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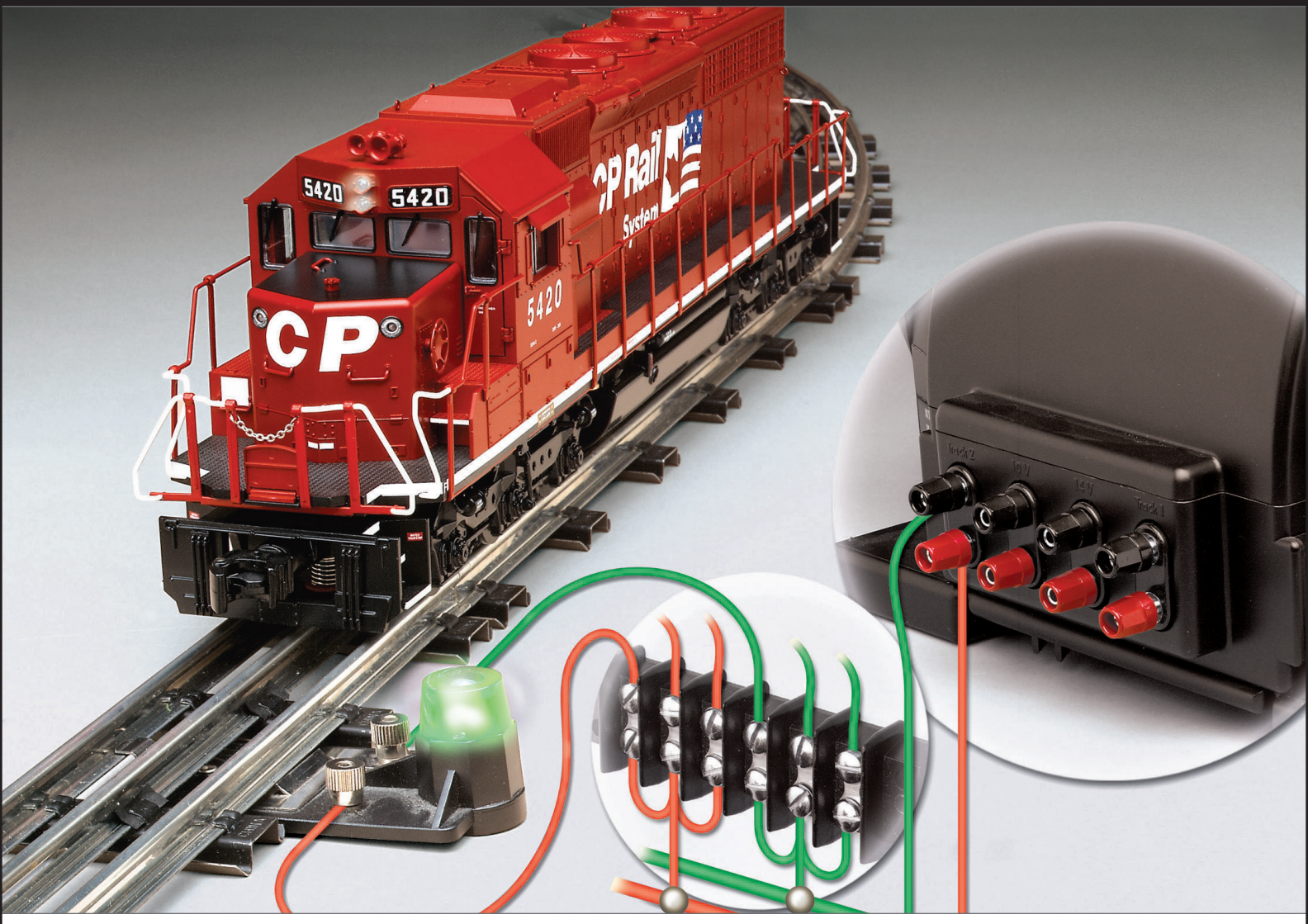


WIRING A TRAIN LAYOUT

20 FAST WIRING TIPS

TROUBLESHOOTING BAD WIRES

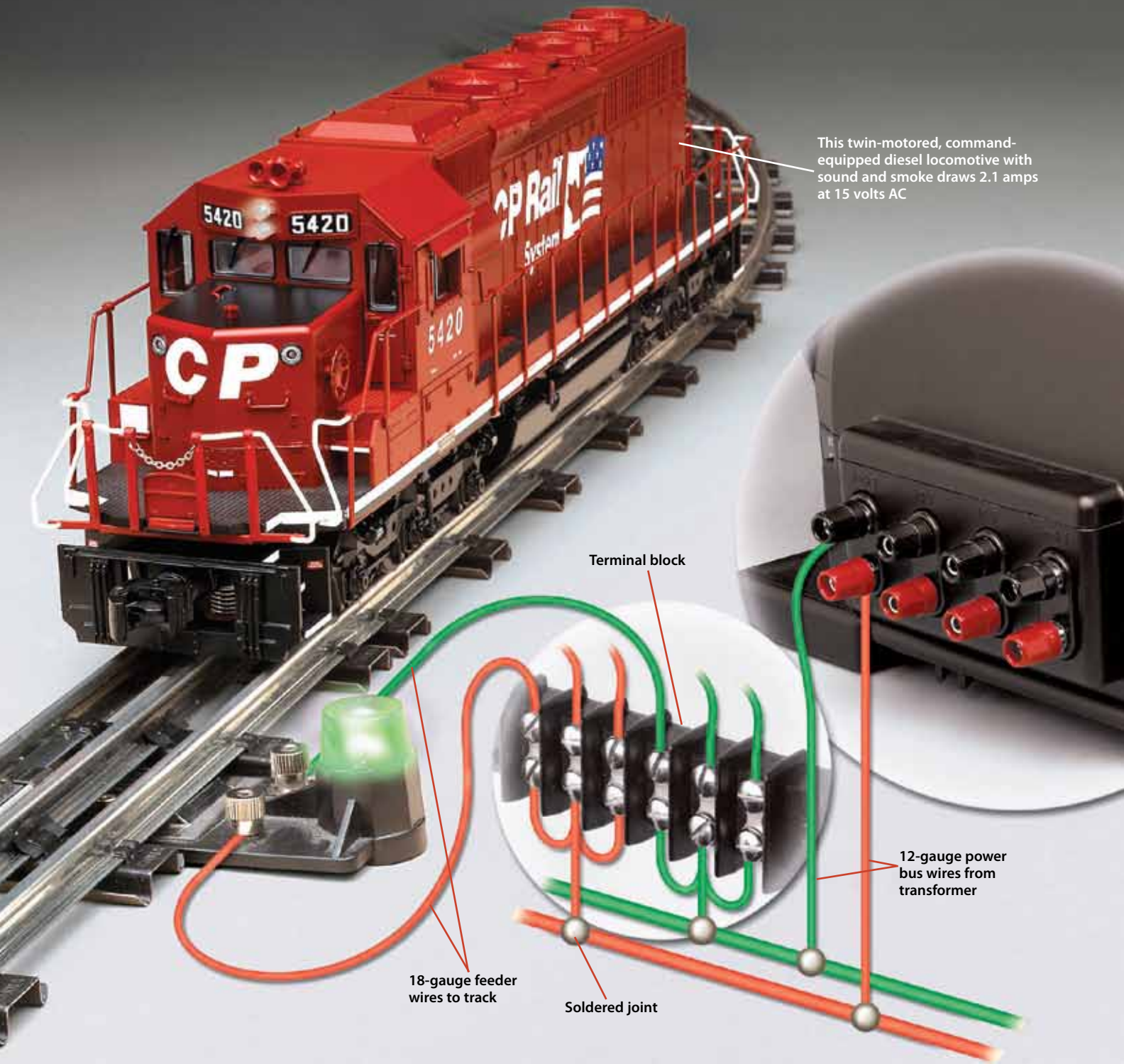
HOW TO SOLDER LIKE A PRO

BASICS OF ELECTRICAL SWITCHES

LESSONS in layout wiring

Tools, tips, and techniques to bring power to your trains

by Don Woodwell | photos by Jim Forbes



There's arguably nothing more critical to the enjoyment of an electric toy train layout than a safe and reliable network of wires. Without a means to route 110-volt household current from a wall outlet to a transformer and then on to the layout, your locomotives, operating cars, signals, lights, sound systems, and accessories would all go dormant.

To install layout wiring you'll likely need to route wires from one point to another, and then solder the joints or add connectors to terminate the ends. While these tasks aren't difficult to master, you can improve the efficiency of your work and reliability of the entire network by sticking with basic electrical principles, practical tools, and proven installation techniques, many of which are referenced in the paragraphs that follow. GTT

A twin-motored diesel draws more power than does a small motorized unit with a single motor.

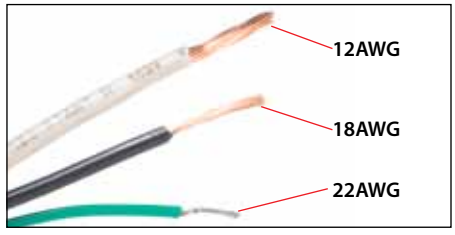
1 TERMS OF THE TRADE

Many hobbyists are reluctant to work with electrical wiring because they're intimidated by the terminology. While a universal understanding of electrical terms isn't essential, there are a few things you should know before you start wiring a layout.

Draw: The amount of current a device requires to operate. What everyone should understand is that a twin-motored locomotive, complete with sound and smoke features, needs more electrical current and higher voltage (the combination of current and voltage is often called "power") to run at speed than a caboose needs to illuminate its single light bulb.

Gauge: If you're discussing track, this term refers to the distance between the outer rails. However, as it relates to electricity, "gauge" identifies the diameter of electrical wire or cable. When using the American wire gauge system (AWG), higher numbers denote thinner wire (e.g., 22-gauge wire is smaller than 12-gauge wire).

Along with knowing wire types and sizes, you'll also want to know when and where to use them. One easy rule to remember – the greater the demand for electricity, the greater the size of wire needed to carry it. Consequently, the wires needed to supply the higher power requirements of mainline locomotives need to be larger than those for a remote-control track-switch machine.



2 TOOLS AND MATERIALS OF THE TRADE

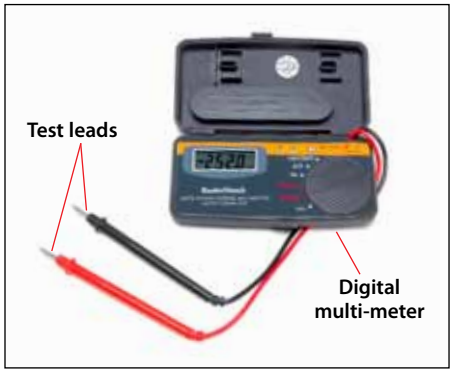
With a basic electrical know-how under your belt and the right tools strapped to it, wiring a toy train layout can be much less daunting than you think. Before you start any wiring project, you'll want to be sure your toolbox includes all the equipment needed to complete the task. The following list of tools covers the basics, but you can always add others.

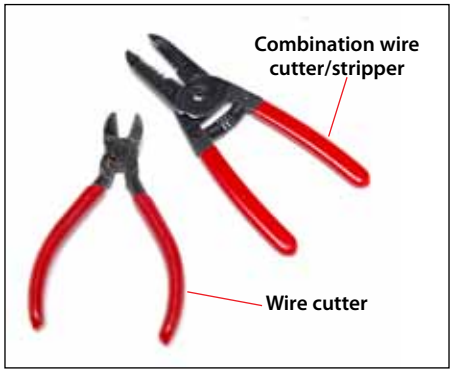
Multi-meter: An instrument that measures electrical properties, such as current, resistance, and voltage. Meters come in analog (swinging needle) or digital (numeric readout) varieties that provide an indication of the electrical circuit established through two attached probes. If your trains aren't running smoothly, you can test the track voltage at different points to determine if voltage is lost due to track, wire, or connection resistance.

Wire cutter: This hand tool makes clean cuts through insulated wire. After cutting a wire to length, a wire stripper removes the insulation. These two functions are sometimes combined into a single tool, but be sure that the wire-stripping component accommodates 12- to 22-gauge wire.

Flathead- and Phillips-style screwdrivers: Large and small sizes are useful for securing wires to terminal strips.

Soldering iron or gun: Where terminal blocks and solderless terminals are not feasible, this heating tool melts tin and lead used to join bare wire or metal. A 75-watt iron or gun is capable of heating larger gauge wires to a temperature that allows the melted solder to flow through the joint. A firmly soldered joint is a key component to making your layout wiring more reliable.





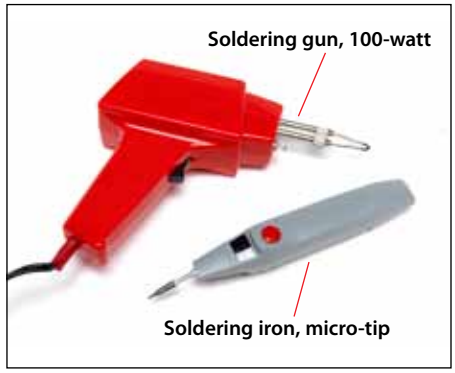


Illustration by Rick Johnson

3 TANGIBLES OF THE TRADE

Solid- and stranded-conductor wire: Electrical wire comes in these two forms. As with gauge, the appropriate type of wire to select varies by application. Solid-conductor, made up of one solid piece of metal, is best used when connecting wires to terminal screws. Stranded-conductor, made up of multiple smaller strands, can carry the same current as solid-conductor, but is more flexible.

Terminal blocks: Made from insulated materials, these blocks are lined with two or more paired-screw terminals that are electrically isolated from all the others. These items allow you to easily join wires without soldering, change the gauge or type of wire used, and keep wires organized to aid layout troubleshooting.

When coupled with terminal bridges, terminal blocks can also be used to distribute power from a single source. For example, I run 16-gauge, two-conductor wire from two transformer terminals to a single-terminal post on two different blocks. I then use a terminal bridge on each block to electrically link each of the positions. This gives me multiple locations to connect wires routing from the tracks.

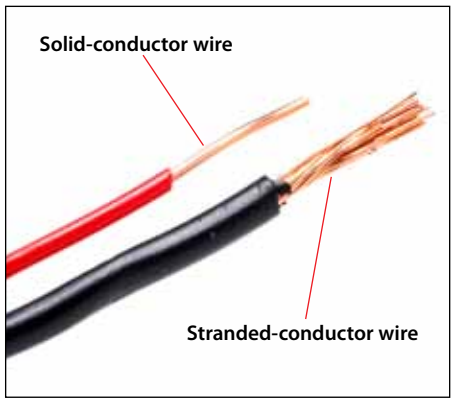
Solderless connectors: These aluminum pieces typically come with plastic-insulated sleeves fastened to one end and a spade, hook, or loop to the other. Crimping these connectors to the end of an exposed wire allows you to make quick and secure solderless connections to a terminal block.

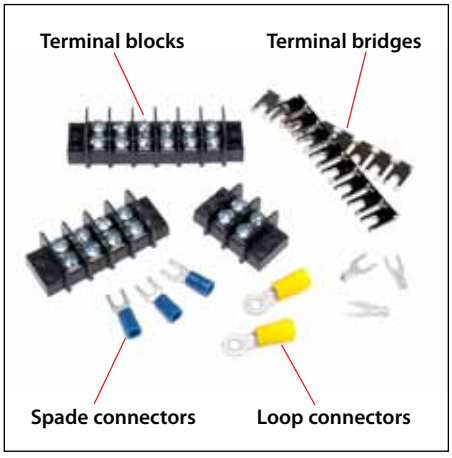
A splice connector is another type of solderless connector used to connect two wire ends together. This is often even easier than soldering and provides a joint that's equally secure.

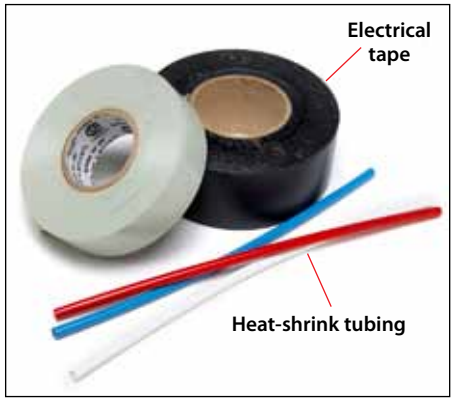
Wire insulators: There are numerous sizes and lengths of plastic tubing you can use to cover and insulate exposed wire joints. Heat-shrink tubing, as the name implies, requires direct heat from a heat gun to shrink the tubing around a joint.

Use professional-quality electrical tape to insulate solder joints made between larger wires (16-gauge and heavier). For smaller wires that aren't well suited for heat-shrink tubing or tape, I prefer using brush-on liquid electrical tape to provide a coating for the joint.

Cable ties: To keep things neat and orderly under your layout, use plastic straps for securing bundles of wires.







REFERENCES

Wiring books from Kalmbach Publishing Co. (cttbooks.com or call 800-533-6644):

Build a Better Toy Train Layout, 10-8803
Command Control for Toy Trains, 10-8315
Wiring Your Toy Train Layout, 10-8320

4 POWER-DISTRIBUTION

Bus (a single wire or conductor carrying a number of connections) and star (multiple wires radiating from a central point) wiring methods are two common choices for distributing power across a layout. While each method is unique, there are advantages to using one method over the other, or even using a combination of both. For the most part, your layout's power demands will determine which choice is best.

Bus wiring results from stringing a long run of 12- or 14-gauge wire from the transformer terminal blocks under the layout and then making 16- to 22-gauge feeder-wire connections every 3 or 4 feet along the wire route. This application is useful for providing power to your track, and it saves money since you use less wire.

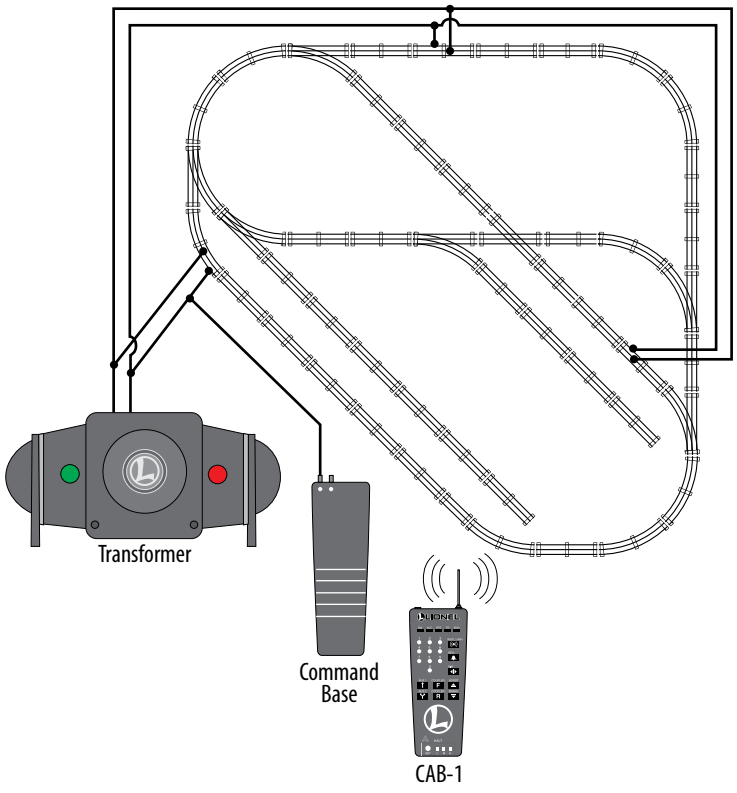
Star wiring uses 12-gauge wire to route power to multiple distribution points, or hubs, placed in strategic locations under a layout. From these hubs, you can connect numerous 16- to 22-gauge feeder wires. As the name suggests, the resulting array of wires strung in this pattern tends to resemble the shape of a star. This method is most practical for wiring lights and accessories, but it's also suggested for routing power and signals from some command-control systems.

5 PLAN FOR PRECISION

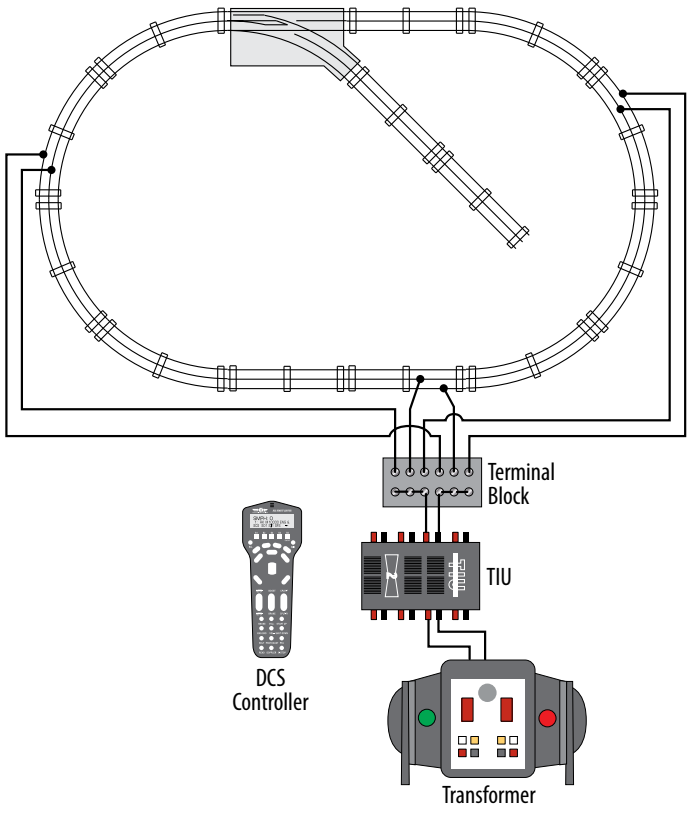
One of the easiest ways to maintain logical and proper wiring practices is to develop a wiring schematic for your entire layout. I always draw a schematic and then use it to plot the completion of my tasks. Even when I have a manufacturer-supplied wiring diagram, I first check it for accuracy.

To complete a wiring diagram, start with a copy of your finalized track plan. Use a pencil and a small ruler to mark the beginning and ending points of each wire you plan to install. If you're using multiple wire gauges on your layout, be sure to color-code the diagram accordingly.

