TONY'S TECH REPORT

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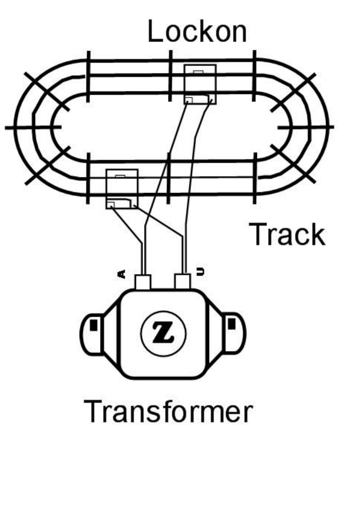
"Basic Training"

OK YOU MAGGOTS!! Line up, shut up, and listen good. I don't want any of you gettin' killed because you didn't hear something important! Well…you may not get killed, but if you don't pay attention to this article, you could wind up with some lousy operating sessions. In my last article, we went over some facts about electricity. Now, we'll go over some basic steps to get your train running.

Getting electrical power to the track is the goal here and completing an electric circuit is how you do it. For any power source there are at least two connections. In the bottom figure, we have a generic transformer with these two connections. For typical alternating current (AC) applications (which covers 90% of all toy train items), we'll call one of the connections "common" and the other "hot". In the figure below, we use the traditional designations of "U" for common and "A" for hot. (Common has an important meaning that we will cover later). To complete a circuit to the track, we run a wire from "A" to the THREE-RAIL lockon "1" connection and another wire from "U" to the lockon "2" connection. The "1" connection is connected to the center rail while the "2" connection is good for either outer rail. If you have a large loop of track, a second (or even third) lockon is recommended. **WHY? Because steel track is a lousy conductor of electricity compared to copper wire.** Just make sure you keep the A-1 and U-2 connections consistent. *This is the atomic level of toy train operating – it doesn't get more basic than this.*

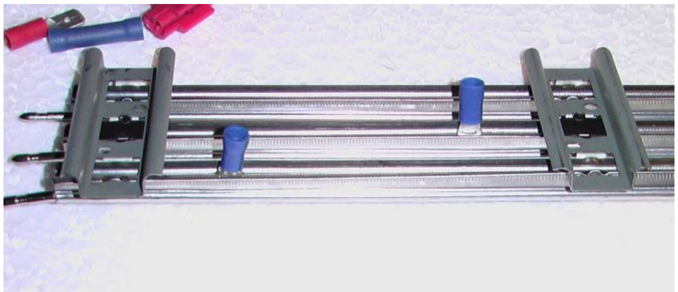


TONY'S AXIOM 1: The amount of fun you have with your layout is inversely proportional to the distance between power connections on the track. (The more power connections you have to your track, the better the train will run.)

But this is just the beginning – we want to be better than this. If your layout is at all permanent, the first improvement is to get rid of the lockons. Oh, they're cute and cuddly, but they go bad real quick. The problem with the lockons is that oxides (or just plain rust) are always building up on the metal surfaces along with collecting dirt and grease. The electrical contact between the lockon and track is always getting worse.

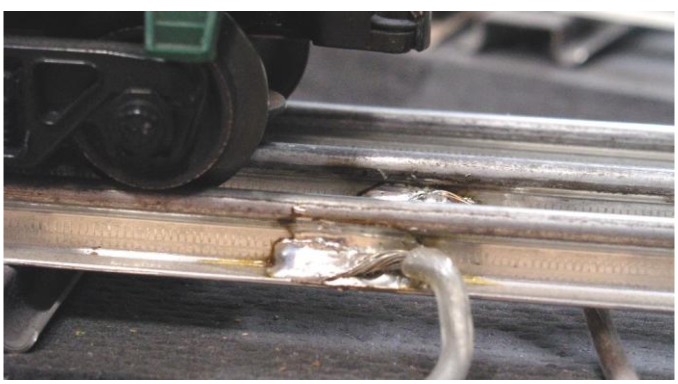
There are two ways around this if you're using traditional tubular steel track. The first is to use crimp terminals. If you want a quick improvement method, this is the way to go. Crimp terminals (shown below) come in ring, spade, and fork styles. Also, there are standard hole sizes for the rings and standard colors for wire weights. Red is good for 22 through 18 AWG, blue is good for 18-12, and Yellow is for 12 through 8. They are available at all hardware stores in the electrical aisle.

In the next picture, you can see how fork or ring terminals can be used to make an electrical connection to traditional tubular track. Simply force the terminal into the slit under the rail – or get your one of your grandkids to do it if your grip isn't what it used to be.



