a separate axle (plastic, brass, or steel) are among the options available.

The stock wheels on many HO models have a .110" wheel tread width (flange and tread), which is compatible with most model track. This is also the width noted in National Model Railroad Association (NMRA) Recommended Practice 25. However, these wheels are significantly wider than those found on prototype cars.

Many solid-bearing trucks were converted to roller bearings. They're easy to spot, as the journal-box covers are removed for the conversion.

This Barber S-2 70-ton roller-bearing truck is on an 89-foot piggyback flatcar. 70-ton trucks have two visible springs; 100-ton trucks have three.

The ASF Ride Control truck is offered in 70- through 125-ton versions. Originally built for the Soo Line, this 100-ton truck is on a Minnesota Northern Pullman-Standard 4,427-cubic-foot-capacity covered hopper.

If you compare this Barber S-2 caboose truck to the freight car version in photo 15, you can see they follow similar lines. The big difference is the elliptical leaf springs used on this truck, which provides a smoother ride for the crew.

To address the oversized .110" wheels, some manufacturers have produced "semi-scale" wheels with a tread width of .088". Though narrower, the wheels still operate on most commercial track. There are instances where .088" wheels may fall into flangeways on some turnouts. It's always best to run a test car with semi-scale wheels across your layout to check for trouble spots before replacing the wheelsets on all your freight cars.

A few manufacturers offer wheels that are truly scale size, following specific prototype dimensions. These wheels are used by modelers building their layout to fine scale, or Proto:87, standards. For a comparison of the three wheel styles, see **24**.

Scale wheels look terrific, but they unfortunately aren't compatible with most commercial track. Sectional turnouts and crossings are designed with wider tolerances, which means scale wheels can drop into flangeways and turnout frog gaps.

For many years, Micro-Trains N scale cars featured one-piece plastic wheelsets with oversized flanges, dubbed "pizza cutters" by modelers. While the wheelsets worked well on code 80 track (track with rails .080" tall), they proved problematic on code 55 (.055"-tall) rail, which has gained in popularity for its near-scale appearance. The oversized flanges bump the molded spike heads on the track.

Micro-Trains now offers wheelsets with shallow flanges, which perform well on code 55 track. You can see the differences in flanges in **25**.

In addition, a variety of manufacturers produce metal wheelsets in various prototypical diameters, including BLMA (now Atlas Model Railroad Co.), Con-Cor, Fox Valley Models, InterMountain, and NorthWest Short Line, among others.

Regardless of the scale, if you replace stock wheelsets with aftermarket offerings, make sure the new wheelsets will fit in the trucks. Most replacement wheelsets specify the axle length or the specific trucks for which the wheelsets are designed.

Plastic or metal wheelsets?

One debate among modelers is whether to use plastic or metal wheels. The discussion has quieted down in HO scale circles, as most new models come with metal wheelsets. However, in N scale there are still a sizeable number of models with plastic wheelsets.

On the surface, the choice may seem obvious. Real trains use metal wheels, so our models should too, right? However, plastic does have some advantages. If the wheels and axle are a single casting, such as those found on Accurail (HO) and Micro-Trains (N) freight cars, the wheels will stay in gauge, **26**. That doesn't hold true on wheelsets included with Athearn and Model Die Casting (Roundhouse) HO kits, where the plastic wheels were mounted on a metal axle, **27**.