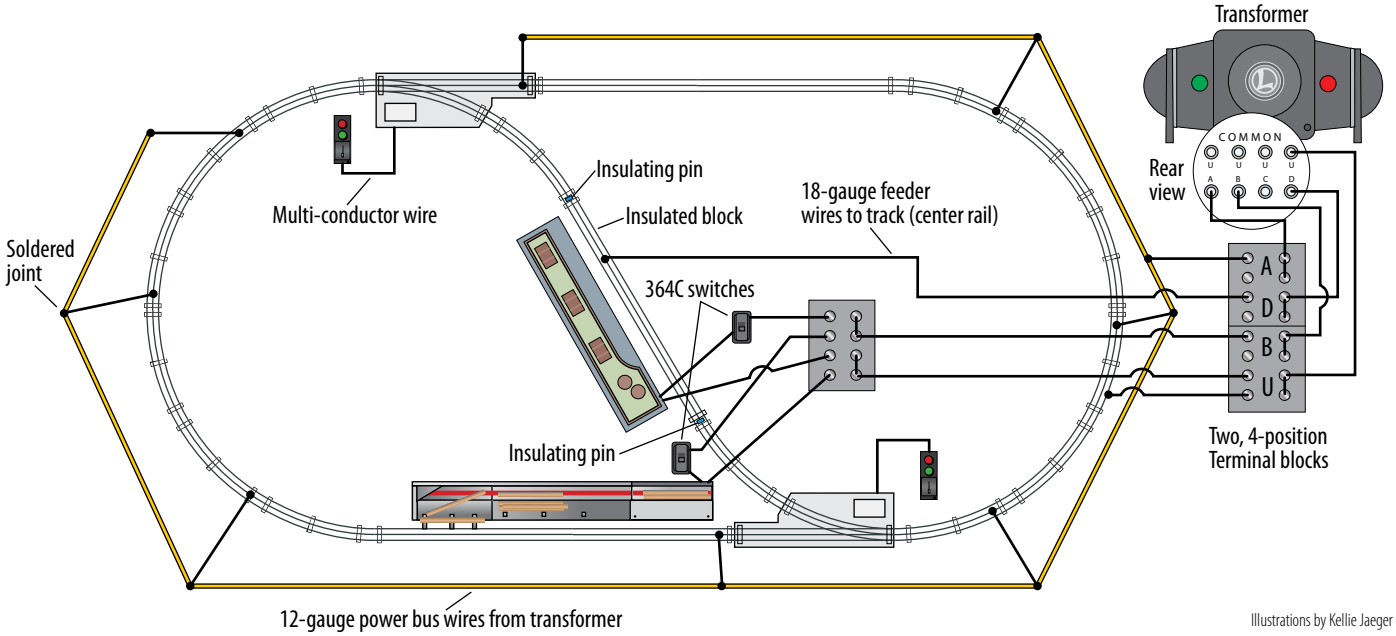
You'll also want to show terminal blocks and connections to power sources and devices, along with making notes about the types of connectors required. Finally, when you begin to connect your circuits, use your diagram to ensure reliable layout wiring.



Bus wiring used to accommodate multiple feeders to the rails



Star wiring between the terminal block and the accessories



Illustrations by Kellie Jaeger

All about wires

A little knowledge leads to better connections

by Dennis Eichenberg | photos by Jim Forbes

WE'VE ALL WIRED UP our trains before. A couple pieces of hookup wire run from the transformer to the tracks and we're all done. Right? Sure, that'll get the trains moving, but it falls far short of providing the peak performance that we expect from our trains.

A good wiring job, aided by an understanding of wires in general, increases reliability, enhances appearance, and gives you much greater toy train satisfaction.

Evolution of wire

Despite its outward appearances and mystique, electrical wire is really just a long, thin, flexible rod made of ductile metals. The primary ductile metals are copper, iron, brass, platinum, gold, silver, and aluminum.

Today's fine strands of wire look nothing like their historical counterparts. From early ages until the 14th century, wire was made by hammering metal into plates. These plates were cut into strips and rounded by hammering. Machine-drawn wire was first made in England in the mid-1800s.

Today, the process is highly automated. After metal billets are rolled, they come out as long rods about a quarter of an inch in diameter. These rods, rolled onto reels while they're still hot and cleaned in sulfuric acid and water, are drawn through a series of dies, like thread through the eye of a needle. Because wire has a tendency to harden when it is drawn, it is softened in high-heat cast-iron pots – a process called annealing.

Electrical wires are often coated with insulation, which prevents the metal conductors from touching each other and causing a short circuit.

Toy train wires

Among the different wire types used for toy train layouts are single- or multi-conductor, solid, or stranded wires (fig. 1). Copper is the most popular wire for toy train use. Wires may be either one solid conductor or stranded. Stranded wires consist of many small wires formed together to make the required size conductor – the greater the number of strands, the more flexible the wire. Most toy train wire is stranded because of the need for flexibility in train operations.

Electrical wire may be either bare or insulated. Most toy train wire is insulated. There are many different types of insulation available and each has its own characteristics.

Temperature rating, flexibility, and strength are the most important insulation characteristics. A temperature rating of –20 degrees to +60 degrees Celsius is acceptable for toy train use.

Most modern toy train wire is insulated with polyvinyl chloride (PVC). Older toy trains often used rubber insulation, which is still available. Other insulation types such as Teflon, silicone, and neoprene are available, but they are not normally used for toy trains. Wire insulation is available in many different colors, which makes it easy to identify the different wires.

Fig. 1 – Wires come in solid and the more flexible stranded varieties, as well as in a variety of diameters (gauges).

Fig. 2 – Multi-conductor cables, commonly used with Lionel remote uncoupler or remote switch controllers, have long been a part of toy trains.

Multi-conductor cables, which have two or more insulated wires packaged in one cable, are convenient for many toy train applications where several different wires are required. The various wires in a multi-conductor cable are usually color coded for reliable identification purposes.

Zip cord, a multi-conductor cable which is usually used for lamp cords or speaker wires, works great for toy train applications because it is very flexible, is easily separated and stripped, and clearly identifies the wires inside. The insulation is usually smooth on one side and ribbed on the other, and the individual wires may be of contrasting colors such as copper and silver.

Lionel, as well as other manufacturers, frequently uses flat multi-conductor wire (fig. 2) on controllers for switches (turnouts) and uncoupler sections. This type of wire is available from several different toy train wire suppliers.

Toy train pickup rollers require extremely flexible wire, which must accommodate the constant bending back and forth as your train moves through curves on your layout. Look under your lighted caboose or passenger car and you'll likely see a great example of one of the most durable wires used in toy trains.

Another flexible and durable wire, out of necessity, is attached to your toy train transformer. Because that transformer cord carries a full 120 volts before the voltage is stepped down for train use, it represents a prospective shock hazard and should be inspected regularly for any sign of wear. If it needs to be replaced, be sure to use the proper cord.

Wire sizes and uses

Here are some suggestions for choosing wire size. Your specific needs are determined by the nature of your wiring project.

Gauge	Toy train uses
32	Small electronics
30	Small electronics
28	Electronics and miniature lamps
26	Miniature lamps
24	Small lamps
22	Lighted accessories
20	Modern-era motorized accessories
18	Older motorized accessories/track power for modern era and smaller layouts
16	Track power for postwar, prewar, or mid-size layouts
14	Track power for large layouts
12	Bus wire

Sizing them up

The most important characteristic of wire for toy train use is its diameter. Electrical wire diameter is categorized by "gauge" and, most importantly, determines how a wire should be used.

The accepted standard, the American Wire Gauge (AWG), assigns numbers to various sizes of wires. Wire gauge sizes are opposite their physical sizes – the smaller the AWG number the larger the wire size.

The table to the left lists common wire sizes and some suggested uses. Keep in mind these are suggestions only – the nature of your layout or wiring project will determine your specific needs.

When determining what wire size to use, ampacity and voltage drop are key issues in safety and performance. Ampacity is the safe current-carrying capacity of a wire, in amperes.

When current flows through wire it emits heat. The greater the current

Fig. 3 – Electrical tape and heat shrink tubing are both useful for insulating exposed wires to prevent short circuits.

Fig. 4 – Wire nuts and insulated butt splices help make good wire connections. Wire nuts can be easily removed and replaced.

flowing, the greater the heat, which is wasted energy. The wasted power also causes a voltage drop, which means that less voltage is delivered to the load. Moreover, if the current is too great, the wire may become so hot that it will be damaged and can even cause a fire. To avoid such risks, use as large a wire size as possible.

Multiple wires, or parallel wires, can be used to increase ampacity and decrease voltage drop. This is an excellent strategy for toy train uses as opposed to simply using larger diameter wires, which do not bend very easily and are very difficult to run throughout a layout.

On my layout, I typically use No. 18 AWG wires for powering trains, and No. 22 AWG wires for accessories. Lionel lockons can accommodate No. 18 AWG wire, and several lockons can be distributed throughout your layout to minimize voltage drop.

Making connections

Many different wiring accessories help make wires better performers. Neatness counts.

One essential tool in any toy train wiring scheme is a roll of good electrical tape or insulating tubing (fig. 3), either of which can be used to insulate connections and prevent electrical short circuits.

Electrical tape, which is essentially like rubbery insulating masking tape, is best wrapped spirally with a slight overlap so that no bare wire is exposed. A second layer spiraling in the opposite direction ensures a more dependable barrier of insulation.

Tubing you can slip over bare wire is available in non-shrink and heat-shrink types. Either provides excellent insulation and makes a very neat appearance. The heat-shrink type shrinks down around the wire when hot air is applied from a heat gun or similar source.

Wire nuts (fig. 4) and crimp-type connectors make connecting two wires simple and reliable without the need for soldering. Easy-to-use wire nuts provide a good electrical connection and insulation and can handle several conductors. They also simplify wiring changes, since you merely unscrew them to disconnect joined wires. You can reattach the wires easily by screwing the wire nuts back on.

Of the many crimp type connectors available, insulated butt splices are excellent for attaching and extending wires and come in different sizes to accommodate different wire gauges. With insulated butt splices, you can strip back a section of wire, insert it into the splice, and crimp it securely with a crimp tool.

Ring terminals and spade terminals (fig. 5) serve similar purposes. Ring terminals are excellent for securing wires to threaded terminals such as those on the transformer. They keep the wire neatly in place and prevent short circuits. Spade terminals are similar to ring terminals, but are easier to slip in and out of a threaded terminal.

Organizing layout wires

Neatness also counts when it comes to organizing wires and making temporary connections.

Cable ties and pads (fig. 6) are useful in securing loose wires. Wire ties are available in many different sizes, and are very easy to use. You bring the end of the wire tie through the other end, pull tight, and cut to length. Mounting pads often have a self-adhesive backing, or they can be secured with a fastener. Test leads with alligator clips (also fig. 6) are excellent for making temporary connections. They are available in many different sizes and colors.

Finally, wires can be identified by color coding or labeling. I prefer to use small printer labels for identifying the ends of the various wires on the layout. The labels are pre-cut, can be written upon easily while they are still on the sheet, removed from the sheet, and wrapped around the wire end. You should write a good wire description on the label for future use. The labels will remain securely in place.

As a hobbyist, I find a basic understanding of wiring to be rewarding and useful. It helps me in my goal to be able to sit behind a panel that controls all of my toy train activity effortlessly though simple fingertip controls, with no shorts or overburdened wiring to get in the way of fun. CTT

Fig. 5 – Ring terminals and spade terminals are used to create easy and neat connections to transformers and accessory terminals.

Fig. 6 – Test leads and cable ties (both available in different sizes and colors) and cable mounting pads keep your wiring efforts neat and orderly.

20 FAST WIRING TIPS

PRODUCTS AND TECHNIQUES THAT SAVE TIME AND IMPROVE YOUR LAYOUT

by Neil Besougloff

EVERY ELECTRIC toy train layout on the planet shares one common element: wiring. Here are 20 tips – some new and some old – from hobbyists and from the staff of CLASSIC TOY TRAINS that will save you time, spare a few headaches, and enhance the wiring and operation of your layout. CTT

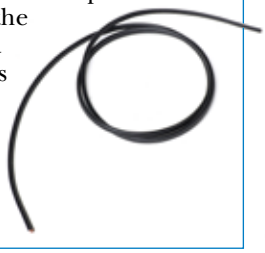
1 Power for removable sections. Here is a clever and low-cost way to make electrical connections to removable sections of a layout – use a trailer-light connector. It's cheap, durable, and available at hardware and auto parts stores. Peter Riddle, a regular contributor to CTT and the author of several toy train books, gets credit for this idea.

2 Male terminals instead of solder. Here's another idea popularized by Peter Riddle. When building a layout with Gar-Graves, Ross, or other styles of tubular track, you can make wiring connections using solderless male terminals. Crimp a feed wire to the terminal, and then insert the terminal into the seam on the underside of the rail (you'll need to drill holes in your roadbed to accommodate the base of the terminals). If it feels a little loose, put a little kink in the smooth end of the terminal and re-insert it beneath the track. Friction will hold it in place.

3 Suitcases instead of solder. Few hobbyists enjoy soldering wires together beneath a layout. Instead of soldering, use "suitcase" connectors sold in the electrical aisle of hardware and home-improvement stores. Labeled "tap-splice connectors," they are ideal for connecting track-feeder wires to bus wires and require only a pair of pliers to use. Be sure to get the right color: red for 22-14 gauge wire, blue for 18-14 gauge wire. Nearly all connectors and terminals use this same red/blue size code.

4 Christmas lights under your layout. Can't see under your layout when making repairs or additions? Get an old set of white Christmas lights (or buy a set for half-price after Christmas). Hang or staple the lights beneath your layout and plug them in when you need to work underneath your layout.

5 Use lamp cord for track wiring. Consider using lamp cord when wiring your layout, especially a modest-sized one with only a handful of connections. Lamp cord is cheap, available cut to any length at hardware and home-improvement stores, and is sold in gauges (14, 16, or 18) that make sense for toy train layouts. Since you'll need to distinguish between power and neutral wires on your layout, purchase the type of lamp cord with one ribbed wire (even though both lamp-cord wires are the same color, you can feel the ribs with your fingernail or see them in good lighting).



6 Install indicator lights. CTT columnist Ray L. Plummer gets credit for this one. When you are uncertain if a hidden block of track is receiving power, wire a light bulb into the circuit. The bulb socket doesn't have to be mounted to a control panel, in this drawing it is inside a switch tower. In the diagram, two bulbs – yellow and red – show a train as it nears the end of a spur track.

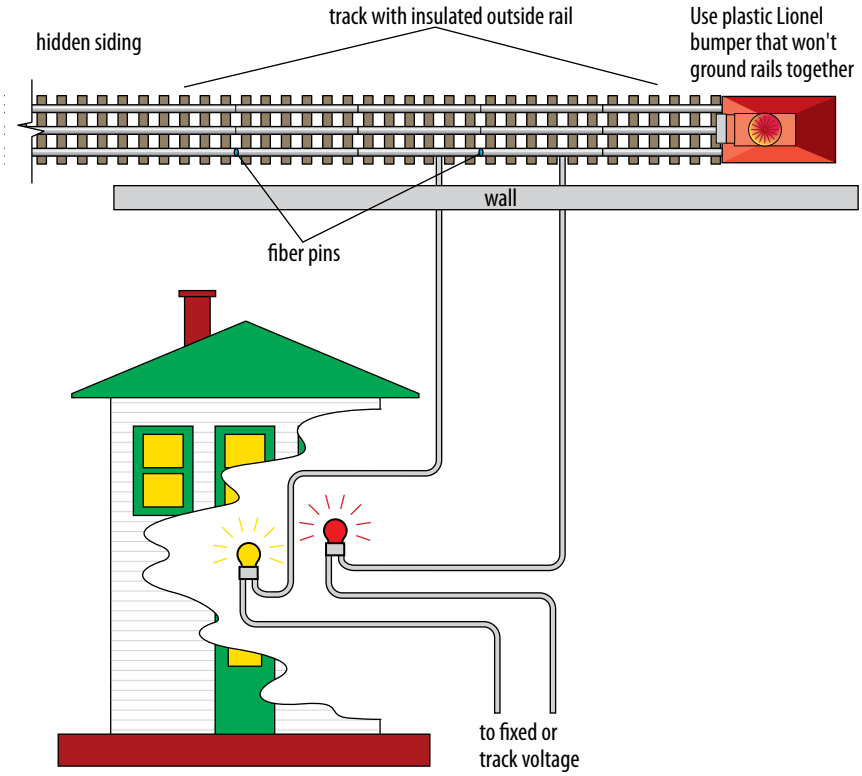


Illustration by Kellie Jaeger

7 Adaptor plugs for old cords. It's worth your while to keep older transformers in phase with each other. Once the proper phase is identified (see the "Wiring Diagrams" column in the October 2006 issue), you can mark one side of the old cord plug (both blades the same size) with a dab of paint. But you might forget over time what the dab of paint indicates (power or neutral blade). Instead, get an adaptor plug (with one blade larger than the other) from a hardware store and always leave it on the end of the old cord. Now the old transformer will always be in phase.

8 TMCC and DCS together. Do you want to have Lionel's TrainMaster Command Control and MTH's Digital Command System on the same layout? Are you reluctant to electrically intermingle the two? Using a double-pole double-throw (DPDT) switch can give you either TMCC or DCS on the same loop of track. Look at the diagram. In one position the switch connects DCS to the center terminals and then to the track. In the other position the switch connects TMCC to the center terminals and then to the track. That's all there is to it. On the downside, this schematic calls for two separate power supplies – one for TMCC and one for DCS.

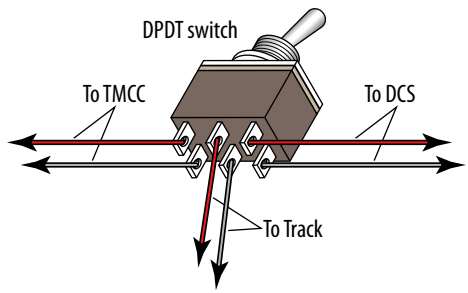


Illustration by Kellie Jaeger

INFORMATION STATION

To purchase more information about wiring your layout, go to ClassicToyTrains.com and click on "Downloads."

9 DC locomotives on AC layouts. Once in a while you'll come across a three-rail O gauge locomotive that requires DC instead of AC. Lionel made some during the 1970s and '80s, and many European three-rail steamers are DC only. If you are reluctant to modify the locomotive to insert a full-wave bridge rectifier, you can instead use a DPDT switch to add a rectifier into your track-power circuit. Throw the switch one way for AC trains, the other way for DC trains. Add a second DPDT switch for DC forward and reverse.

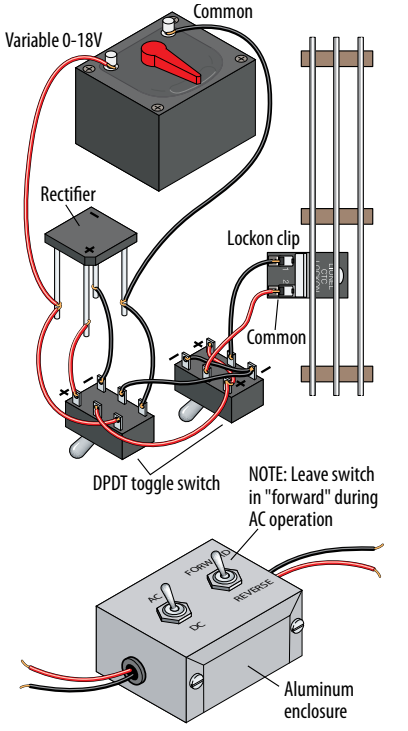
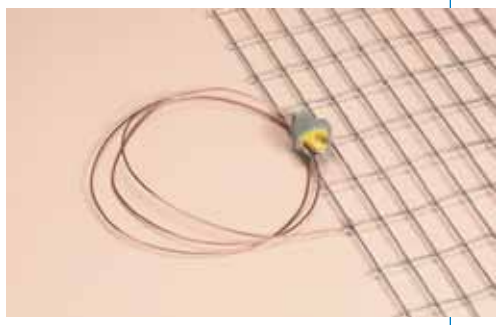


Illustration by Kellie Jaeger

10 Label wires with tape tags. Color-code your layout wiring and mark it with tags. You'll thank yourself in years to come. If you don't want to buy or make professional-looking tags, use white cloth medical tape (the type sold for bandages) and a Sharpie marker. The white tape is easy to write on and will last longer than other types of tape.

11 Safe TMCC signal grounding. In the November 2004 issue, CTT contributor Dick Teal provided tips to improve TMCC reception on a layout. One of his tips involved creating an earth-ground grid between a stretch of elevated track and one below. Dick suggested buying a three-prong wall plug and connecting a wire from the metal grid to the ground prong of the plug while leaving the other prongs empty. If tinkering with a ground wire that goes into a wall outlet makes you nervous, you can buy a grounding cord used by technicians who repair computers and other high-tech equipment or by consumers trying to shield themselves from unwanted electro-magnetic frequencies. The cord plugs into a wall outlet and contains an earth-ground wire, but no power and neutral wires. I found one for just $6 on an Internet site (lessemf.com/ground.html) earlier this year with a three-prong safety plug (catalog no. A295-3-ring) on one end and a ring terminal on the other, just right for TMCC layout applications.



12 Cup hooks to hold wires. When building your layout, leave some slack in the wiring below just in case you need to make changes, additions, and repairs. To keep those wires from looking like Droopy Dog, screw cup hooks into the underside of your benchwork, bundle the wires with cable ties, and place the bundled wires in the crook of the hook. Your wiring will be safely out of the way of harm, yet that slack will be available when you need it.

13 Terminal strips and jumpers. There will come a time when you need to remove a transformer, accessory, or other wired device from your layout. Instead of cutting wires, use terminal strips or barrier strips, which use screws or another type of reversible fastener to connect wires. These strips are also quite handy when a power or neutral wire needs to be broken up into multiple branches. MTH sells strips (no. 50-1014), and they can also be found at Radio Shack and electrical supply outlets.

14 Rectify your AC power. Often low-voltage electrical components, like relays suitable for toy train layouts, are easy to find in DC but tough to find in AC. Rectifying AC power for DC relays and other DC applications is easy using a full-wave bridge rectifier. All you need to do is solder four connections – two unmarked to your AC transformer and two (+ and –) to the DC device. All Electronics (see tip no. 16) sells an 8-amp, 800-volt, full-wave bridge rectifier (catalog no. FWB-88) that's more than adequate for the job.