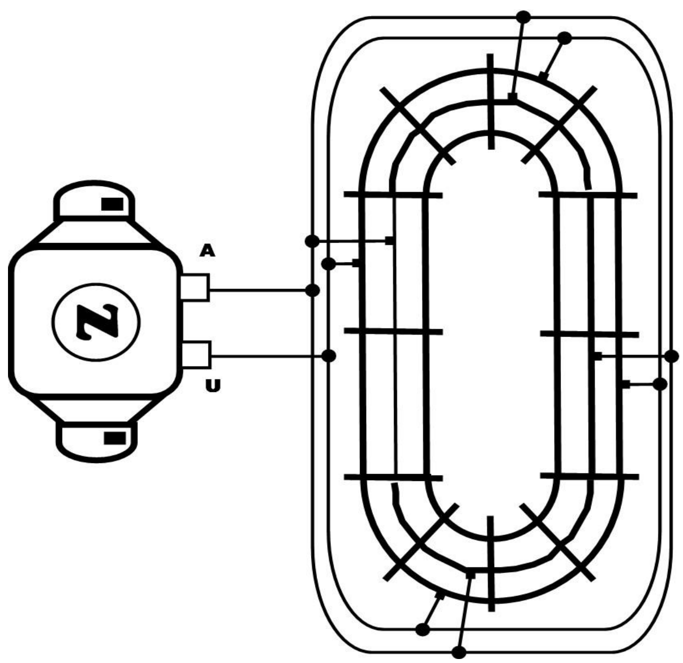
But here's a catch – you may have difficulty crimping the wire to the terminal after it's in the track. And if you try to crimp the wire first, you'll have to first run the wire through the deck of your layout first, crimp the wire, and then make sure the terminal is forced into the track at the right place…not the easiest set of steps to follow and get right.

The other way (and I think the best way) to make a connection to the track is to solder the wire to the rail. To do this, you will need a high-power soldering gun (100 to 140 Watts) and rosin-core electrical solder. Once the track is on the layout, drill a hole right near the place where you need a connection, bring your wire up through the hole, and solder it to the rail. Below is a picture of one of the many soldered connections on my layout.

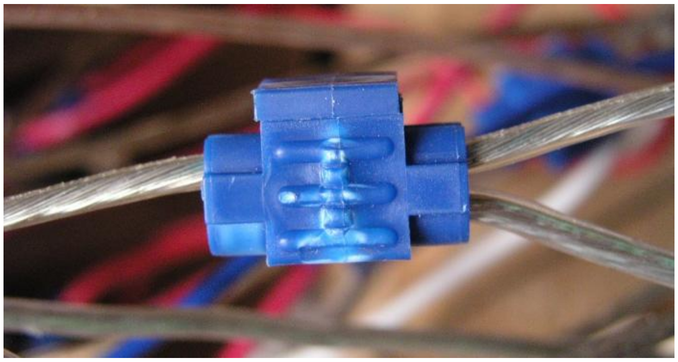


Now there are those who would never solder to the side of the rail like in the picture – it could interfere with a flange on the inside of the rail or would not look realistic on the outside of the rail. You can solder to the bottom of the rail, but this requires that you need to get the solder joint near the hole where the wire is coming from WHILE you solder to a piece of track that is, by necessity, turned over and not is place. One way around this is to solder short wires (about 6-10" long) to the bottom of the rails, temporarily assemble and position the track, mark the places on the layout where the wires need to penetrate the deck, remove the track, and drill the needed holes. Next, reassemble and place the track, secure it, and then make connections to end of the wires that are now under the layout deck. Proper ballasting will completely cover the connection. All of these extra steps are why I solder to the sides of the rails.

At this point we have good track connections with several pairs of wires going back to our transformer. This works, but we can do better. Instead of using several pairs of wires coming back to our transformer to do the same job, let's replace them with an electrical ***wire bus***. In the drawing below, the transformer is connected to a loop of wire that follows the track. (This loop, of course, is under the layout.) So we need to "tap" the bus every 3 to 4 track sections (black dots) to connect wires to the track – very much like the 6-10" long sections described before (the small squares are soldered connections)