15 Fuses and old transformers. Postwar Lionel transformers have slow-acting circuit breakers. Those breakers are designed to save the transformer from harm, but they offer minimal protection when it comes to the circuit boards inside your new trains. To play it safe, use a 15-amp fast-acting fuse (not a "slow-blow" fuse) and holder, available at Radio Shack (part nos. 270-1217 and 270-1073) and auto-parts stores, between your postwar transformer and the track. Buy some extra fuses to keep on hand. If you want a re-settable circuit breaker instead, go to scottsodds-n-ends.com, which sells electrical supplies for toy train use, and click on circuit breakers.

16 Add an amp meter. With a throttle handle you control the voltage going to the rails of your layout, but you can't quite control the amperage. Adding a low-voltage AC amp meter to your control panel allows you to monitor the power required to move your trains. More importantly, an amp meter can be used as a troubleshooting device, letting you know that a particular locomotive, not your trackwork or wiring, is not working properly. While you can't find AC meters suitable for toy train use at typical discount stores or home-improvement centers, you can find 5-amp and 15-amp AC panel meters (catalog nos. PMA-5A and PMA-15A) at All Electronics (allelectronics.com, 888-826-5432) for $12 each. Wire your amp meter in series on the hot wire between your transformer and track.

17 Light bulb trick for DCS. Without getting into a scientific explanation, the presence of a light bulb in your track circuit enhances the flow of digital information when using MTH's Digital Command System. The bulb is nothing fancy – an 18- or 24-volt toy train bulb and socket will do. Test your bulb in different locations in your track circuit using alligator clips, and monitor the track-signal mode of your DCS controller to determine which location creates the strongest signal. Our friends at Scotts Odds-n-Ends (scottsodds-n-ends.com) sell lamps and sockets for DCS in three different colors, or you can create one from parts in your scrap box.

18 Low-tech insulated outside rail. Often after a layout is built, an accessory is added that requires an insulated outside rail for activation. Instead of tearing up a section of track, you can use an old tubular-track trick that dates back to Marx trains. Use a scrap piece of brass or even a piece of tubular rail, and shape it so that it slips over an existing track rail without causing too much of a bump for train wheels (you may need to bevel the ends of the scrap piece with a file). Remove the scrap piece, and cover the existing track rail with a piece of electric tape. Solder a wire to the scrap piece. Then place the scrap piece over the tape and the existing rail to form a tape-and-rail sandwich, and voilà, you've made an insulated outside rail to activate your accessory.

19 Lighted lockons to monitor power. If you're new to toy trains (or not so new), a lighted lockon clipped to your track is a great troubleshooting device. If your train won't move when you turn up the throttle, look at the lockon. If the bulb is lit, the problem lies with the locomotive. If it's dark, power is not getting from the transformer to the rails, or not flowing from the wall outlet to the transformer.

20 Mount components vertically. Even a modest-sized command-control layout tends to accumulate more transformers and related components than can fit on a typical control panel. Instead of stacking components like towels in a linen closet, mount them vertically on a board. Then at a glance you'll be able to check wiring connections and the status of pieces of equipment (many of which use LED indicator lights to show their status). If a component lacks mounting holes, use large cable ties (found in the electrical supplies aisle) to strap down the component through small holes drilled in your board.

Troubleshooting your "bad" wires

Attack wiring gremlins one at a time

by Terry Thompson | illustrations by Kellie Jaeger

THREE-RAILERS LOVE THE LIGHTS and motion of an operating layout. That is, when everything *works*. A trouble-plagued pike can make you wish for the days of two wires and an oval, or even that beloved Marx windup.

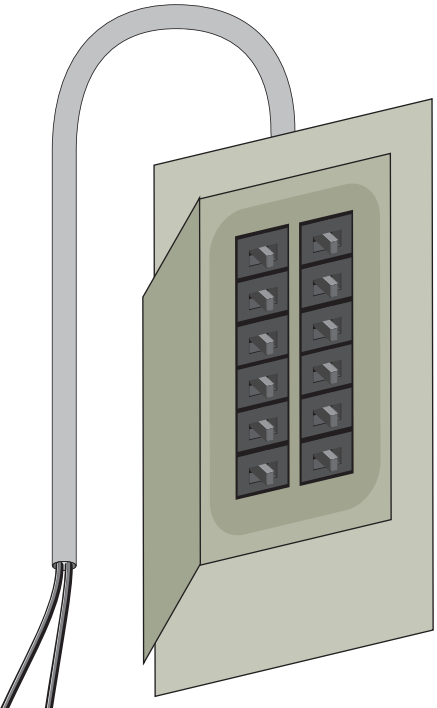
Even if you're not an electrical engineer, you don't have to give up on having an operating layout, even one with complex operation. By teaching yourself how to troubleshoot your wiring, you can simplify the process of installing new features and fix problems when they arise.

What kinds of electrical gremlins affect layouts? Unfortunately, many possibilities exist. Fortunately, they fall into a few basic categories.

Get shorty

The most common electrical problem, and potentially the most damaging, is the short circuit. A "short" occurs when the normal electrical path is shortened, causing the flow to bypass the circuit's normal load. Often, this means two wires that should be separated are touching each other. Unless a circuit breaker or a fuse cuts the current flow, a short can damage equipment, melt wires, or even cause a fire.

Derailments often cause shorts when a wheel bridges two rails or, more subtly, when they dislodge accessories or snag wires. Misplaced objects (such as a forgotten screwdriver or a metal-banded wristwatch) can also cause a short. So can degraded insulation (often caused by a chafed wire) or a too-long tail of wire at a transformer terminal or lockon. If your trains won't run and you hear humming or popping, smell burning insulation, or a circuit breaker opens, start looking for a short.



Powerless

If part or all of your layout is dead and you don't find a short, at least one circuit on your transformer may have failed.

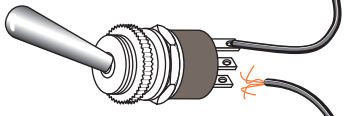
Check to make sure that it's plugged in and that the electrical outlet is live. Unless it is extremely large, your layout alone is not likely to overload a house circuit, but the main breaker could pop if one of your transformers has a short in its primary winding or if there is a problem with an unrelated household appliance plugged into the same circuit. An electrical short on your layout could also overload a house circuit if your transformer has a broken circuit breaker. In fact, shorted primary windings and non-functional breakers are the two most dangerous layout problems you can have.

If a 110-volt circuit breaker has thrown, shut your layout down for a minute or two, reset the breaker (or replace the fuse), then power the layout up again, one circuit at a time. If the breaker trips again, unplug all power cords leading to the layout, disconnect the transformers, and have a professional examine your layout wiring. If everything from your layout checks out fine, have an electrician take a look at your 110-volt wiring, because you may have more serious electrical trouble.

A variation on this problem comes from a load that's too large for the transformer, but not large enough to pop the breaker. Adding a few lighted coaches to your passenger train, for example, may increase the load enough that your locomotive runs sluggishly, the whistle won't blow, or your accessories won't run. Go back and calculate the load on the transformer (see CTT's October 2003 or January 1999 issues). You may be surprised by what you find.

Bad connection

If your layout won't operate, but you don't find a short and your transformers appear to be functioning normally, a wire may have come loose. Bad connections are especially likely when you've wrapped your wires around screw terminals (spade lugs really aren't that expensive – break down and buy a box). But wires also break, especially solid wires that have been bent a few times. Also, soldered and crimped connections can break – often invisibly.



The easiest way to test for a lack of power is with a voltmeter or test light. Make sure one lead is grounded, then use the other to check for voltage at each junction point in the circuit, starting at the transformer. If you can't find the correct voltage at a point in the circuit where you should, the break is between there and the last point where you had it.

Start your investigation by disconnecting, then reconnecting the wires, because a bad connection is the most likely culprit. If that doesn't work, it may be simpler just to run a new wire, rather than spend your time troubleshooting. Just remember to remove or mark the old wire to prevent any future confusion.

Wrong connection

If the gremlins have control of your layout – things just don't act right – you may have a wrong connection. Often this occurs when you disconnect a wire for some reason. Did the wire go back where it should have? Or did the new component set up an electrical path you didn't expect? Lighted components often create an alternate path that may not cause a short, but will prevent trains or accessories from working normally.

Trace the wires leading to and from the component or track section, checking as you go. If that doesn't reveal a bad connection, look at the connections to the component itself. Are the wires connected correctly? Check a Lionel service manual for wiring diagrams for postwar and most modern-era accessories. Sometimes problems stem from something as simple as a wire hooked to the wrong terminal. Or are you trying to do something that isn't possible? Some accessories, for example, won't work properly if you try to enhance them by adding lights. Others have metal frames that can cause erratic operation if they contact the track.

4 hints for troubleshooting

Once trouble starts, keep this hints checklist in mind to home in on the problem.

1) Start simple. Your troubles may have an exotic cause, like a shorted transformer coil or bad track insulation, but those aren't likely. Shorts and bad connections are – start by looking for them.

2) Get a test light, a voltmeter, or both. It's much simpler to chase down your troubles when you have a way of telling where the circuit is broken. A volt-ohmmeter (VOM) is even better than a test lamp, because it alerts you when the voltage is other than what it should be.

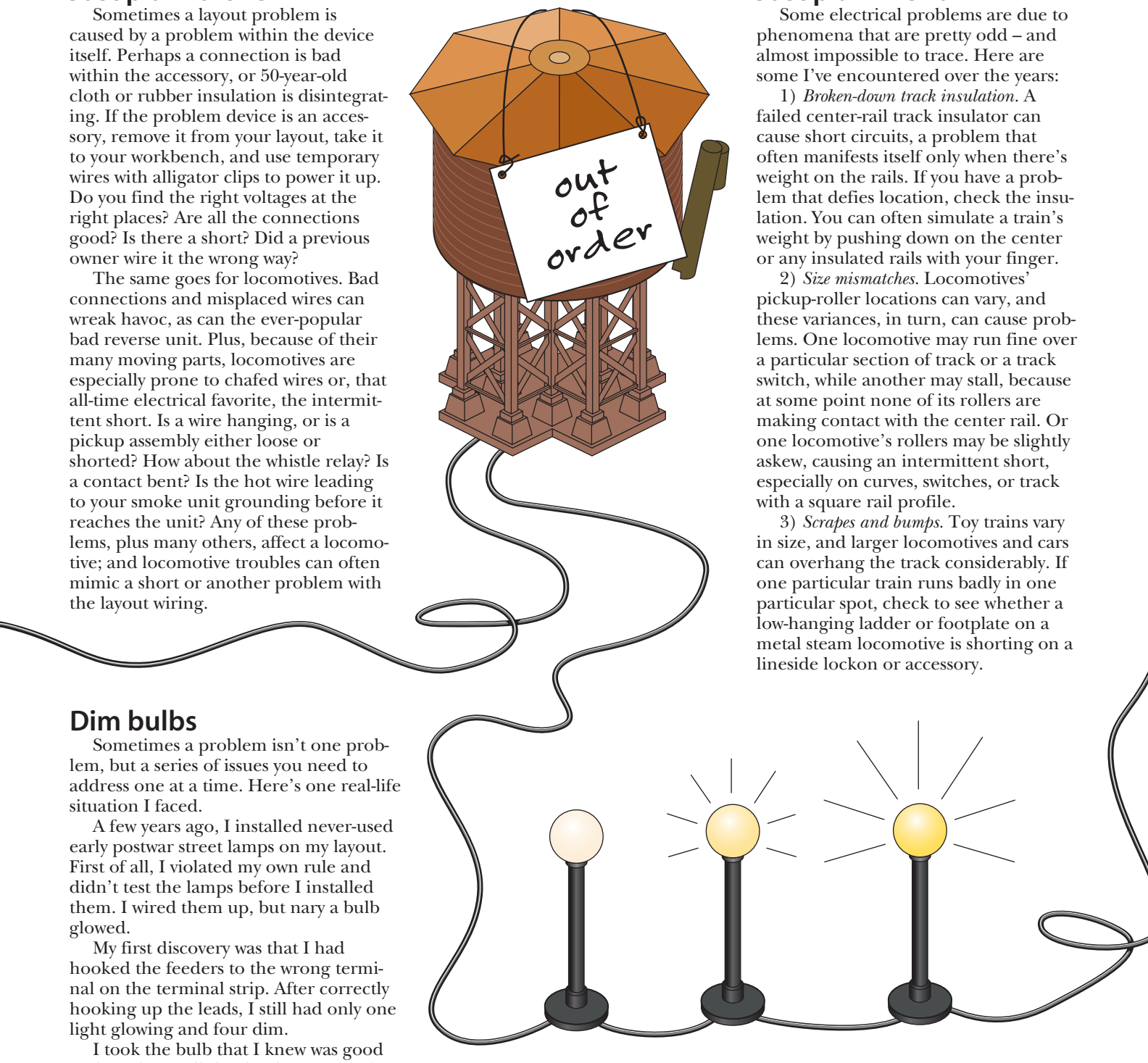
3) Be methodical. Disconnect one connection at a time, and test after each change. Check a circuit thoroughly before checking another. Skipping from circuit to circuit, or disconnecting several things at once, can drive you batty.

4) Think things through. Did you change anything recently? Add anything? Was the cat on the layout? Did your child's friends stop by, or did your buddy the prankster leave a quarter on the track? Some problems, such as those due to poor connections, can occur at any time, but most have an immediate cause.

Just plain broken

Sometimes a layout problem is caused by a problem within the device itself. Perhaps a connection is bad within the accessory, or 50-year-old cloth or rubber insulation is disintegrating. If the problem device is an accessory, remove it from your layout, take it to your workbench, and use temporary wires with alligator clips to power it up. Do you find the right voltages at the right places? Are all the connections good? Is there a short? Did a previous owner wire it the wrong way?

The same goes for locomotives. Bad connections and misplaced wires can wreak havoc, as can the ever-popular bad reverse unit. Plus, because of their many moving parts, locomotives are especially prone to chafed wires or, that all-time electrical favorite, the intermittent short. Is a wire hanging, or is a pickup assembly either loose or shorted? How about the whistle relay? Is a contact bent? Is the hot wire leading to your smoke unit grounding before it reaches the unit? Any of these problems, plus many others, affect a locomotive; and locomotive troubles can often mimic a short or another problem with the layout wiring.



Just plain weird

Some electrical problems are due to phenomena that are pretty odd – and almost impossible to trace. Here are some I've encountered over the years:

1) *Broken-down track insulation.* A failed center-rail track insulator can cause short circuits, a problem that often manifests itself only when there's weight on the rails. If you have a problem that defies location, check the insulation. You can often simulate a train's weight by pushing down on the center or any insulated rails with your finger.

2) *Size mismatches.* Locomotives' pickup-roller locations can vary, and these variances, in turn, can cause problems. One locomotive may run fine over a particular section of track or a track switch, while another may stall, because at some point none of its rollers are making contact with the center rail. Or one locomotive's rollers may be slightly askew, causing an intermittent short, especially on curves, switches, or track with a square rail profile.

3) *Scrapes and bumps.* Toy trains vary in size, and larger locomotives and cars can overhang the track considerably. If one particular train runs badly in one particular spot, check to see whether a low-hanging ladder or footplate on a metal steam locomotive is shorting on a lineside lockon or accessory.

Dim bulbs

Sometimes a problem isn't one problem, but a series of issues you need to address one at a time. Here's one real-life situation I faced.

A few years ago, I installed never-used early postwar street lamps on my layout. First of all, I violated my own rule and didn't test the lamps before I installed them. I wired them up, but nary a bulb glowed.

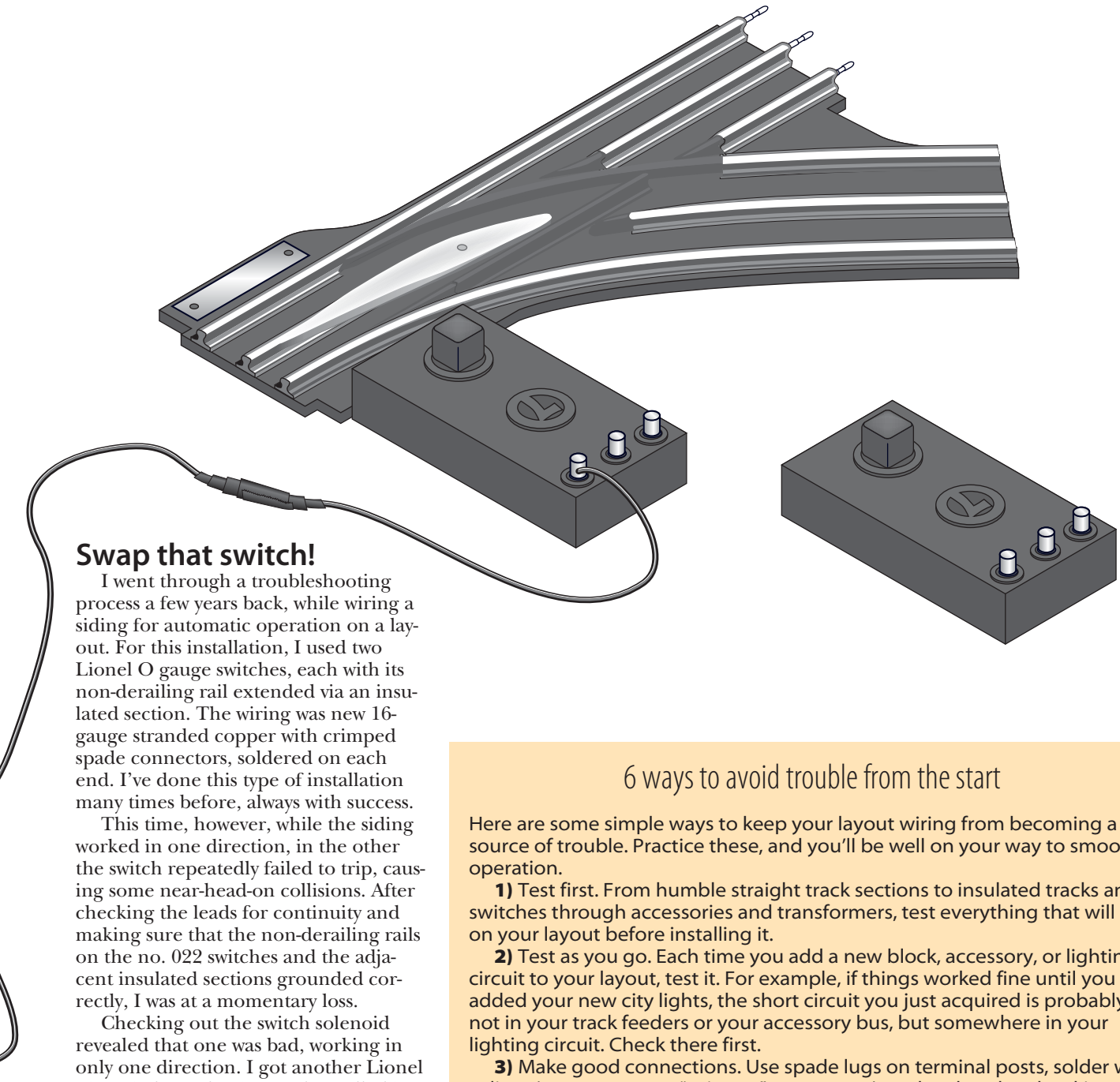
My first discovery was that I had hooked the feeders to the wrong terminal on the terminal strip. After correctly hooking up the leads, I still had only one light glowing and four dim.

I took the bulb that I knew was good and tried it in all the dim-lit fixtures. As a result, I discovered one of those four bulbs was bad (despite no visible breaks in the filament). I swapped in a new good bulb, giving me two working lamps.

Wondering whether 50 years of corrosion had affected any of the lamps, I cleaned the hot contact of each and screwed a bulb in and out a few times. That solved the puzzle on one more fixture, giving me three working lamps.

I took the two stubborn street lamps to the workbench, where I discovered that neither grounded properly due to corrosion in the 50-year-old mechanical connection between the ground wires and the fixtures. While removing the corrosion on each, the lead on one fixture broke. Not wanting to break 50-year-old zinc by hammering or drilling, I filed a groove inside the cast socket, then ran a second wire up through the pole and placed this wire's stripped end in the groove. Once everything was in place, and with a new bulb installed, it lit.

When I reinstalled the lamps, however, one still failed to light. I checked things out again – and found that one of the suitcase connectors I used under the layout was bad. Having already crimped two onto the wire, I didn't want to try a third, so I soldered the leads together and then – finally – enjoyed the sight of my five new lamps.



Swap that switch!

I went through a troubleshooting process a few years back, while wiring a siding for automatic operation on a layout. For this installation, I used two Lionel O gauge switches, each with its non-derailing rail extended via an insulated section. The wiring was new 16-gauge stranded copper with crimped spade connectors, soldered on each end. I've done this type of installation many times before, always with success.

This time, however, while the siding worked in one direction, in the other the switch repeatedly failed to trip, causing some near-head-on collisions. After checking the leads for continuity and making sure that the non-derailing rails on the no. 022 switches and the adjacent insulated sections grounded correctly, I was at a momentary loss.

Checking out the switch solenoid revealed that one was bad, working in only one direction. I got another Lionel 022 switch mechanism and installed it, only to find that the same problem occurred.

Running back through the process of checking the leads and rails, I found myself at the same point. Had I missed something? No. Actually, the second MPC-era 022 solenoid had the same defect as the first. Changing to a good postwar mechanism got the automatic siding working right, every time.

Even if your layout is small or you use command control, it still uses at least a few wires. And as sure as can be, one of these days something will stop working. But if you can troubleshoot it yourself, you'll be back railroading in no time. CTT

6 ways to avoid trouble from the start

Here are some simple ways to keep your layout wiring from becoming a source of trouble. Practice these, and you'll be well on your way to smooth operation.

1) Test first. From humble straight track sections to insulated tracks and switches through accessories and transformers, test everything that will go on your layout before installing it.

2) Test as you go. Each time you add a new block, accessory, or lighting circuit to your layout, test it. For example, if things worked fine until you added your new city lights, the short circuit you just acquired is probably not in your track feeders or your accessory bus, but somewhere in your lighting circuit. Check there first.