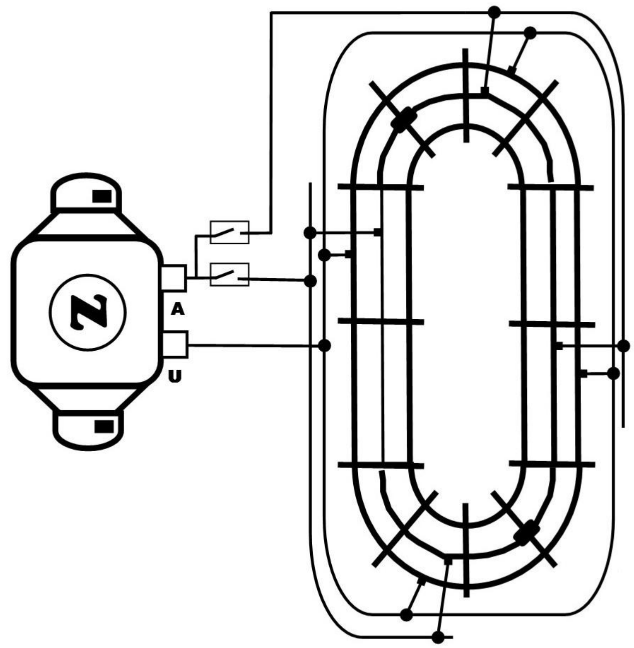
To make connections to the bus wires you can either use more soldered connections or use a 3-way splice crimp. These allow you to make easy connections between a long run of wire and a cut end of another wire without cutting the original wire. Just slide the bus wire into the 3-way, take the end of the other wire and place it in the 3-way in the right hole (you'll figure out which one that it when you look at one). Then squeeze the crimp with pliers, close the lid and you're done. The picture below shows a finished 3-way splice.



With this type of track wiring system using a copper wire bus, you have a robust, reliable, and expandable bus that will ensure years of good operating time. The train will run well since there will be almost no voltage drops in the track. Also, the track (or the bus) provides a reliable ground/common connection for accessories or lights on the layout.

Now, for the final touches. Let's break up the loop into blocks. Blocks are areas of the track where power control can be separated from other parts of the track. Some may consider this an "old fashioned" concept since the development of TrainMaster Command Control (TMCC) allows independent control of trains while a constant voltage is maintained in the track throughout the layout. However, for proper power management, blocks are still a good idea. And, if you are planning on running conventional trains (speed controlled by supply voltage), you will need blocks to run more than one train on a single loop.

In the next drawing, we have taken the track loop and inserted two fiber pins (shown as rectangles in the center rail) in two locations. By breaking the center rail in two places, the two sections are electrically isolated, but still share the common ("U") connection. In addition, two ON/OFF switches are added to the wires feeding the center rail from the transformer. With these switches, one side of the loop can be powered while the other is "dead". This is the essence of track block control.



But is this the end? It can be for you, but for me there are still a few missing items. Here's some further recommendations to consider:

1) After the ON/OFF switch, insert a terminal strip (remember those from the last article?). This will keep your wiring neat and provide an auxiliary connection to the track. This is useful for control panel indicators that show which track blocks are energized or for a connection to a TMCC Block Controller.

2) After the transformer "U" connection, insert a bus bar (remember those too?). This will give you a convenient connection for ganging multiple transformers together. (NOTE: This requires *PHASING* the transformers and we'll discuss this later – don't gang up transformers until then.)

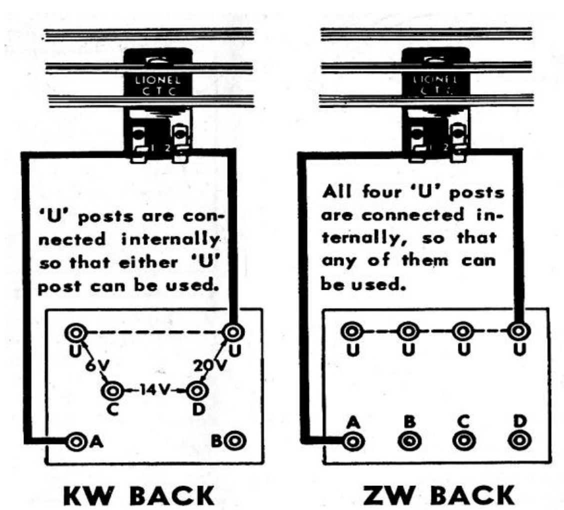
3) Insert TWO bus bars after the transformer "U" connection – this will let you gang transformers AND give you a place to insert an AMP meter (between the two bus bars) to monitor the layout's power load. Necessary? No…but it looks REAL GOOOOOD!

"More Basic Training"

So far, I've shown you how to wire a reliable blocked loop of track using wiring buses. Now, we'll tackle some wiring techniques for multiple loops and those two toy train staples, the O22 turnout and the UCS track. Also along the way, I'll show you the importance of the COMMON connection on your transformer.