3) Make good connections. Use spade lugs on terminal posts, solder wire splices (or use snap-on "suitcase" connectors), and, rather than hooking several wires together into one spider web, use terminal strips. Even crimp-on connectors can fail – go ahead and solder them as well, using resin-core (not acid-core) solder.

4) Color code and label your wiring. Use different-colored wire insulation and either tag the wires, make a schematic, or both. Sooner or later trouble's bound to occur, or you're going to want to add something to your layout, and having the wires color-coded helps immensely.

5) More circuits. It's possible to run a layout from a single pair of binding posts, provided you have a transformer that's large enough, but it's not the best method. Breaking things down into multiple circuits spreads the electrical load, allows you to run accessories at their optimum voltages, and makes troubleshooting much simpler.

6) Neatness counts. Bundle wires and avoid droopy wires under your layout. It's simpler to trace neat wiring, and while a little slack is useful, big hanging loops of wire are snares for arms, legs, and pets, which can lead to injuries or broken connections.

FROM THE CTT STAFF

WIRING DIAGRAMS

Barrier strips keep wiring under control

Terminal barrier strips, also sometimes called barrier bars, serve two useful purposes on toy train layouts.

First, they allow you to break and restore electrical connections without cutting through permanent wiring. For example, a terminal barrier strip makes it possible to easily remove a motorized accessory from your layout for maintenance and repair.

Second, terminal barrier strips let you neatly route power to multiple feeder wires without the need to twist a bundle of loose wires together. Used in this manner, you can add as many feeder wires as terminals on the strip and use metal "jumpers" (often purchased separately) to carry electricity over the plastic "barriers." A similar device – called a "power distribution block" – takes the terminal-strip concept one step further by utilizing built-in jumpers. – *Neil Besougloff*

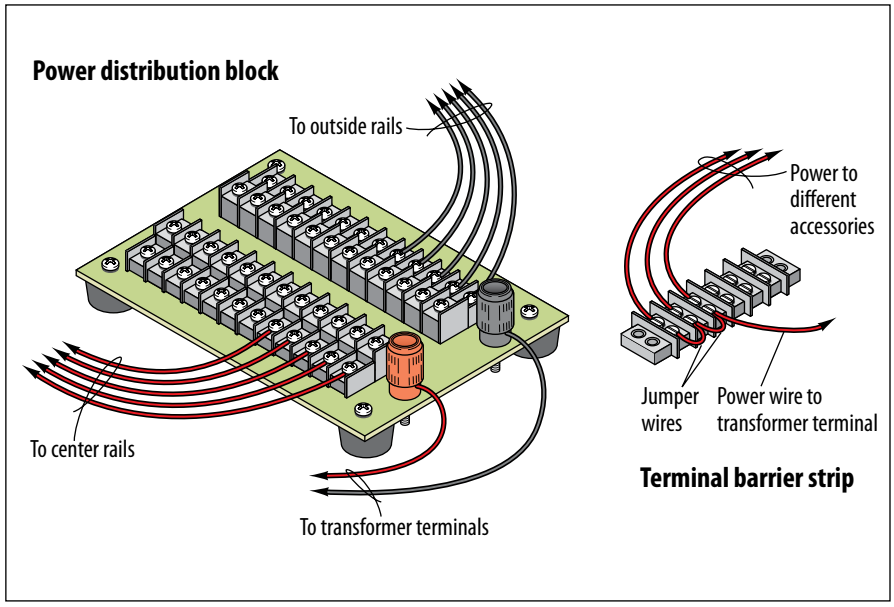


Illustration by Kellie Jaeger

FROM THE CTT STAFF

WIRING DIAGRAMS

Old transformers: which terminals to use

Fifty-year-old transformers are still viable power supplies for contemporary toy train layouts. But from a 21st century perspective, Lionel created confusion in the way it labeled postwar transformer terminals.

On popular ZW transformers, the terminals marked "U" are for neutral wires that connect to the outside rails of a section of track. But on Lionel 1033/1044, LW, RW, and TW transformers, the "U" terminals are hot terminals that connect to the center rail of a section of track.

Fixed-voltage terminals are another inconsistency. Depending on the transformer, you can create fixed-voltage circuits of 5, 6, 9, 10, 14, 15, 18, 19, 20, and even 25 volts. The labels in this diagram, taken from a postwar Lionel handbook, show which terminals are for what on five transformers. – *Neil Besougloff*

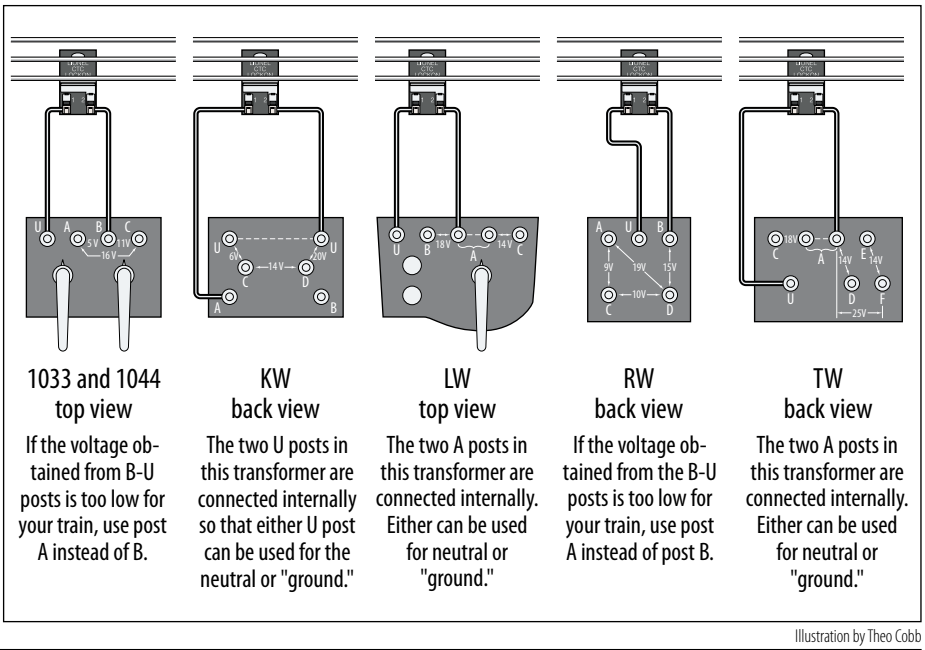
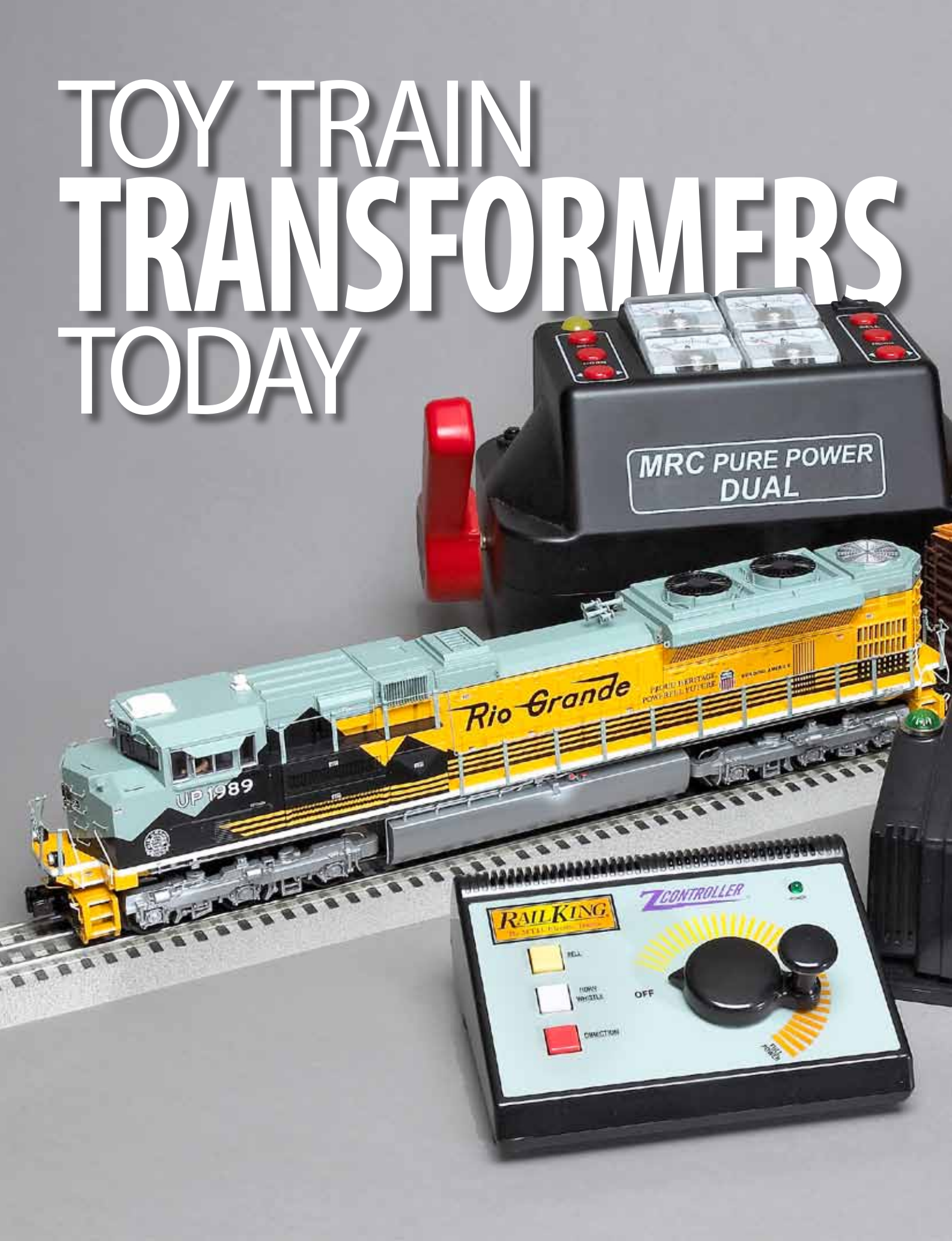


Illustration by Theo Cobb

TOY TRAIN TRANSFORMERS TODAY



There is no reason other than nostalgia to be using a 60-year-old transformer. Today, you can find AC power supplies made by six manufacturers, in a wide range of models and power levels, all suited to meet your operational requirements.

AC POWER COMES IN A VARIETY OF WATTAGES AND PRICES

by Bob Keller

Captain James T. Kirk of the starship *Enterprise* was often seen shouting to Scotty, the ship's engineer, "We need more power!" This was true in *Star Trek*, and it's also true of the model railroading community.

It isn't uncommon to enter the toy train hobby by purchasing a starter set. But before long, as experienced hobbyists know, a fleet of rolling stock (and shiny new types of locomotion) can outdistance the power supply of a starter set. Other hobbyists come to toy trains by finding (or being given) a box of old trains. Many of these hobbyists will eventually want to run their trains and desire an efficient power supply.

To help anyone who has a need for more power, let's take a look at the AC transformers that are currently available on the market. Here is our snapshot of power supplies available as this issue goes to press. CTT

AMERICAN MODELS

▶ SDK-2053 TRANSFORMER

American Models has created the first AC transformer for the S gauge market since the postwar years. The SDK is a solidly constructed model that will deliver 75VA to your trains. Not surprisingly, this power supply performed well for American Flyer, American Models, and S-Helper Service trains.

O gauge trains are another matter. It ran Atlas O's conventional and command-equipped locomotives well, but the horn/bell and sound systems didn't function. Williams engines ran well, but the horns didn't work; MTH's ProtoSound 2.0 locomotives didn't move or power up at all. So gizmo-free postwar gear may be the best target for this model if you use it for O gauge.

ATLAS O

▶ 80-WATT TRANSFORMER

Atlas O has been patiently building a full-range O gauge product line. In 2006, the firm introduced its Trainman line sets, which offered a locomotive, cars, and track, but lacked a transformer. All that changes this year.

As we go to press, the new line of Atlas power supplies is beginning to reach store shelves. First up is an 80-watt power supply that's designed for starter sets and can also feed accessories.

30-WATT TRANSFORMER

Also just released is a 30-watt transformer designed for starter sets or trolley sets. It powers track only and has no outputs for accessories.

▲ ZW AND 180-WATT POWERHOUSE POWER SUPPLY SET

Strictly speaking, the modern version of the iconic ZW transformer is literally a shell of its former self. Today, the familiar football shape is a control box for managing power as provided by external Lionel PowerHouse power supplies (which come in 135- and 180-watt versions).

The ZW is sold with two 180-watt power supplies for a maximum output of 360 watts. If coupled with two more 180-watt PowerHouses, it can provide a maximum output of 720 watts. If you don't want to buy two extra PowerHouse units, you can, with an adapter wire, use other transformers to fill the two vacant power slots.

Please note, however, that to meet modern consumer safety requirements, you can't channel more than 180 watts to a single line.

There are four plugs for mating powerhouses on the transformer, and there are four banana-style output plugs. A-U and D-U are for train control, and B-U and C-U are for accessory or throttle operation.

You run trains with the large handles on the ZW. You manage the accessory power with two "thumb" throttles, located inside the larger handles.

Interestingly, for operation in the TrainMaster command-mode, the new ZW takes the place of the PowerMaster unit. You'll still need to buy a CAB-1 heldheld remote control and a Lionel command Base, but the ZW's functionality helps make it easier to take the step into Command-controlled O gauge train operations.

CTT review: October, 2001

180-WATT POWER SUPPLY "BRICK"

This is Lionel's current, standard power brick. It can be used in conjunction with the new ZW or the no. 12969 TrainMaster command set to operate AC-powered trains. By "brick," we mean a power unit, but no controller.

The 180-watt power supplies have a good reputation as being reliable, bulletproof electronic components.

▲ CW-80 80-WATT TRANSFORMER

Basic starter set or post-starter set power supply. Features two pairs of banana-plug connections for track power and accessory power. The accessory line output can be set to a variety of wattages – a particularly nice feature.

The initial versions of this 80-watt transformer had a few quirks. A number of early CW-80s were made with the power/ground posts wired backward. This isn't a problem when you're running a railroad with just the CW-80 providing the power, but operators ran into difficulties when trying to wire early production CW-80s in series with other transformers. The wiring issue was corrected, and newer CW-80s are fairly trouble-free performers.

These transformers are fan-cooled, a major plus, and 80 watts is a good size for a new railroader who needs a little extra capacity.

CTT review: November 2003 (Lionel Train Robbery set review), January 2005 (Polar Express set review)

▲ POWERMAX 30-WATT BASIC TRANSFORMER

This bare-bones starter-set transformer can power the short trains that come with a starter set and perhaps an expansion pack, but not much more. It's an adequate transformer as long as you never plan to expand your layout far beyond the contents of a starter set. Otherwise, after you've upgraded to a more powerful power supply, this would be a good choice for running accessories. We encountered no bugs in our set testing.

CTT review: March 2007 (NASCAR set review)

▲ 1.7-AMP ACCESSORY POWER TRANSFORMER

An inexpensive, self-contained accessory transformer. Good, low-voltage supply for whatever might need a little juice on your layout.

MTH ELECTRIC TRAINS

▲ Z-4000 400 WATT TRANSFORMER

There are many operators who argue that the Z-4000 is to modern era layouts what the classic Lionel ZW was to postwar layouts. The first modern, high-powered model railroad transformer to attain the Underwriter's Laboratory seal of approval, the Z-4000 helped hobbyists move away from 40-year-old ZWs. When first released in the late 1990s, it was in a class by itself, featuring built-in volt and amp meters, 400 watts of power, and the then-new banana plug.

This is a fairly bulletproof modern transformer. CTT's two Z-4000s have been in continuous use since 1998.

CTT review: September 1998

Z-750 75-WATT TRANSFORMER

A 75-watt power supply intended for starter sets and small layouts.

Z-1000B100-WATT ACCESSORY POWER SUPPLY

A single-block power supply with no controller. Can be used on a DCS-controlled layout with a no. 50-1017 TIU/Barrel adapter cable for $9.95 and a no. 50-1003 DCS Track Interface Unit (TIU) for $179.95.

▲ Z-1000 100-WATT TRANSFORMER

A robust 100-watt power supply, standard with some MTH sets.

A generally well-regarded transformer, with few if any bugs. Its relatively high power level will ensure the transformer won't become obsolete when you buy a second locomotive.

MODEL RECTIFIER CORP.

▲ 70-WATT THROTTLEPACK

Just announced as we went to press, this is a brand-new transformer for the O gauge market. It is a two-piece (controller and power block) unit delivering 70-watts for train operation.

Model Rectifier has served the O gauge community for many years with a series of transformers that feature a variety of power levels and accessories. Its product line is well served by three current models: the 270-watt Pure Power Dual, the 130-watt Pure Power AC, and the Throttlepack.

▲ 270-WATT PURE POWER

The Pure Power Dual is an excellent 270-watt transformer, with a retro style designed to appeal to the Tom Corbett (the old TV character) in all of us. The four volt and amp meters have a 1950s techno appeal, and they are functional too.

This is a solid, all-around transformer. Four meters, six buttons, and and twin handles give this a high-tech look. Operationally, it is first rate. If MRC ever did a tweak of the design, replacing the conventional outputs with banana plugs, this would be a perfect transformer. CTT's sample has been in regular use since 2003.

CTT review: March 2004

▲ 130-WATT PURE POWER

A robust and rugged 130 watt transformer. The large red handle and bulky box suggest that it packs some serious railroading power inside. CTT's sample has been in steady use since 2002.

CTT review: September 2002

WILLIAMS TRAINS

150-WATT TRANSFORMER

Williams by Bachmann offers a 150-watt AC transformer designed to operate a moderate- to large-sized layout.

Powerful, basic, no-frills transformer for cost-conscious operators. In addition to the standard throttle, horn and bell buttons, the model features a brake function that lowers the voltage to the track without requiring throttle manipulation.

RULE OF THUMB FOR POWER REQUIREMENTS

Over the years the CTT staff has developed the following rule of thumb for the wattages needed from a transformer to support train operations.

- Single-motor locomotive: 60
- Single-motor locomotive with whistle and smoke: 90
- Two-motor locomotive: 105
- Two-motor locomotive with whistle/smoke: 115
- Motor-powered accessories: 20-25
- Vibrotor-powered accessories: 10-20
- 12-volt light bulb (each): 3
- 18-volt light bulb (each): 5

TABLE OF TRANSFORMER DATA

MFGR	MSRP	Throttles	ACCS lines	Watts	Trk Volt	Accs VA	Meters	Type
AMERICAN MODELS								
SDK-2053	$ 99.95	1	none	75	17	none	none	all-in-one
ATLAS O								
1000080	$79.95	1	1	80	18	16	none	all-in-one
1000030	$39.95	1	none	30	14	none	none	all-in-one
LIONEL								
ZW and 180-w PowerHouse power supply	$429.99	2	2	18	18	to 180	none	component
CW-80	$124.95	1	1	80	18	18	none	all-in-one
PowerMax	set item	1	none	30	30	none	none	all-in-one
32923 Accessory transformer	$36.99	none	1	18	none	18	none	all-in-one
MTH ELECTRIC TRAINS								
Z-4000	$429.95	2	2	400	21	14 and 10	volt/amp	all-in-one
Z-1000	$99.95	1	1	100	18	14	none	component
Z-750	$79.95	1	none	75	21	none	none	component
MODEL RECTIFIER CORP.								
Pure Power Dual	$369.98	2	2	270	21	14	volt/amp	all-in-one
Pure Power AC	$229.98	1	1	130	17½	14	none	all-in-one
Throttlepack	$114.98	1	none	70	17	none	none	component
Tech 4 600	$79.98	1	1	50	17½	18½	none	all-in-one
WILLIAMS BY BACHMANN								
Transformer 150	$149.95	1	1	150	16	12	none	component

Everything you need to know about soldering

How to solder like a pro

by Myles J. Marcovitch

William Zuback

Soldering, so important when building a toy train layout that operates without a hitch, is much easier than you think. The author's many tips and techniques will help you master this skill.

Soldering may seem like black magic to many of you. You've marveled at it for years and always wondered how it's done, but doubt you can ever learn. Let me convince you otherwise! It's easier than you think to make strong and reliable soldered electrical and electronic connections for toy train layouts.

Simply put, soldering is the joining of two metallic surfaces with a metal or alloy (mixture of metals) of a lower melting point. Soldering is an ancient art used in making many metal objects and jewelry, in addition to electrically conductive, permanent connections between wires and electrical components.

Solder, flux, and oxides

Various metals are combined to create alloys used to make solder. These metals include silver and gold (used for jewelry and mechanical connections of great strength) and lead and tin for plumbing and electrical work as well as low-melting-point solders for special purposes.

I'll focus on lead and tin solders. Even though many solders are free of lead, I recommend that you always wear surgical gloves when soldering to avoid handling lead or any chemicals used in place of lead.

Both lead and tin solders for electrical work are generally 60 percent tin and 40 percent lead or 63 percent tin and 37 percent lead. Electrical solders also contain a core of rosin that melts at a slightly lower temperature than the solder alloy and serves to prepare the joint for solder adhesion.

This material, called a "flux," is needed to remove oxide from a joint so the solder can join the wire to the terminal and keep a joint from oxidizing while it's heated. Oxides form when metals are exposed to oxygen in our atmosphere. Even metals that we assume are corrosion proof, such as stainless steel, actually have a thin oxide film that forms to prevent further oxidation (rust) from taking place.

Solder joins metallic surfaces by dissolving into the metals and forming a mixture (amalgam) with them. Once formed, these surfaces can no longer be physically separated. Quite often the solder joint is stronger than the wires it holds.

This mixing can occur only on a surface free of oxide and other contaminants. You can remove oxides by abrading the surfaces with a file or wire brush, but some chemical cleaning is still needed to keep oxides from continuing to form when heat is applied during soldering. Rosin flux removes these oxides and forms a protective layer on the heated connection to prevent further oxides from forming.

Normally, the rosin can do the cleaning, if the surfaces are either freshly manufactured or "pre-tinned" with a coating of solder as part of their manufacturing process. However, there are conditions when rosin isn't enough.