Let's face it - most layouts will be more complex than what I've shown you so far. And for toy train layouts, this means adding more loops. And for some great operating, it also means connecting the two loops with turnouts so that trains can move from one loop to another. This requires some more complex wiring, but nothing you can't handle if you know one basic thing – the COMMON connection.

Now there have been scores of toy train transformers for sale, but two very familiar large ones are the Lionel KW and ZW. The figure below shows the arrangement of connectors on the transformer backs. These transformers have several posts for connecting wires to your layout. Although YOU MUST study your particular transformer carefully, one feature you will notice in the figure (or your large transformer's instructions) is a connection from the transformer to an outer rail of the track. This is the easiest way to identify the COMMON connection.

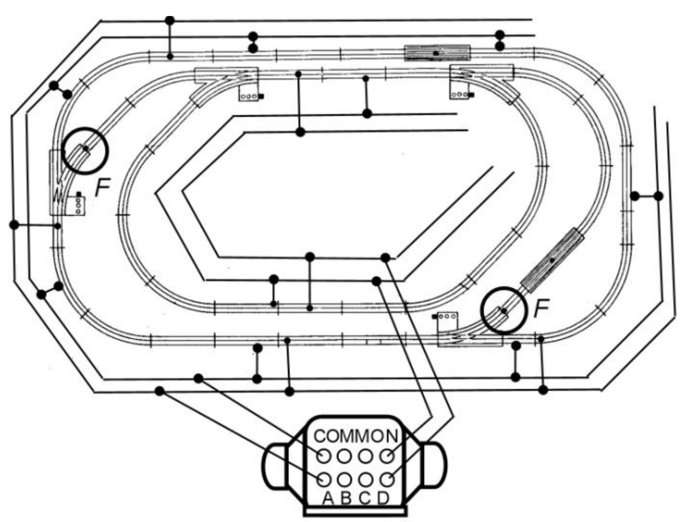


KW and ZW Backs.

The COMMON connection on any transformer is the zero voltage point. This is like the neutral side of your house's AC lines or the negative side of a battery. It is from this connection that all other voltages are measured and all "HOT" connections share this as the low side of any circuit. This means that the COMMON will be connected to ALL the track outer rails and to one side of any accessory that requires power. NOTE: ONE TERRIBLE THING ABOUT LIONEL TRANSFORMERS – "U" DOESN'T ALWAYS MEAN COMMON. YOU MUST READ the instructions for your particular transformer to know what is COMMON and what is "HOT"

So let's see how two loops are wired with a ZW. In the figure below, "U" posts on the ZW are connected to two wire buses for the track outer rails like the one we showed previously. For the center rails, one loop's bus is connected to "A" on the ZW and the other's loop bus is connected to "D". This means that all of the outer rails are at the same voltage (zero), and any train on the outer loop is controlled by the "A" throttle while a train on the inner loop is controlled by the "D" throttle.

BUT HERE'S SOMETHING VERY IMPORTANT – Notice in the figure, two circles with the letter "*F*" next to them. These circles mark two places where FIBER PINS have been used in the center rails. These are plastic pins that do the same job as the steel pins in keeping the tracks together, but they DO NOT CONDUCT ELECTRICITY. These pins are doing the very important job of keeping the two loops electrically isolated. NOTE – there are other fiber pins that are needed to make the switches work properly, but we'll look at those later.



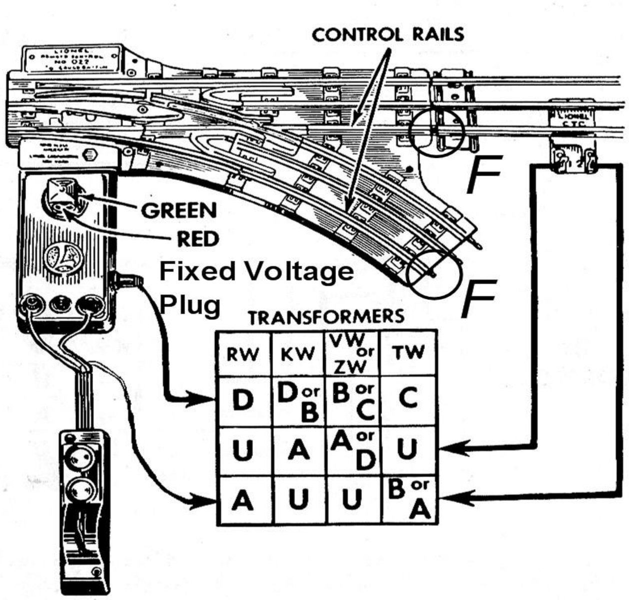
Two-Loop Wiring

If the pins weren't there and the A and D throttles were at different voltages, a short circuit would occur and could possibly damage the transformer. With the pins in place, a train could be stopped or going slowly in the inner loop while another trains runs fast at a higher voltage on the outer loop. If either loop is large, more fiber pins can be used to break the loop up into separate blocks like I showed you before.