One condition involves the blackened center rails on much of the hi-rail track that's currently made. Another is found on old copper surfaces (including circuit boards) that haven't been properly protected or stored. You must remove these oxide coatings mechanically before soldering.

In addition to preventing the solder from properly joining with the connection materials, oxides can prevent heat transfer. Oxides are insulators and, as such, even a very thin film can greatly reduce the heat flow from the soldering iron to the work surface.

To promote heat flow and reduce the time needed to heat the joint, I create a "heat bridge" by melting a bit of solder at the point where the tip of the iron contacts the work. This transfers heat to the work but doesn't provide enough solder to make the joint.

Ensuring good results

Now let me share some specific techniques to help you get good results when soldering. First, rid yourself of the notion that "if a little solder is good, a whole lot must be better." This is completely untrue!

The holding power of the joint is between the underside of the wire and the metal to which it's joined. Solder buildup above the wire serves little purpose other than to obscure the joint and make inspection harder.

WILLIAM ZUBACK

Fig. 1. Soldering can be done with an iron (right and center) or a gun. These tools are available at electronics supply, hardware, and home improvement stores.

ALL REMAINING PHOTOS BY ADAM GAGEIK

Fig. 2. After you place the wire in your wire stripper, squeeze the handles to strip it without leaving any nicks.

Joints should show the contours of the wire as well as the components of the joint assembly. You should be able to see individual wire strands through the solder layer.

The idea of using very little solder seems counterintuitive since we tend to think that solder needs to be obvious if a joint is to be strong. But it has definite advantages. For one thing, it enables you to inspect joints without having to pull them apart.

Don't be misled by globs of solder on the joint. If there is a glob where the solder curves in on itself, the joint probably won't function.

When solder isn't adhering properly to the joint surfaces, it tends to ball up like mercury. If it doesn't have anything better to stick to, it sticks to itself and so there's no solder joint! Sometimes the solder is only being held by the solidified rosin flux. Pry on it and it pops off.

Joints, when properly formed, have a concave appearance. The solder feathers out to a thin film from the wire towards the work surface and is very thin and strong. Only enough solder is melted into the joint to give this appearance. Once the strands of the wire begin to get obscured, you're beginning to put on too much solder.

A second point to remember, especially with joints that must primarily carry electrical current, is to prevent crystallization when the solder changes from a liquid to a solid. If the joint is moved at the critical point of solidification, the crystals that form have a very high electrical resistance.

For the high-current power circuits that power toy trains, this crystallization can cause excessive voltage losses that lead to sluggish locomotive performance far from the power source. In low-current situations found in electronic systems (signaling, train detection, and so forth), crystallized joints can cause circuit failure.

To prevent crystallization (also known as a "cold solder joint"), keep the joint still before and during soldering (especially when cooling and solidifying) and use "eutectic solders" (37 percent lead and 63 percent tin).

Start with adequate mechanical support, which means crimping wires to hold them in place, pressing on a wire with another tool, or putting tension on a wire that has a right-angle bend at the end. Remember that mechanical connections are only to keep a join motionless while the solder cools and creates a bond.

As for eutectic solders, these special alloys prevent cold joints by changing from a liquid to a solid instantly. Other types of lead/tin alloys have some degree of transition phase where the solder is neither solid nor liquid.

Admittedly, eutectic solders are more expensive and can be hard to find, but they make creating flawless connections easier for those of us cursed with unsteady hands.

There's a third point you need to keep in mind before getting started: Molten solder flows toward the heat source.

If a joint is cleaned properly, the temperature is high enough, and the correct solder is used, the solder will flow through the joint toward the iron on the opposite side of the connection.

Be aware that there are cases known as "tinning," where you put solder on the iron first and then transfer it to the work piece. Tinning involves applying a thin film of solder to a surface or wire before making the joint. This speeds up the soldering process, which is beneficial when you have many connections to make.

Although you don't have to tin solid copper wires, it's helpful to tin stranded wires. Tinned wires are easier to form before they're attached to a connector, and they tend to avoid separating and thereby causing short circuits when an errant strand touches another circuit. Tinning is also useful for preparing tinplated rails, particularly blackened center rails, to join with feeder wires.

The tools you'll need

Now that you're familiar with the concept and techniques of soldering, let's consider the tools you'll need to get started.

Soldering iron: Although steel rails require more heat than wire terminals do, it is surprising how small an iron can be used when joints are properly prepared. Even 40-watt chisel-tipped irons are sufficient for almost any application. The chisel point is convenient since it provides a broader contact area to heat larger connections.

Good irons use plated tips that don't require filing. If you file these tips, you destroy their ability to resist oxidation and soon the tip becomes black, pitted, and unusable. Tips require some chemical cleaning periodically using some rosin flux.

You should always draw the soldering iron tip across a wet sponge before approaching any joint. The wet sponge forms steam, which removes the baked rosin that forms on the tip and gives a nice bright surface ready for soldering.

Irons can be obtained in many

different wattages and price ranges (fig. 1). They can also have highly sophisticated temperature-control systems. If you plan on soldering electronic components, rectifiers, and light-emitting diodes (LEDs), you may want to consider a temperature-controlled iron. Otherwise simple irons work fine.

What about soldering guns? I have used one, but find that the time needed for it to heat each time the trigger is pressed becomes annoying when I have a lot of soldering to do.

Solder: Use only rosin-core solder and get the thinnest gauge solder you can for the wire size you're using. Heavy gauge (thick) solders are for plumbing and not wiring. They draw heat from the joint, which increases the time it takes to complete and makes it harder to control the addition of solder to the joint.

Also you may want some liquid or paste rosin flux for applying by brush before soldering. That's useful when you're soldering to steel rails, which aren't readily soldered and benefit from additional flux. Never use solders or pastes containing acids or chlorides because they're so aggressive they can cause a joint to corrode to the point of failure.

Wire stripper: I prefer the Ideal Stripmaster or its equivalent. My pair is 25 years old, but it still works flawlessly and produces excellent stripped ends. These are lever-action tools that have a series of accurately cut dies for different gauge wire. The stripper cuts and removes the insulation in one squeeze without nicking the wires (fig. 2).

You must avoid nicked wires because they form a weakness that can break the wire if it's flexed. Nicking isn't so bad if a wire is to be fixed permanently to a surface. However, if the wire is to move, nicks will cause trouble.

Simple "V-type" strippers (available at any hardware store) can be difficult to use and can scrape and nick wires if not used carefully. Penknives and hobby knives do a poor job and should be used only in a pinch.

Cutters: I prefer using flush-cut wire cutters because they leave a very clear edge. When cutting the leads on electronic components, such as LEDs, you'll transmit only a little shock along the wire to the inside of delicate components when you orient the flush edge towards the component.

But watch out for the other end! The cut scrap will be propelled rapidly away from the tapered jaws of the cutter and can hurt your eyes or switch machines.

Pliers: Although most long-nose pliers will do, try to find the kind without cross-hatch grooves cut into the jaws. These grooves, intended to prevent the work piece from slipping out, can mar wires and create more places for fractures to start. Round-nose pliers, used by jewelers to form chain links, make it easy to form neat loops and bends without damaging a wire.

Work holders: A bench vise with a wire loom attached is useful when tinning wire and holding components and their wires before soldering. Proper support of the joint before soldering is the best way to avoid causing a cold joint. Other holders are also valuable, such as a "third hand" that can support work and keep it still while cooling.

Tinning wires

At last, armed with knowledge and tools, you're ready to earn your degree in soldering. Let's go through the steps needed to prepare stranded wire and then make a connection. Don't worry – the process is easier than you think.

Toy train operators generally use 12 to 22 gauge stranded copper wire. Some manufacturers "pre-tin" their strands of copper, which does make the wire easier to solder.

However most copper wire is not pre-tinned and, depending on how long it has been sitting on a shelf, may be highly oxidized and difficult to solder. By contrast, tinned wire requires less heating time to make the final joint while using less solder.

So let's start by tinning stranded wire. First strip away insulation to expose about ⅜ inches of bare wire. Tighten the wire's twist to keep the strands together by twirling the insulated wire with one hand and restraining the bare wires lightly between the fingers of the other.

Fig. 3. To tin wire, first secure it facing down so gravity will draw off excess solder. Then place a drop of solder on the tip of your iron to conduct heat to the wire. Place the iron beneath the wire and additional solder above. As the new solder melts, pull the iron and solder down and off the wire.

Fig. 4. When you have finished, the solder should saturate the wires yet leave the strands visible.

Place the wire in a wire loom in a bench vise or support the wire in any other way with the bare end facing downwards. Then wipe your soldering iron on the wet sponge and melt a drop of solder on its tip. Now place the iron under the wire near the insulation. At the same time, place the solder on top of the wire over the iron (fig. 3).

The instant the solder melts, pull the iron and the solder down and off the end of the wire. This pulls the excess solder off the wire and keeps the tinning at its thinnest possible level. If the tinning is too thick, it is difficult to bend the wire to make a joint.

If the job is done correctly, the wire strands should be completely

Fig. 5. Soldering a wire to track requires that you first remove any black oxide finish on the center rail. Then apply a coating of rosin-core flux on the rail.

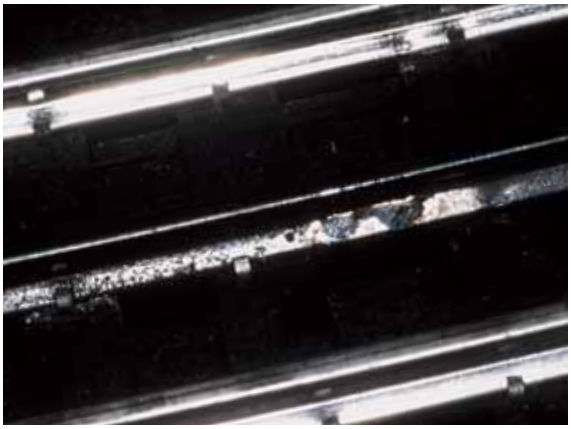


Fig. 6. Place the solder and your iron on the rail and slide the iron backward to coat the bare rail with solder. This will prepare the rail to accept the wire.

visible with the solder penetrating through all of them and leaving the wire tip solid (fig. 4). Solder should not have penetrated under the insulation or damaged it in any way.

Soldering feeder wires to rails

With the wires tinned, you're ready to make some connections. The most common soldered connections used on toy train layouts link feeder wires to track. These wires can be joined to either the bottom or the side of the rail. I prefer the side because, though it's less attractive, it gives more surface area to which to join and is easier to solder since the ties aren't in the way.

In either case, you must remove the black oxide from the center rail on track such as the GarGraves track I'm using on my layout. The outside rails, which are usually tinplated steel, already hold solder quite well and don't need abrading.

A rubberized abrasive wheel on a motor tool does a good job of removing the black oxide; quit when you see shining steel showing evenly on the surface. The black oxide is only a few microns thick and doesn't need much work to get it off (fig. 5).

Use a small amount of liquid or paste rosin-core flux and then coat the area on the rail to be joined. Prepare the wire by flattening the tinned end modestly with long-nose pliers (be careful you don't separate the strands by crushing it completely). This flattened surface gives a broader contact area on the rail and makes soldering easier.

Prepare the rail by first cleaning the iron on the wet sponge, lightly tinning the iron for a heat bridge, and placing the iron tip at one end of the area on the rail to be soldered. After a few seconds, while still holding the iron on the rail, melt the solder right where the tip touches it.

When solder starts melting into the joint (not on the top of the iron), pull the iron tip backwards and drag it along the surface of the rail while moving the solder with it (fig. 6). When you reach the other end of the soldering area, raise the iron and the solder.

There should be a nice and shiny coating of solder on the steel. If the solder tries to adhere to the iron, either the work piece isn't hot enough or the joint area simply isn't clean.

Now comes the tricky part. Take the flattened tinned wire, and place it on the rail (the solder on the rail should have solidified). Since the rail and the wire have both been tinned, you won't need to add more solder. All the solder you need is on the joint. You just have to heat the rail and the wire long enough to melt them together.

You need to hold the wire firmly in place during this process. Press a small flathead screwdriver to the back end of the wire near the insulation. Be sure to press firmly yet not so hard as to cause the wire to jump off the rail.

Once you've stabilized the wire, just place the cleaned iron (wet sponge again) onto the tinned end of the wire and press lightly until you feel the solder in the wire melting under the iron (fig. 7).

Hold it for a few seconds – but not too long – and remove the iron while holding the screwdriver securely. Blow on the joint to cool it quickly and remove the screwdriver.

Next, use a little isopropyl alcohol to remove the excess rosin. Even though it isn't corrosive like acid or chloride flux, rosin can mar the surface. The resultant joint should be shiny, with all the wire strands visible (not spread out) and firmly fastened to the track (fig. 8).

Connecting wires to terminals

A second project involves connecting wires to terminals. Tin the wire as before but don't flatten it. Then, depending on the size and shape of the terminal, bend the wire to fit into it. Crimp the wire to secure it to the terminal, but avoid overdoing it. Just stabilize the wire – it's not going to provide the strength of the joint.

Next, put some tension on the wire by taping it down or hanging a weight from it so it doesn't pull against the terminal. With the wire stabilized and the crimp pulled tightly into the joint, take a clean soldering iron and touch the tip to a point on the terminal that touches both the wire and the terminal.

At this touch point, melt a bit of solder to form a heat bridge. Immediately after, move the solder to the other side of the joint and continue melting solder until the joint is saturated but the wire isn't obscured. This step should take no more than a couple of seconds. Using the thinnest solder is advantageous because it allows you to control the amount of solder melted.

Without jostling the wire, remove the solder and the iron from the joint. Let the connection cool for a few seconds. Don't move the work piece until the solder has solidified. Clean it with isopropyl alcohol if you wish.

The finished joint should be shiny and not grainy. It should show all the contours of the components in joint, but be fully covered with solder. And it should feather out at the edges and not have a convex appearance.

Connecting one wire to another

The third procedure to learn involves joining one wire to another – either a tap into the side of a bus wire or a splice of two wires end to end.

You'll deviate from what I've specified by not tinning the wires before you make the mechanical connection. That way the wires will be as flexible as possible. Once you heat the joint, solder will penetrate sufficiently.

Create the mechanical connection so the wires are securely fastened together. To make the splice, strip ¾ inches of insulation from both ends of the wires being joined. Twist the bare ends as you did before to ensure that all the strands are well contained.

Place the two bare ends together facing one another and hold them at a 45-degree angle. Wrap one wire around the other, usually about two or more turns, then wrap the remaining wire around the first wire. Stabilize the wires and melt a bit of solder on the iron tip for a heat bridge. Place the iron under the splice to be made.

Position the solder on top, and melt it into joint until it penetrates. Once the solder flows completely into the joint, remove the solder and the iron and let everything cool.

After inspecting the joint, use electrical tape or heat-shrink tubing to insulate the exposed splice. Remember to put the tubing on the wire before you make the splice, or you won't ever get it on.

To shrink the tubing, place the hot iron below but not touching it. Heat rising from the iron will shrink the tubing. You can also use liquid insulation products for this purpose.

To make a 90-degree junction for joining feeder wires to the ground or power bus under a layout, follow the same steps with a few changes.

Strip back a section of the bus wire where you want to make the junction. Do this carefully, as stripping a wire in the middle is tricky because the insulation has nowhere to go and must compress. Then go ahead and neatly trim the excess insulation with a utility knife.

Wrap the feeder wire around the bus wire two to three times until it's secure (remember, neither wire has to be tinned). Place the iron with its heat bridge under the junction so you apply heat to both wires at the same time. Melt solder from above to saturate the junction, stopping when it has penetrated.

Remove the solder and the iron, and inspect the joint. Wire strands should still be visible, but the wire should be completely covered with a layer of solder. Insulate the joint with electrical tape and you're finished.

Congrats! You're a pro

These three types of solder joints illustrate the basic techniques needed to make successful soldered connections. The pre-tinning technique is useful when connecting wires to flat surfaces where it's difficult to stabilize the joint from moving.

Since one hand has to hold the iron and the other has to hold the tool to keep pressure on the wire, there's no hand left to apply the solder. Therefore, coat both surfaces (wire and substrate) in advance and heat them to join them.

In the wire/terminal connection, you mechanically stabilize the joint by bending and crimping the pre-tinned wire so you have both hands free, one for the iron and one to apply the solder.

In junctions and splices we don't tin the wires so we can twist, bend, and manipulate them to make a secure mechanical connection before soldering.

Follow these techniques and you'll be soldering like an expert. I've used them to teach more than 1,000 people how to make high-quality electronic assemblies, including a few with poor vision and shaky hands. Magnification cured the first problem and proper support when soldering joints took care of the second.

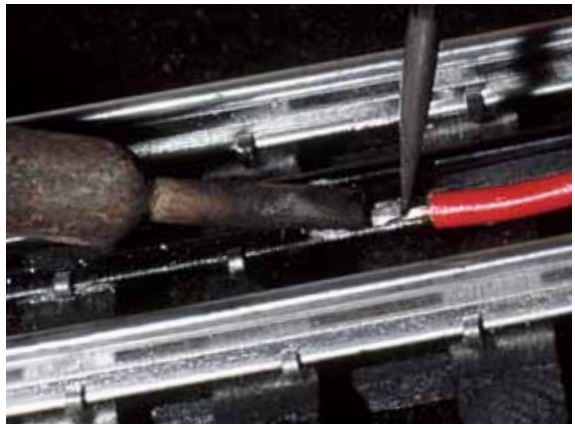


Fig. 7. Flatten the wire with a non-serrated long-nose pliers. Then stabilize the wire on the tinned rail and heat the wire with your iron to melt the wire solder to the rail.

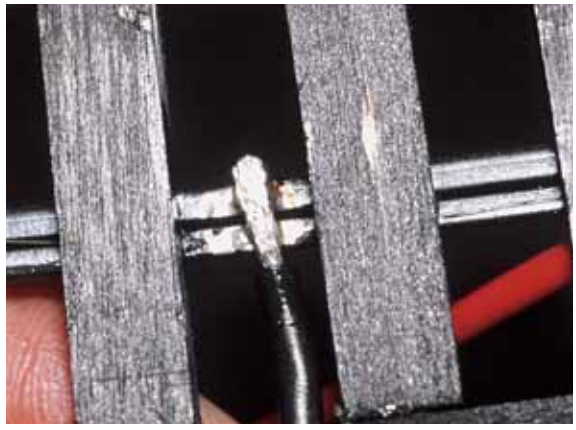


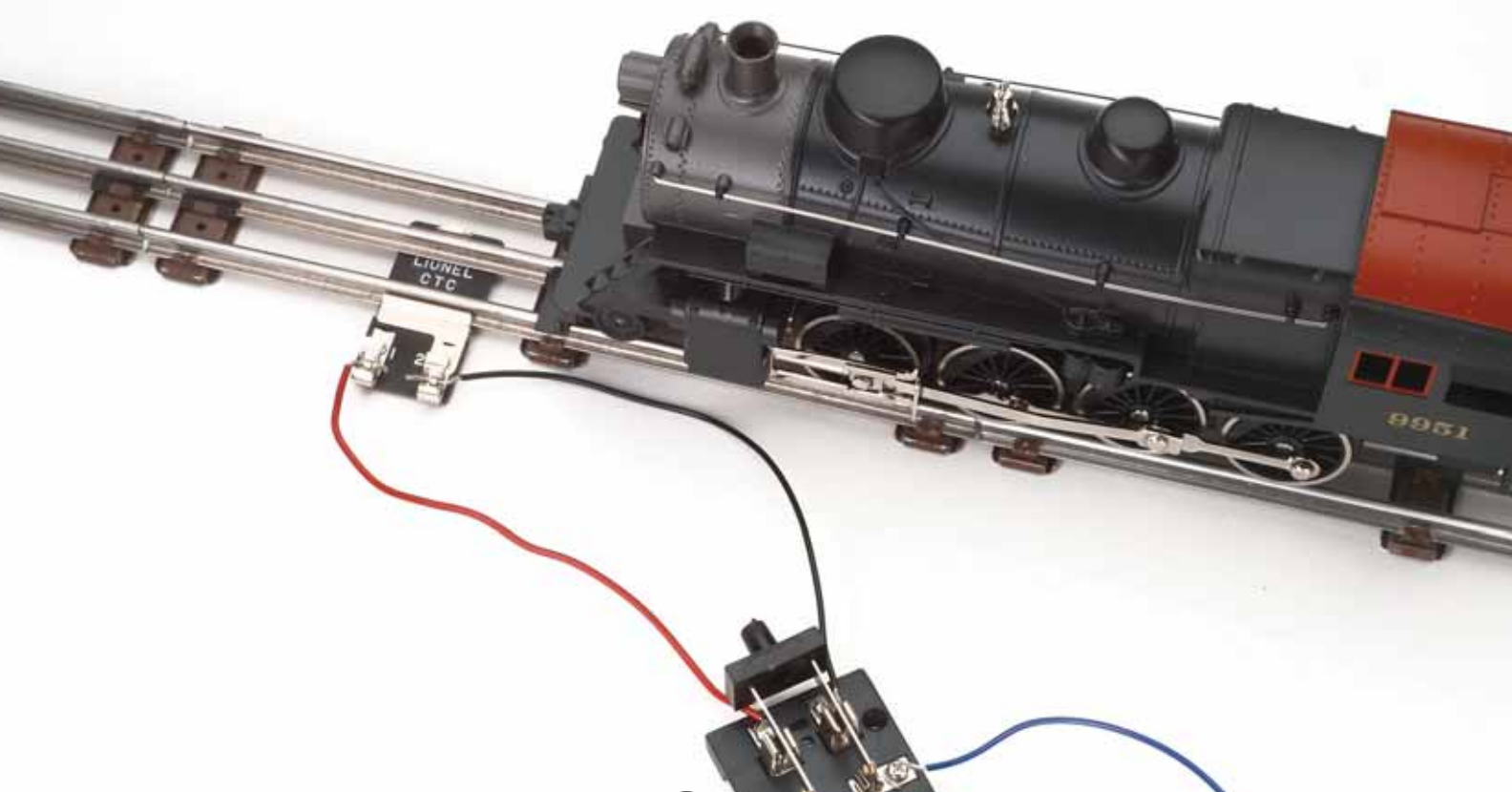
Fig. 8. If everything has been done correctly, the wire strands of the soldered connection will show through, all the while providing full electrical contact.

Get out your tools and warm up the iron. Then set up a magnifier, rest your fingers on the edge of a bench vise or worktable, and make some perfect connections. The heat may be on, but you can relax and feel confident that you know all the secrets of soldering. CTT

To learn more about soldering, check out Basic Wiring for Model Railroaders: The Complete Photo Guide, *which is available from Kalmbach Publishing Co. To order item no. 12212, call 1-800-533-6644 or email kalmbachbooks.com.*

CLASSTRAIN.COM

For more information on the electrical aspects of toy trains, please consult our website classtrain.com



Basics of electrical switches

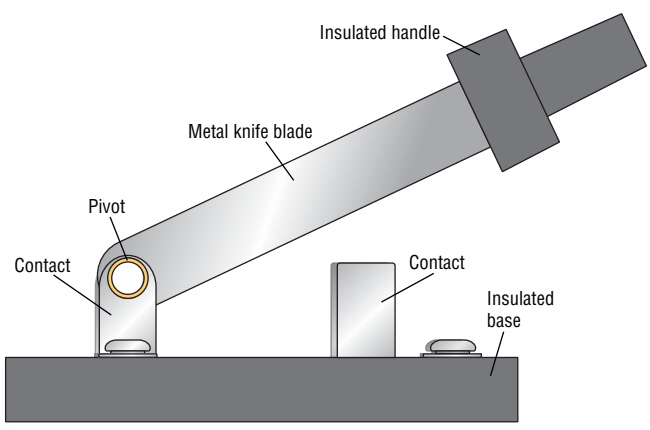
Knowing the right switch puts you in control of your layout

by Dennis Eichenberg

USE THE TERM "SWITCHES" around toy train enthusiasts and most will visualize a piece of track. But take a look at a toy train layout and you'll see that toy train operators are no strangers to the "other" kind of switches.

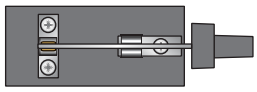
Electrical switches are as vital to the performance of a layout as the track kind. They are also more mysterious to some hobbyists.

Selecting the right switch for various toy train applications can be a bit confusing, and selecting the wrong switch can cause your trains to malfunction. If you select the right switch, it will provide proper train operation, ensure long and reliable switch life, and look professional on your control panel.

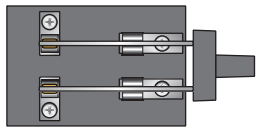


One of the most basic electrical switches is the knife switch. When the handle is up the switch is off, and when the handle is down the switch is on.

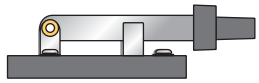
Illustrations by Kellie Jaeger



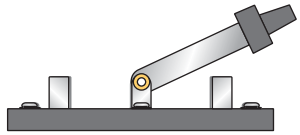
A single-pole switch controls one circuit.



A double-pole switch controls two circuits simultaneously.



A single-throw switch completes a circuit in one position.



A double-throw switch completes a circuit in two positions.

What is a switch?

An electrical switch is a device that connects or disconnects a circuit.

The most familiar example, a light switch used in homes, ordinarily has two contacts. When the switch is turned on, the contacts are joined, current flows in one contact and out of the other, and the light bulb turns on. When the switch is turned off, the contacts are separated, the current stops flowing, and the bulb goes dark.

A common switch is the knife switch. A pivoted knife-like blade is pushed into a metal slot shaped like a "U" to turn the circuit on. The blade is pulled out of the metal slot to turn the circuit off.

Lionel's 1928 catalog included the no. 437 illuminated switch signal tower, the no. 438 illuminated signal tower, and the no. 439 panel board, which all included knife switches to turn various electrical devices around the layout on and off.

But switches have other configurations, enabling functions that can be more complex.

Poles, throws, and styles

Electrical switches have standard designations. Before you go out to buy any, you should understand the basic configurations.

The number of *poles* refers to the number of circuits controlled by a single switch. So "single-pole" means that the switch controls one circuit, while "double-pole" switches control two circuits. Most of the switches used on train layouts are single-pole types.

The number of *throws* refers to the number of positions of the switch that complete a circuit. Thus a "single-throw" switch has one "on" position, while a "double-throw" switch has two "on" positions. Most of the switches used on toy train layouts are single-throw types.

Switches also come in many styles. A toggle switch is operated by a lever, a rocker switch by rocking the contacts into position, and a slide switch by sliding the contacts into position. A rotary switch, as the name implies, has contact points arranged in a circle and usually requires a separate knob to indicate the position of the switch. A pushbutton switch is operated by depressing a button.

Rocker switch

Pushbutton switch

Toggle switch

Slide switch

Rotary knob

Rotary switch

Specialized, maintained and momentary

Many specialized switch types are available that may be useful on your train layout.

Key switches require the use of a key to turn the switch on, much like the ignition switch in your car. A key switch is very useful if security is important – such as where a duck-under bridge can be raised at the push of button.

Illuminated switches are available with indicator lights installed. These can facilitate train operation and look great on your control panel.

A switch can either be "maintained," which holds the position selected, or "momentary," which reverts back to its original position after you let go of the switch lever or button.

Center-off switches select no circuits when set in the center position.

Combinations of these basic switch configurations are available to provide a wide variety of functions.

Voltage and current

The most important switch specifications are its voltage and current ratings.

In alternating current (AC) circuits, such as most toy train applications, the voltage and current vary. In direct current (DC) circuits, they do not. Therefore, when turning a switch on or off in a DC circuit, the load is more severe and shortens switch life. Only a switch identified as a DC switch should be used in a DC circuit.

Any switch with a voltage rating greater than 25 volts AC is fine for most toy train uses. Most switches are rated well above 25 volts, so voltage-rating limits are usually not an issue when you're purchasing switches for your layout.

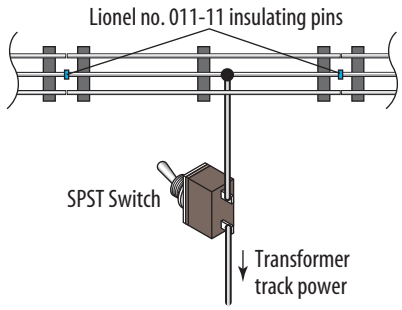
However, the current rating of a switch is very critical and must be observed carefully. A toy train locomotive under way usually requires up to 3 amps. An operating accessory can require up to 2 amps. A typical large train lamp requires 0.3 amps.

The switch you select must have a minimum rating to handle the load. In general, when dealing with track and locomotives, switches with a current rating of 7 amps or more should be used.

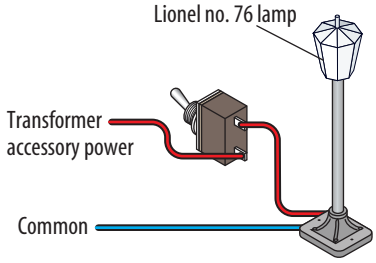
Switches are available in a variety of contact materials. For special applications requiring very low currents of 0.1 amps or less, use gold-plated contacts, which don't tarnish and permit low currents to flow properly. Silver contacts are recommended for current above 0.1 amps. Although silver tarnishes, the electrical energy of the circuit is sufficient to break through the tarnish to provide reliable performance.

Switches are available with screw terminals or solder terminals. Either is acceptable for toy train applications, but those with screw terminals allow you to make changes more easily. On the other hand, solder terminals provide a better electrical connection.

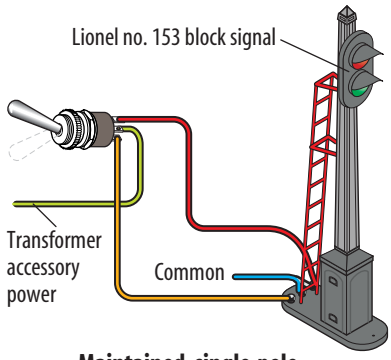
See the chart on the next page for some sources for electrical switches.



Maintained, single-pole single-throw (SPST) switch

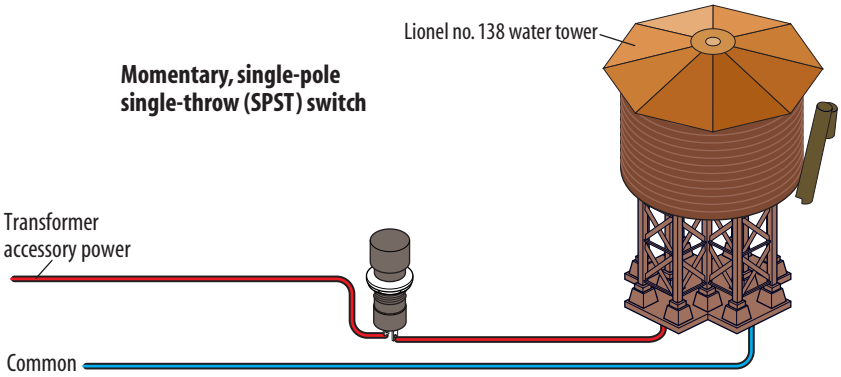


Maintained, single-pole single-throw (SPST) switch

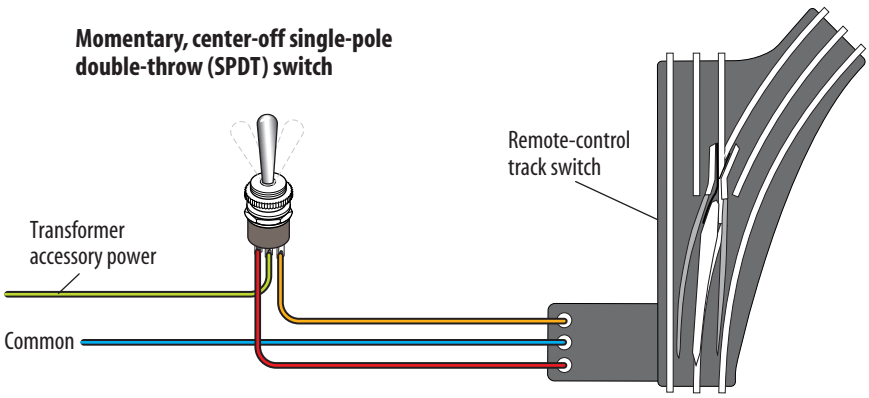


Maintained, single-pole double-throw (SPDT) switch

Momentary, single-pole single-throw (SPST) switch



Momentary, center-off single-pole double-throw (SPDT) switch



Applications

Selecting the right switch for the right function will provide many years of reliable switch operation.

Most switches used for toy train applications are maintained, single-pole single-throw (SPST) switches. These switches are ideal for controlling track power and accessories where maintained contacts are required.

A maintained, single-pole double-throw (SPDT) switch is useful for controlling an accessory such as a Lionel no. 153 block signal. In one position the switch turns on the green lamp, and in the other position the switch turns on the red lamp.

A momentary, single-pole single-throw (SPST) switch is useful for controlling an accessory such as a Lionel no. 138 water tower, in which the operating water spout is turned on for only a few moments at a time.

Lionel, MTH, K-Line and other model train manufacturers use momentary, center-off, single-pole double-throw (SPDT) switches to operate remote-control turnouts. CTT

Switch sources

You can buy many types of switches at local hardware stores, home centers, and auto parts stores. Common and, in particular, specialty switches also are available at these electrical product suppliers.

Allied Electronics
7410 Pebble Dr.
Fort Worth, TX 76118
1-800-433-5700
alliedelec.com

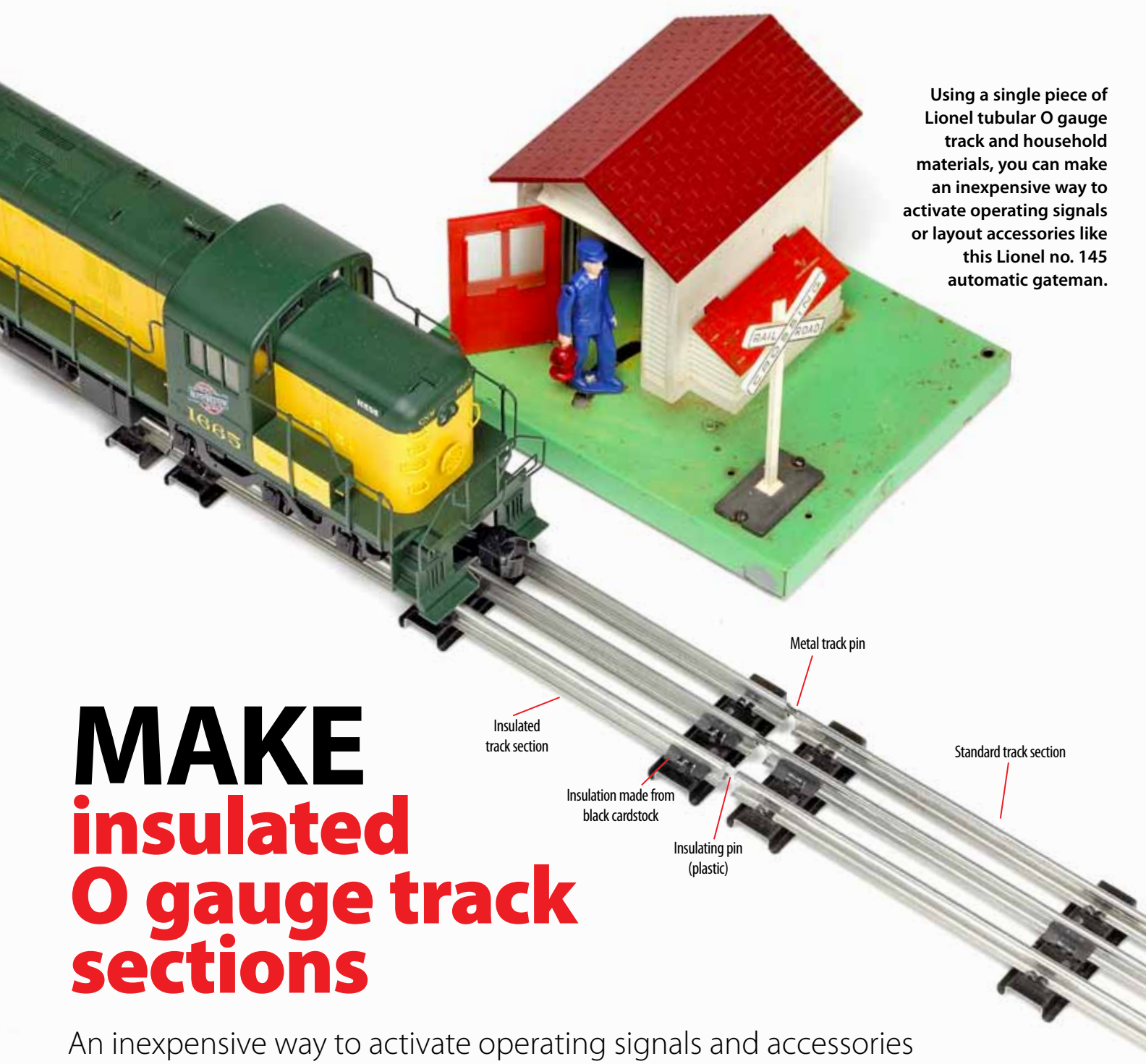
Digi-Key Corporation
701 Brooks Ave. S.
Thief River Falls, MN 56701-0677
800-344-4539
www.digi-key.com

Jameco Electronics
1355 Shoreway Rd.
Belmont, CA 94002-4100
800-831-4242
jameco.com

Mouser Electronics
1000 N. Main St.
Mansfield, TX 76063-1514
800-346-6873
mouser.com

Newark InOne
4801 N. Ravenswood
Chicago, IL 60640
800-463-9275
www.newark.com

RadioShack Corp.
Suite 1200
300 W. 3rd St.
Fort Worth, TX 76102-2912
800-843-7422
radioshack.com



Using a single piece of Lionel tubular O gauge track and household materials, you can make an inexpensive way to activate operating signals or layout accessories like this Lionel no. 145 automatic gateman.

MAKE insulated O gauge track sections

An inexpensive way to activate operating signals and accessories

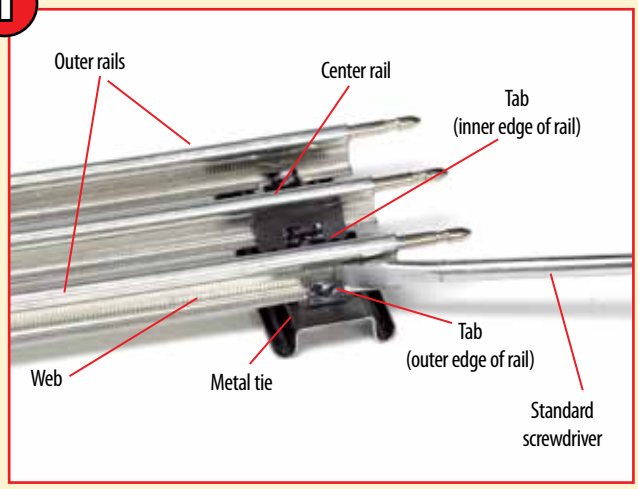
story by John Rusterholz | photos by Jim Forbes

Even with a wealth of new O gauge track styles and brands currently available to layout operators, many of us still have a ready supply of O gauge tubular track sections we can use to build a layout. Tubular track is time-tested and proven to be relatively easy to use. Additionally, just about any configuration of tubular track you'd need can be either purchased or fabricated from existing sections.

Case in point, countless articles have suggested replacing the spring-loaded Lionel no. 153C contactor, used for controlling accessories such as block signals and crossing gates, with an insulated track section. While it is possible to buy track with an insulated outside rail, using the techniques described in this article, you can modify a standard track section cheaply and easily to accomplish the same thing. There are just a few things you'll need to understand before you begin this simple project.

On a section of three-rail track, the center rail is already insulated from the metal track ties and the outside rails, but the two outside rails are electrically connected to each other by the metal ties. By insulating one of the outer rails from the ties (and from the neighboring track sections), you can use it to sense when a train is present on that section of track. This technique works on either straight or curved sections, though it's generally easier to work with straights. The process works on either regular O or O27 gauge track. Let's get started.

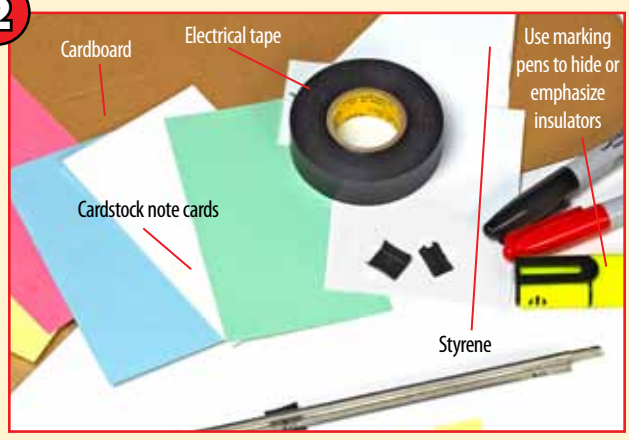
1



Disassembling the rail

TO MAKE AN insulated O gauge track section, you'll need to disassemble a piece of Lionel (any vintage) straight track. First, decide which outer rail you'll remove, and then use a screwdriver with a flat and narrow blade to carefully bend up the two metal tabs that attach a single rail to each tie. Hold the screwdriver parallel to the rail and insert it with the blade flat against the web of the rail. After you loosen the metal tabs, grasp the outer rail with your fingers and then twist it free from the track section.

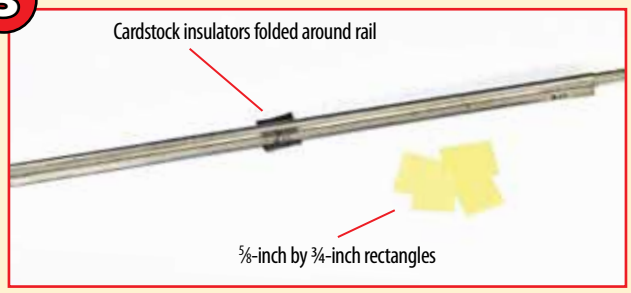
2



Insulating materials

OVER THE YEARS, layout builders have used cardboard, cardstock, electrical tape, fiberboard, paper, and plastic to electrically isolate a rail. For this project, I used 3- by 5-inch note cards made from cardstock. Using white cardstock will help you locate your insulated sections at a glance. You can make them stand out even more by using colored cardstock or painting the white note cards with a brightly colored highlighting pen or marker. Alternatively, if you prefer to mask these insulated sections, use black cardstock or color the white note cards with a black marker.

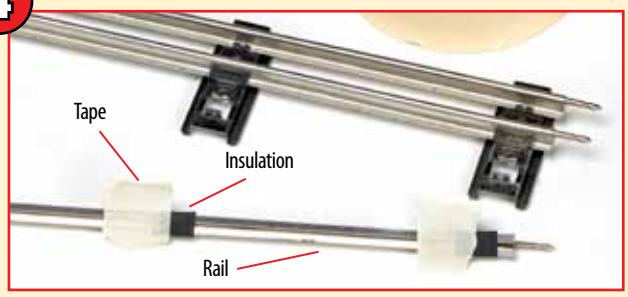
3



Shape the insulation

CUT OUT SEVERAL ⅝-inch by ¾-inch rectangles from the note cards. This is the same size rectangle Lionel uses for its center-rail insulators, but it's fine if your pieces are slightly larger. You'll need to make one piece of insulation for each tie. To install the cardstock material, fold each insulator around the bottom of the rail as shown.

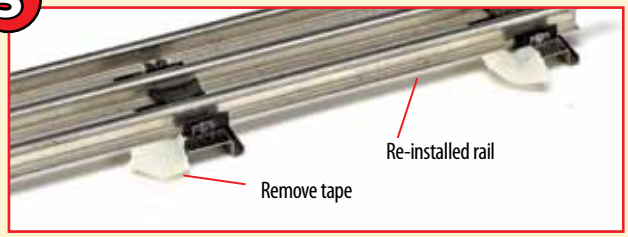
4



Hold the insulation in place

IT CAN BE challenging to re-install the rails while keeping all three insulators in the proper position to align with the metal ties. To make things easier, use masking tape to hold the insulators to the bottom of the rail. The tape is only temporary, so you can remove it once everything is back in place.

5



Reinserting the rail

IT'S TIME to reinsert the rail into the tie. In an effort to avoid damaging the insulators while reassembling the track, use pliers to gently bend the metal tabs open a bit further. Now, place the rail, with its insulators taped in place, against the inner set of tabs and then twist it into position. Check to make sure the insulators are centered on each tie. If not, simply lift the rail enough to reposition the insulator.

6

Keeping the track gauge true

TO AVOID damaging the ties or altering the track gauge (width between the two outer rails), you'll need to use the proper tools to bend the metal tabs down into place. In this case, the most important "tool" is a 5-inch-long strip of wood that measures ½ inch by ½ inch in cross section. Before working with the metal tabs, insert this strip under the tie. The wood supports the tie and keeps the top surface flat and true as you bend the tabs.

7

Bend the tabs down

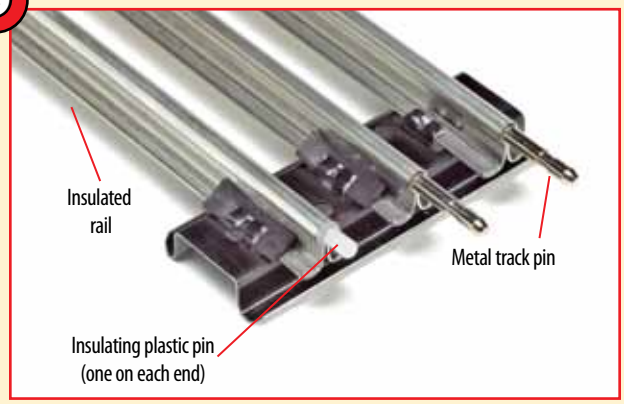
USE A STANDARD screwdriver to force the tabs into position. First, hold the screwdriver against the outer tab, and then lightly tap the end of the handle with a hammer. Continue bending the outer tab until its angle matches the angle of the corresponding inner tab. After that, alternate work between the two tabs on the tie, with the goal of keeping the rail centered. Continue this process on the remaining ties.

8

Testing the insulation

BEFORE LEAVING the workbench, it's a good idea to make sure that the insulation is doing its job. Use a multi-meter to check the resistance (or lack of continuity) between the two outer rails. Minus the multimeter, you can also test for continuity using a transformer and an 18-volt bulb with leads attached.

9



Replace pins

IF YOUR TRACK section will serve as a signal or accessory control, then you'll need to electrically separate the insulated rail from the adjoining pieces of track. Use pliers to pull the metal pins from the ends of the insulated rail, and then replace them with plastic, fiber, or wood pins that insulate but retain the rail alignment.

REMOVING
metal pins from track

MOST LAYOUTS formed using tubular track require you to remove one or more pins from the ends of track sections. I've heard numerous suggestions on ways to do this, but my favorite technique works as follows.

On a hard workbench or layout surface, stand a piece of track on its end, with the metal pins directed upwards. Now, use a lightweight hammer (ball-peen or tack) to tap the pin inward. Yes, inward. Don't force the pin all the way into the rail end, but just move it far enough (about ¼ inch) so it breaks free of the rail crimp that grips the notch found on each end of a metal pin. Finally, grab hold of the pin with a pair of pliers, and you'll find it comes out easily, without deforming the end of the rail.

INFORMATION STATION

To purchase more information about wiring and electricity for toy train layouts, go to classictoytrains.com and scroll down to "Information Station" at the bottom of the page. Click on the link and you'll find downloadable files addressing layout wiring, command control systems, and transformers.

FROM THE CTT STAFF

WIRING DIAGRAMS

How to use bus wiring on your layout

Layout builders have been using "bus bars" for decades, but the idea can be puzzling to newcomers. A bus bar is simply a metal bar or a large wire that supplies power to several electrical circuits.

In a way a bus bar is like an interstate highway: there's a main route (the bus bar) with periodic ramps (the feeder wires). Feeder wires can be connected to accessories and/or track blocks.

You can use a metal bar or strip as a bus, but it's easier to work with wire.

Because bus wires carry a larger load – in this drawing, the bus wires carry electricity for all of the streetlights – they need to be heavier than feeder wires. For a medium-sized layout, 14-gauge wire will work just fine. If in doubt, use one size larger. Also, with a bus wire, you can add new accessories by just tapping into the bus. – *Neil Besougloff*

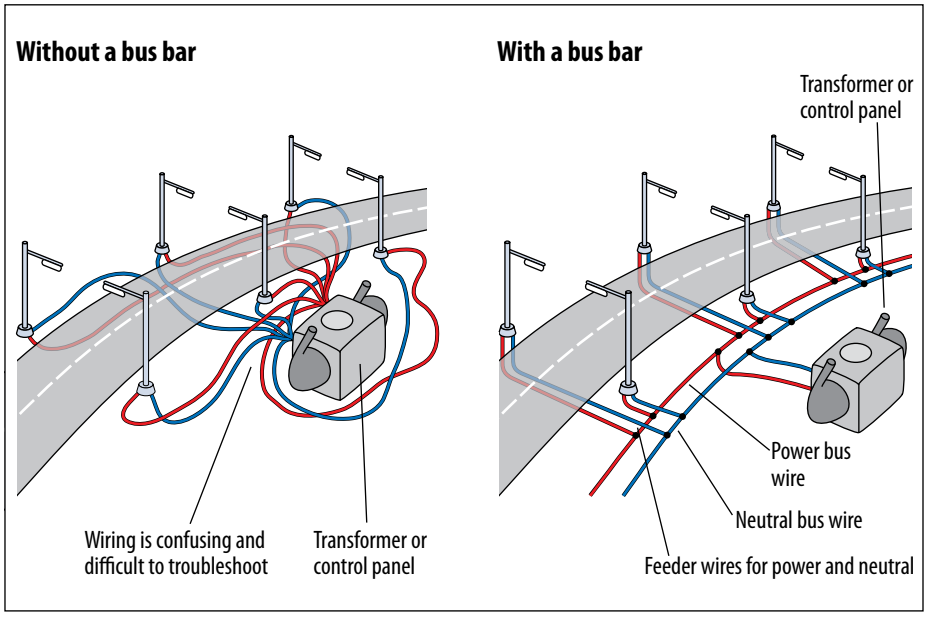


Illustration by Theo Cobb

FROM THE CTT STAFF

WIRING DIAGRAMS

'Star' wiring helps MTH's control system

MTH's Digital Command System uses digital signals to command trains, but it delivers them through a layout's network of wires and rails in a manner different from Lionel's system. That difference led MTH to recommend the use of "star" wiring on DCS layouts to enhance signal reception.

Center and outside-rail feeder wires radiate from a terminal barrier strip to different points on a layout like rays of light, hence the "star" name. Star wiring may require more wire than bus wiring. Star wiring isn't a must for DCS, and many hobbyists have successfully added DCS to existing bus-wire networks.

Correction: In March's issue, we used a 1960 Lionel pamphlet as a wiring source. It has an error that we repeated. The no. 1033 transformer U terminal is neutral or return. – *Neil Besougloff*

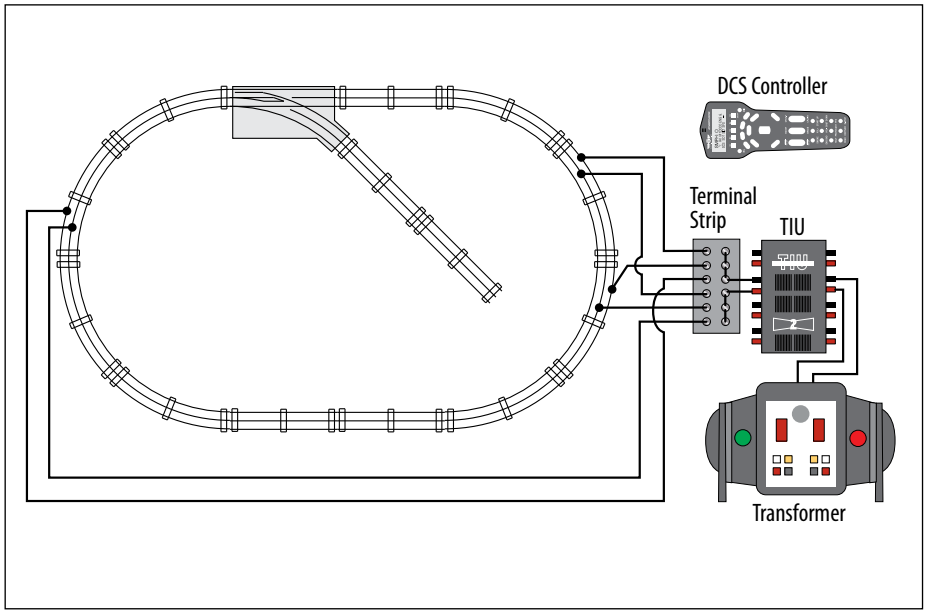


Illustration by Kellie Jaeger

SPECIAL REPORT

DCS delivers

by Neil Besougloff

MTH's new Digital Control System makes MTH ProtoSound 2.0 locomotives shine in command-control mode operation. The hand-held controller offers an array of selections made easier with an LCD screen.

It's here. MTH announced its eagerly anticipated Digital Command System (DCS) in February 2000. The system was delayed, and then it had to be de-bugged. At last, it has been delivered.

CTT associate editor Bob Keller and I each received our DCS components just a few weeks before the deadline for this issue of Classic Toy Trains. Without further delay, here's our preliminary report.

Control competition

DCS is MTH's response to Lionel's TrainMaster Command Control (TMCC). Comparisons between the two systems are inevitable, and discussions between brand-loyal operators can run hot.

DCS allows you to run multiple command-equipped locomotives independently on the same layout. DCS allows you to change any of several dozen locomotive and track special-effect features to your heart's content.

DCS also allows you to operate any brand or vintage locomotive in conventional mode by simply raising and lowering track voltage according to your input on the hand-held controller. If all of that sounds familiar, it should – Lionel uses the same concept.

MTH's awaited control system hits its target

But DCS and TMCC are not the same. MTH designed DCS to operate ProtoSound 2.0 locomotives in command mode. Lionel designed TMCC to operate TMCC-equipped locomotives in command mode. Both DCS and TMCC also can run all non-command locomotives of any brand – from modern Williams diesels to postwar Lionel steamers – in conventional mode. DCS is new and benefits from the latest in 21st-century technology. TMCC's core design is nearly a decade old.

And in a marketing coup for MTH, you can run a TMCC-equipped locomotive in command mode with DCS, however, you cannot run a ProtoSound 2.0 locomotive in command mode with TMCC.

What you need for DCS

You need two MTH components to add DCS on your layout: the hand-held controller and the Track Interface Unit (TIU). You need a third component – a transformer of your choice – to supply power to the track. Any brand or vintage transformer will do, but you're better off with a transformer that uses a modern circuit breaker.

There is only one peripheral DCS component – the Accessory Interface Unit (AIU) – to control switches and accessories. You don't need an AIU if you only want to run trains.

The DCS hand-held controller has the body of a TV/VCR remote and brains like a cell phone. It has a liquid crystal display (LCD) screen, 31 buttons, and a notched thumb-wheel throttle that also doubles as a menu selector. That's seven more buttons than Lionel's CAB-1, and the buttons along the top of the DCS controller are "soft" keys that can take on numerous secondary functions, depending on your menu selection and LCD screen display.

The screen shows you the name of your locomotive, its track, its speed rate, and the status of auxiliary functions such as sound and lighting. You can spend an entire evening experimenting with just sound effects (I did).

All menu items are reached using the throttle thumb dial. When you highlight the menu you want to open, depress the thumb wheel as if you are clicking on a mouse and you'll enter that menu. Good in theory, but both Bob and I found that we sometimes depressed the thumb wheel inadvertently when we meant to scroll it a notch instead.

Like a home computer, the hand-held controller has a memory. It remembers the locomotives on your roster, their settings, and the track settings from your previous session.

The TIU is the Grand Central Terminal of DCS. Power flows in, and power with an added digital signal flows out. The TIU receives a 900-Mhz bandwidth signal from the handheld controller and converts that signal into a digital code overlaid onto the AC power that's going to the track. While Lionel's TMCC "broadcasts" signals to TMCC locomotives by using the rails as a transmitting antenna, DCS sends signals directly to locomotives through the metal rails and metal pickup rollers.

The TIU has four banana-plug input sockets and four banana-plug output sockets. The inner two are command-only sockets and the outer two are variable-voltage sockets. If you want to switch between command and conventional operation, you'll need to use the variable voltage sockets.

The TIU itself needs power to operate (it displays a red LED indicator when turned on). If you are using the command-only sockets the TIU is automatically powered. If you use the variable-voltage sockets as I did, you must add jumper wires to the inner socket or use a small, independent transformer (like the block transformer from an MTH or Lionel starter set) that has a mini-jack to plug into the side of the TIU.

The TIU has a 12-amp circuit breaker that resets automatically. Each output socket can put up to 190 watts to the track, the same wattage as a single side of an MTH Z-4000 transformer. MTH recommends you do not exceed 190 watts per input socket.

In addition to the equipment, you also need a few hours to digest the 120-page instruction manual and watch the half-hour video supplied with each DCS set. I'm just as guilty as the next guy when it comes to not reading the instructions, but DCS is sophisticated and you need to understand what it does before you can do it yourself. The manual describes ProtoSound 2.0 operation thoroughly, but is brief on conventional control setup, especially relating to the TIU sockets.

Wiring and electricity

MTH has publicized "home run," or "star," wiring to optimize the flow of electricity and digital signals to the far reaches of your layout. Home-run wiring uses a pair of wires leading from a power source to a terminal strip. From that terminal strip additional pairs of wires run to each track-feed location. If the terminal strip is under the center of your layout, the wiring pattern looks like a star.

The TIU adds a stream of digital signals to the AC track power. Because the DCS signal must travel through the wires and then through the rails to reach a ProtoSound 2.0 locomotive, and because the locomotive "talks" back and forth

with DCS, a clear signal path is critical. Star wiring creates a good signal path. (TMCC broadcasts a radio signal to its locomotives using the track as a broadcast antenna, so wiring schemes don't especially matter.)

Unfortunately, most toy train layouts use "bus" wiring, where hot and common wires run beneath the length of a layout and feeders to the track branch off like limbs of a tree at set intervals. As a wiring scheme, it's neater, more economical, and it's probably how our fathers taught us.

Both Bob and I have bus wiring on our layouts, but our DCS components worked fine. You may have different results specific to your layout.

You'll want to jump right in, but there is some required reading and viewing: The 120-page DCS instruction booklet and DCS videotape.

Command operation

Getting started in command mode is different than anything you have done before. You don't assign your locomotive a number; its smart internal circuitry already knows its name and its odometer and chronometer readings. Very slick, and by using the menus you'll know all of this information as well.

Place your ProtoSound 2.0 locomotive on the track, navigate to the "add engine" menu, and press the thumb wheel. DCS then sends out a digital signal to the track asking, "Is anyone out there?" The ProtoSound 2.0 locomotive will reply "Here I am," with its name such as RK M-10000 (short for the RailKing M-10000 streamliner), and DCS will add it to your named-and-numbered roster.

The roster is electronically stored for you in the hand-held controller, so the next time you power up your layout, the locomotive's already there. If you have more than one yellow Union Pacific M-10000 streamliner, or your train buddy Frank brings over his M-10000, you can change the electronic roster to read "Frank's streamliner" to avoid confusion.

Both Bob and I struggled at times to add locomotives to our rosters. We experienced frequent "RF signal range" messages which, according to the DCS manual, meant our hand-controllers were out of radio-frequency range. Not so, since we were only a foot away. After three or four tries DCS "found" the engine and the LCD screen then displayed a message congratulating us for adding the locomotive to our roster.

Good digital signal strength is mandatory when adding a locomotive to the DCS roster. The "catch" is that you don't know whether your signal strength is strong or weak until you've got that first locomotive up and running (see the sidebar story on page 48). Bob and I later found out our layout signal strength was fine for command mode operation, but marginal when it came to that data-heavy digital process of adding locomotives to our rosters or moving locomotives from the inactive to the active roster.

Operating locomotives is just as innovative and different as the process of putting them onto your roster. You drive your car in miles per hour. With DCS, you operate your train in scale mph and the LCD screen is your dashboard speedometer. Each notch of the thumb wheel is 1 scale mph. Bob checked the accuracy of the scale mph reading with a stopwatch and a measured section of track and found the LCD readings varied with his readings by only 1.5 to 2.1 scale mph.

I ran as many different ProtoSound 2.0 locomotives I could get my hands on in command mode. The locomotives

Now, for the fun stuff

DCS digs deep to break new ground with sound and other sensory effects.

Diesel locomotives have eight rpm steps. On my M-10000, the prime mover was screaming by step eight, and I half expected to hear the sound of a piston rod bust through the engine block.

On the steam side, you have three other smoke output levels to choose from: minimum, medium, and maximum. Labored chuff is just that, with an even higher-level smoke output to match. The chuff rate per wheel revolution can be changed to any number from 2 to 16 on the fly.

There's nothing quite like the Proto-Doppler effect. Proto-Doppler is to audio what forced-perspective is to visual. Stand at one end of your layout and start the Doppler recording. As your locomotive completes a lap of your layout, hit the button again. Now, as the locomotive reaches the far end of your layout, its sound system automatically notches down to near silence, as if the locomotive was far, far away. As the locomotive returns to you, its sound increases, reaching a peak as it passes before you. Very cool.

Tossing aside realism, DCS also offers voice and music. Plug a portable cassette or CD player into the TIU jack and instead of the sound of EMD prime movers, you can hear Ozzy Osbourne screeching from your diesel's underbelly speaker. Don't expect Bose-quality audio, though, since the locomotive speaker is no bigger than a silver dollar.

Use the microphone and AM-frequency transmitter built into the DCS handheld remote, and you can be a dispatcher or a Karaoke singer via the locomotive speaker. Or you can announce to your spouse you'll be skipping dinner tonight to play with trains.

You can record up to 15 personalized sounds (like Bugs Bunny saying, "What's up Doc?") and replay them on command.

There are other sounds you can play with: coupler slack, station and freight yard sounds, maintenance, re-fueling, wheel clickety-clack, and train wreck (it sounds like mild wreck with a few "are you all right?" voices).

You also can selectively control sound volumes, like the horn independent of the bell.

MTH offers downloadable locomotive sounds from its website that you can drop into your PC and then into your locomotive.

Beyond sound effects, you can record and play back routes or other controller inputs, and there are chronometer and odometer readings for each locomotive.

To steal a phrase from a luxury car salesman, DCS has all the toys.

– Neil Besougloff

responded to all throttle inputs and all menu-driven sound and special-effect commands. Specific button functions, such as boost, brake, couplers, smoke on/off, rev up/down, direction, and emergency stop, all worked properly.

Using a thumb wheel to change speed also changes the nature of toy train operation. To reach a full stop from 20 scale mph requires wheeling through 19 notches on the thumb wheel. That takes about 10 seconds of thumb action, so you'll need to think ahead when operating or you'll be using the panic stop button frequently.

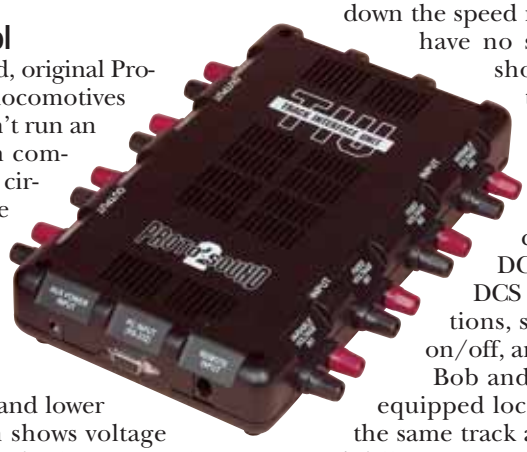
Even if you're quick with the thumb-wheel, the digital commands take a moment to shuttle back and forth from the controller through the TIU and to the locomotive, so locomotive throttle response will never be as quick as slapping down the handle of a postwar ZW. Using the direction button stops the locomotive much quicker, but short of a panic stop.

Re-starting after a derailment isn't as simple as righting your locomotive and turning up the power again. The hand-held controller remembers your last settings, so though your locomotive is half off the track and the circuit breaker has thrown, the controller still shows you cruising at 40 scale mph with 18 volts on the track.

Even without a derailment, if you shut down your layout without taking the time to throttle down and then shut down the hand-held controller properly, you may find your locomotives out of sync at your next operating session.

Conventional control

DCS operates all MTH LocoSound, original ProtoSound, and horn or whistle-only locomotives in conventional control only. You can't run an original ProtoSound locomotive in command control – it does not have the circuitry to receive DCS commands. We tested more than 20 different brand and vintage locomotives with DCS in conventional mode. All locomotives, even exotics such Ace, ETS, and hot-rodded MTH engines with QSI upgrades, worked.



In conventional mode, you raise and lower the track voltage. The LCD screen shows voltage readings instead of scale mph. Voltage begins at zero. One click of the thumb wheel brings the screen to 5 volts, and each click thereafter raises the track-voltage readout a half-volt up to 22 volts. I checked the LCD screen voltage readings with two different voltmeters and the readings were off slightly. Turns out the LCD screen doesn't show actual voltage; it shows the proportion of power (in increments from 5 to 22) on the track relative to total voltage available. It's a little confusing, and for most of us the difference doesn't matter.

Lionel's TMCC uses pulses of AC power for refined low-voltage control in conventional mode. Each turn of the CAB 1 dial is a tiny increment. DCS uses a "phase control" similar to TMCC, but adds filtering to assist original ProtoSound locomotives and some QSI sound-equipped locomotives that respond poorly to the phase-altered but non-filtered power.

I ran numerous can-motored locomotives – from starter set Lionel diesels to Atlas O's original SW switcher – in DCS conventional mode. The electrically efficient locomotives all leapt to a start when the DCS controller moved from zero directly to a 5-volt reading. The effect is not very satisfying. Postwar and prewar locomotives, with their power-hungry Pullmor motors, don't get under way until 8 volts or more, so they did not suffer the same abrupt starts.

Remember the clinks and clanks to change the features of original ProtoSound locomotives? DCS uses menu-driven commands to let you change original ProtoSound settings. It's similar to changing settings using a Z-4000 transformer, but without the dramatic "ca-chunk ca-chunk" sounds as the transformer toggles power settings to reach a programming level.

Lionel TMCC with DCS?

Yes. DCS can operate TMCC-equipped locomotives in command mode as well as its own native ProtoSound 2.0 locomotives. How? MTH sells a cable that connects the TIU to the back of Lionel's TMCC Command Base. The TIU sends signals to the Command Base in a language the Command Base understands and the Command Base sends signals to TMCC-equipped locomotives.

How does the TIU speak TMCC language? Sly MTH used the command coding printed on the back pages of Lionel's TMCC instruction booklet. The digital instructions were given for operators wishing to use a PC instead of the CAB 1 to run their TMCC-equipped layouts. MTH picked up the ball and ran with it.

With the DCS controller I tried 15 different TMCC-equipped locomotives from Lionel, Atlas O, K-Line, 3rd Rail, and Weaver, including locomotives with Lionel's Odyssey speed-control system. Ditto for a pair MTH original ProtoSound locomotives upgraded to TMCC.

While ProtoSound 2.0-equipped locomotives move up and down the speed range in scale mph, TMCC locomotives have no such speedometers. The LCD screen shows a numerical readout based on thumb-wheel clicks, and the TMCC locomotives respond in their own native speed steps. The soft key functions displayed on the LCD screen substitute for any AUX keys on the Lionel CAB 1 controller that aren't part of the regular DCS controller labels. You use the regular DCS controller keys for TMCC AUX key functions, such as sound volume up/down, lights on/off, and engine rev up/down.

Bob and I repeatedly operated Lionel TMCC-equipped locomotives and an MTH locomotives on the same track at the same time. However, the companies' different approaches to speed increments were very evident, and at times that discouraged us from mixing TMCC and ProtoSound 2.0 locomotives in close proximity.

We did have some difficulty with the strength of TMCC signals. My Lionel TMCC-equipped locomotives all responded to commands from the DCS controller, but judging by the flickering headlights on some of the locomotives, the TMCC signal was weak. I tried an Atlas O locomotive with TMCC circuitry, and it balked slightly. An MTH doodlebug that I converted to TMCC ignored most of the signals I sent through the DCS controller and, when it moved, ran around the layout like a banshee.

MTH suggests moving the Command Base signal wire (marked "U") from a track connection to a TIU output jack. Electronically savvy hobbyists have already come up with other modifications, such as adding a diode to pin no. 5 on the cable connecting the TIU to TMCC's Command Base. The diode acts as a filter for the signal's common wire.

Also, MTH is aware of a flaw in the software of the initial shipment of DCS sets. Pushing the direction button for a TMCC locomotive also sends the signal to all TMCC locomotives in operation, not just the locomotive you intended.

MTH's DCS components are designed to accept software upgrades, such as a fix for the TMCC direction-button. The

upgrades can be downloaded from MTH's website (MTH-RailKing.com). You'll need computer cables, a healthy PC (no Macs), a fast modem, the ability to temporarily park your TIU next to your PC, and some general computer savvy when it comes to downloading and uploading files. Full instructions are on the website.

But there's a simpler way for you to use TMCC and ProtoSound 2.0 locomotives at the same time. The DCS controller and the TMCC CAB 1 use different bandwidths to communicate with their base units and different methods of transmitting data to locomotives. Neither interferes with each other. You can set up DCS according to MTH's instructions, but also attach a Lionel Command Base to the track. Under this setup, Bob and I used a DCS hand-held controller to operate ProtoSound 2.0 locomotives in command mode and at the same time a CAB 1 to operate TMCC-equipped locomotives. We didn't witness any shaky signal responses, and even my banshee doodlebug behaved like a Sunday school teacher. Since the DCS signal rides with the AC power to the track, you'll have to provide 18 volts to the track via the TIU, and without some tricky wiring you won't be able to use a Lionel PowerMaster or TPC300/400.

In addition to native ProtoSound 2.0 locomotives, MTH's DCS can operate any locomotive equipped with Lionel's TrainMaster Command Control in command mode. You can use the DCS hand-held controller or your Lionel CAB 1 controller.

Locomotive upgrades

You can't upgrade an original MTH ProtoSound locomotive to ProtoSound 2.0 to run the locomotive in command mode. ProtoSound 2.0 requires everything new from the frame up. You can't convert any other brand of locomotive to DCS, either. MTH does not offer an refit service, and MTH president Mike Wolf said in the past he will not be licensing technology to outside vendors or other train manufacturers like Lionel does with TMCC.

MTH suggests you convert older MTH locomotives to TMCC, since DCS can control TMCC gear. The DCS instruction manual, however, hints that in time and given enough demand, there may be an upgrade kit or at least upgrade parts available

Our advice

Since we first powered up our hand-held controllers, Bob and I have been impressed with DCS. Topping our benefits list are DCS' scale mph operation, its LCD screen, and the long, long, long list of features.

At $299 for a TIU and a hand-held controller, DCS is about the price of a mid-level locomotive. Lionel's basic TMCC setup is cheaper at only $99, but with fewer features. Adding Lionel/IC Controls auxilliary components to create a better match with DCS negates Lionel's big price advantage.

Bob and I found DCS lacking only in low-voltage conventional control and its dependence on home run wiring to boost signal strength, especially on large layouts with numerous track blocks. Initially, we found it more comfortable to operate TMCC-equipped locomotives via the CAB 1 instead of the DCS controller.

Help is available at the MTH website (MTH-RailKing.com) and directly from MTH. Question-and-answer postings, many with specific information that will relate directly to the way you have wired your own layout, can be found on several toy train discussion sites and mailing lists.

This is our initial report on DCS, but, given the system's sophistication, it won't be our last. Rather than rewrite the DCS instruction booklet, we first want to give you a sense of what it's all about.

DCS, like TMCC, won't appeal to everyone. Many hobbyists operate trains just fine with hefty postwar ZW transformers on fixed control panels. But the number of high-tech operators who want more is growing each day.

Our bottom-line advice? Join those high-tech operators, because in our tests DCS delivers. CTT

Signal strength is key

How do you know if your layout wiring is ready for DCS? The system can tell you itself. One of the menu functions in command mode is signal strength. Open the signal strength menu while operating a ProtoSound 2.0 locomotive, look at the LCD screen, and you'll see a fluctuating signal strength reading of 1 through 10. One is a weak signal; 10 is the best. I highly recommend you check your signal strength.

You can boost your signal by cleaning the track. If that doesn't help, add paired feeder wires as suggested in MTH's wiring diagrams in the DCS booklet, although your neat-and-tidy under-layout wiring may become quite messy.

I use bus wiring on my home layout and, even with dirty track, got a reading of between 9 and 6, but with a notable exception. When my locomotive entered a block of track controlled by a relay, the signal strength dropped to between 4 and 2.

As soon as the locomotive left the block, the signal strength jumped back to the 6 to 9 range. The same thing but worse happened when the locomotive went around a reverse loop on my layout that can be toggled on and off. Although the signal was only 1, and the LCD screen flashed "check track" intermittently, I did not lose control of the locomotive.

My co-worker Bob Keller's 16 by 22-foot layout has bus wiring with dozens of feeders but no independent blocks. His signal strength varied from 4 to 1, but he did not lose control of any locomotives, either. Both Bob and I noticed that different ProtoSound 2.0 locomotives showed subtly different signal strengths.

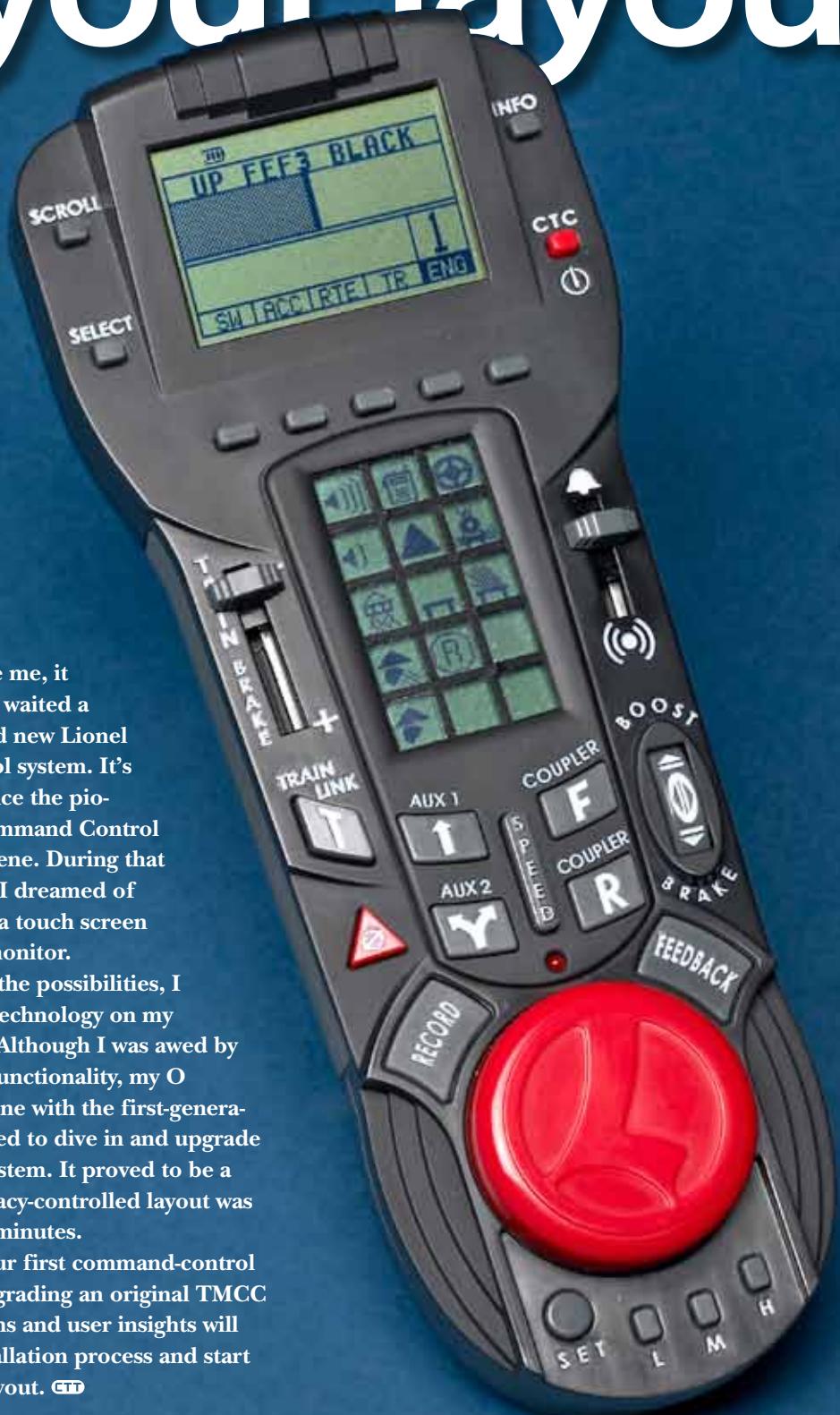
Depending on the design of your layout and the number of track blocks and how they are wired, weak signals may be no problem or a calamity.

Solutions may be as simple as hooking up jumper wires or as involved as adding a second web of wiring to your trackwork. Your layout is as unique as you are. As more operators use DCS there will be more discoveries and more solutions to signal-strength questions. – *Neil Besougloff*

Lionel Legacy on your layout

A GUIDE TO QUICK INSTALLATION AND ENJOYABLE OPERATION OF LIONEL'S LATEST CONTROL SYSTEM

by Kent Johnson
photos by Jim Forbes



If you're anything like me, it probably seems like you waited a lifetime for the heralded new Lionel Legacy command control system. It's been almost 15 years since the pioneering Lionel TrainMaster Command Control (TMCC) system burst on the scene. During that span, I can't tell you how often I dreamed of running trains controlled from a touch screen keypad with a miniature LCD monitor.

After all this time imagining the possibilities, I still hesitated to install Legacy technology on my TMCC-equipped home layout. Although I was awed by the system's new features and functionality, my O gauge layout was running just fine with the first-generation system. In the end, I decided to dive in and upgrade to the new command control system. It proved to be a painless transition, and my Legacy-controlled layout was up and running in less than 15 minutes.

It doesn't matter if this is your first command-control system or if, like me, you're upgrading an original TMCC setup. The following instructions and user insights will help you work through the installation process and start enjoying a Legacy-controlled layout. CTT

Out of the box and onto your layout

While a Lionel 990 Legacy command set (no. 14295) includes essential command-control components, you'll still need a reliable AC transformer to power your track and accessories.

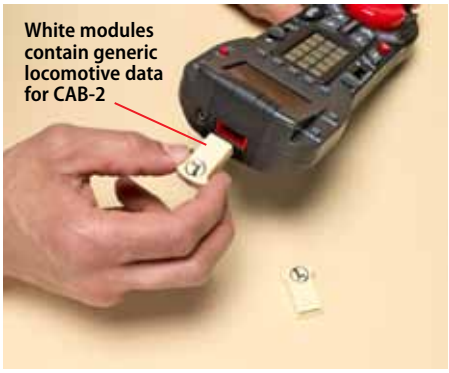
1 Manual and paperwork. Be sure to peruse the enclosed instructions. You may not have the patience to read every word, but even a quick scan will help you become more familiar with new features. Also, check lionel.com to download manual updates.

2 Power supplies. The 18-volt (output) AC transformer supplies power for the base and battery charger. Plug this directly into an unswitched wall outlet to keep the supplied NiMH batteries charging when you're not running trains.

3 CAB-2 controller. The touch screen keypad, LCD, backlighting, and other electronics in the handheld controller draw power from three NiMH batteries. Three AA-size alkaline batteries can be substituted, but you ***must not*** attempt to recharge them.

4 Command base and antenna. Place the base on a horizontal or vertical surface, but retain access to the channel select button and the charger on/off switch on the underside. Allow space for air to circulate around a recharging base.

5 Y-cable. This cable becomes essential if you want to operate trains simultaneously using CAB-1 and CAB-2 controllers. In addition to the Y-cable, you'll need a Lionel TMCC Command Base, PowerMaster or TPC controller, and associated cables.



6 Memory modules. These modules retain data used in the base and CAB-2 remote. White modules are used with the wireless CAB-2 remote, blue modules restore base and CAB-2 factory settings, and orange modules contain locomotive-specific data for the CAB-2 remote.

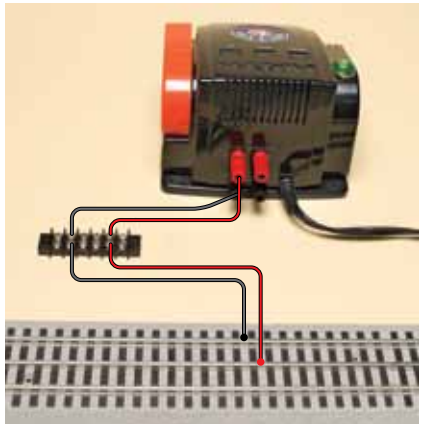
Simplest Legacy setup

This setup adds Legacy command control to a simple 4 x 8-foot layout that begins with a Lionel starter set, complete with FasTrack, a CW-80 transformer, and a conventionally controlled locomotive.

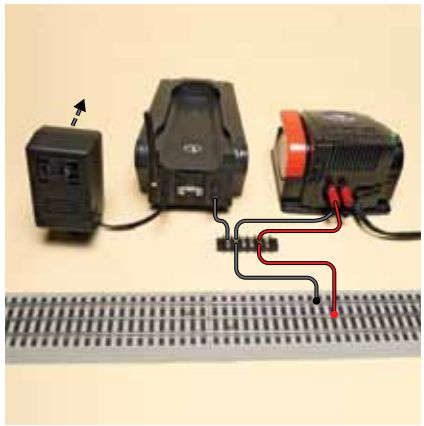
Pick up a barrier strip and 18-gauge electrical wire from a hobby shop or hardware store, select a TMCC or Legacy-equipped locomotive (see "Postwar power performs" on the next page), and then set your timer to 15 minutes – that's all you'll need to start enjoying Legacy on this type of layout.

1 Disconnect terminal track wires. Small layouts with starter set origins often include a terminal track with one wire connected to the center rail and another attached to an outer rail. There's no need to remove this track, but you'll want to disconnect the two wires from the transformer.

2 Add barrier strip and wires. Although the Legacy system requires one additional wire to your track, it's always a good idea to leave room for expansion. That's why I use a barrier strip to channel electrical connections from the transformer, track, and Legacy base.



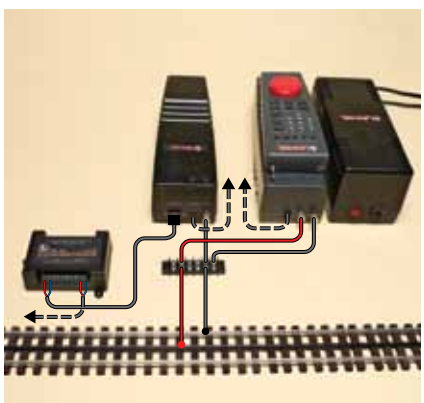
3 Insert Legacy base. Add one Legacy base and one wire from the base binding post to the barrier strip. Use a jumper wire to connect adjacent posts. Plug the Legacy transformer into the base, and you're ready to bring your command-equipped locomotives to life.



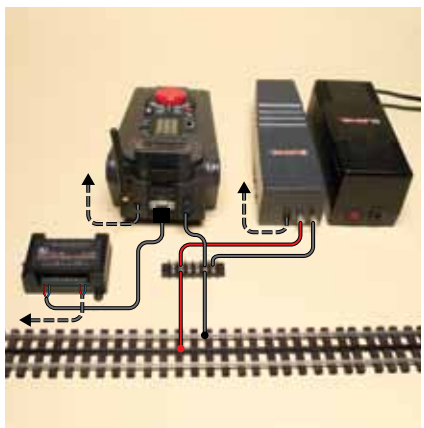
Upgrade from TMCC to Legacy

This scenario replicates the command-control environment I have in service on my O gauge layout. The performance of my first-generation PowerMaster/PowerHouse combos and additional TMCC Action Recorder Controller (ARC) and Accessory Switch Controller (ASC) components has been flawless, so I never felt the need to upgrade them prior to the introduction of Legacy. What amounted to a quick swap of an old TMCC command base for a new Legacy base did have one drawback. With my PowerMaster/PowerHouse setup, I can't use my CAB-2 remote to control non-command locomotives – at least until the Lionel no. 789-PMBR PowerMaster Bridge arrives.

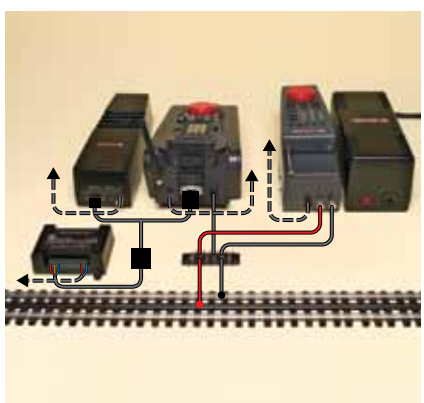
1 Remove TMCC command base. Since TMCC and Legacy talk on different frequencies, you'll need to remove the TMCC Command Base and CAB-1 before installing Legacy. The PowerMaster/PowerHouse pair still provide power to the track.



2 Insert Legacy base. Add one Legacy system, and restore the electrical connections from the base to the track and from the base to any ancillary components, such as an ARC or ASC used to activate track switches and accessories.



3 Two-timing. The use of additional CAB-1 controllers along with a CAB-2 is possible, provided you link a Lionel TMCC Command Base and PowerMaster or Track Power Controller (TPC) to the Legacy base via the enclosed Y-cable.



The more you use any high-tech device, the sooner you begin to appreciate its value. It doesn't matter if it's a cell phone, MP3 player, video game, GPS device, or control system for toy trains. However, that's not to say there won't be moments of frustration. The following collection of tips and tricks represents a sampling of the issues and solutions CTT staff members and other Legacy users have patiently worked through.

ON THE WEB

Subscribers can view a video demonstration of some Legacy tips by going to ClassicToyTrains.com and clicking on "News," and then clicking on "Videos."

Once was lost, now restored. If, for some undetermined reason, your Legacy base fails to transmit a command signal (runaway trains and an unlit "Legacy" logo on the base are two indications of trouble), you may need to restore the base to factory default settings. This should be your last resort, since the process resets all stored names and settings.

Base program module

First, turn off power to the base and CAB-2 and insert the blue "Base" module into the command base slot. Next, power on the base while holding the channel select button. The yellow LED will begin to flash quickly. Release the button and the yellow LED will continue to flash for up to 1 minute. The flashing will stop when the operation ends. Remove the module, restart the base, and layout operation should return to normal.

Although this helpful process was omitted from the printed manual enclosed with my Legacy system, an updated manual can be downloaded at lionel.com

Legacy-equipped locomotive

TMCC-equipped locomotive

Me first! When building a train lash-up using a CAB-2, you'll want to consider which locomotives you include and the order you arrange them in your consist. The trick is to remember that the lead locomotive determines the operating mode (CAB-1, TMCC, Legacy). If a Legacy-equipped locomotive leads a lash-up with a TMCC-equipped locomotive, the TMCC unit will not move. Resolve this issue by programming the TMCC locomotive as the lead unit or by resetting the Legacy locomotive with TMCC attributes through engine info options on the CAB-2.

They're called "memory" modules. Trouble is, I can never seem to remember where I left the one I need. CTT staffer Bob Keller keeps a handle on these small, yet important modules by placing them in an empty 35mm slide case. Large plastic pillboxes work just as well to keep modules cool, dry, and organized – at least until the Lionel LCS memory garage arrives.

CAB-2 to base… can you hear me, over? Legacy operates in the same frequency range as other common wireless devices. Delayed or no response to your CAB-2 input, or a recurring "Base not found" message, are indications of signal interference or quality issue. I've improved operation on my layout by selecting a channel in a higher range – 5 through 9 – and relocating the base above the layout table.

Postwar power performs. You *can* operate prewar, postwar, or modern-era locomotives with a conventional reversing unit using your CAB-2. To do so, your Legacy setup will need to include a Lionel no. 14189 Track Power Controller (TPC) 300 or no. 14179 TPC 400 controller to vary track voltage, which is necessary for controlling non-command locomotives.