And what about more loops? Well, there's no reason you can't wire more loops to the ZW, but it means any loops wired to the same "HOT" post (A through D) will be at the same voltage. However, using some on/off switches in the wire from the transformer to the outer rail bus would allow you to turn off one loop while another was operating. Now there is a way to use more than one transformer to add more loops, but we'll save that for another article.

Now a little bit about the O22 turnouts. In the next figure, the wiring connections for an O22 switch track are shown. Now, I'm sure most of you understand the connections that have to be made to operate the O22 on a fixed voltage (something other than track power). From a fixed voltage or accessory voltage source on your transformer, you run a wire to the fixed voltage plug – simple enough.

But here's a little twist Lionel never talked about much. In the figure, you'll notice that one controller wire (the middle one) isn't going to the middle terminal on the switch motor, but to the "U" (COMMON) post on the ZW or KW.



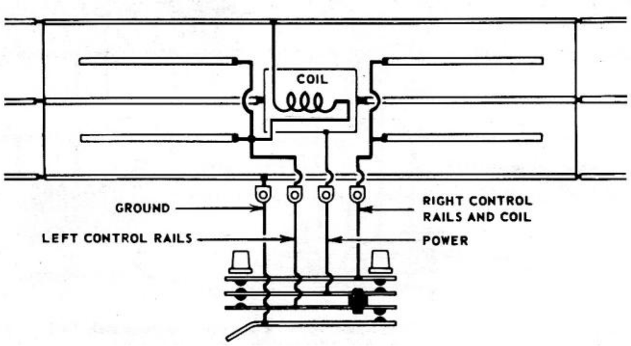
O22 Turnout Wiring

Now isn't that the same thing as connecting it to the outer rails of the track? YES! The middle terminal on the switch motor is actually hard-wired to the track outer rails through the switch motor frame. This means that the terminal could be used like the #2 connection on a lockon. And whether you run the wire to the switch motor middle terminal or the U post, it provides a connection to COMMON so that you connect one of the outer switch motor terminals to COMMON when you move the controller lever – this is what operates the switch motor.

So what's the big deal? It's a simple matter of economics - On a big layout the switch controllers are located on a control panel near the transformers. So instead of running four wires to the switch (three for the controller and one for the fixed voltage), you only need to run three (two to the outer terminals and one to the fixed voltage plug) and make a short connection from the controller middle wire to any COMMON post. I just saved you a bunch of wire!

And don't forget the fiber pins. In the last figure, you'll see two fiber pins in the "Control Rails". It would take another article to describe the O22 operation, but right now, let me say one thing…..NEVER NEVER NEVER NEVER NEVER remove these pins or try to operate an O22 turnout without them. These pins are part of the non-derailing mechanism and are needed to isolate the control rails from the rest of the outer rails so that they can act as "train detectors" to make the turnout throw to the right direction for an approaching train.

And now some similar tricks for that other Lionel staple, the UCS track. Many of us know what the UCS is for, but looking at a control cable with four wires can get scary. The next figure shows a schematic diagram of the UCS track and the controller. This controller is what we engineers call a "double-pole double-throw momentary switch". That means it controls two separate circuits and each circuit can be connected to one of two sources. When you push the "UNCOUPLE" button, the controller connects the short control rails (terminals #2 and #4 on the UCS) and the electromagnet to the center rail (terminal #3 on the UCS). The center rail acts as a "HOT" voltage source to operate the electromagnet (with the other side of it permanently connected to an outer rail – COMMON!). The short control rails are energized to operate the older couplers that have their own built-in electromagnets. It is important to note that the left control rails and the electromagnet share the same UCS terminal - #2.

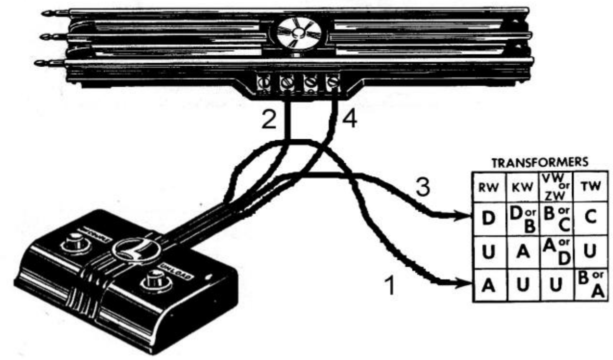


UCS Schematic

When the "UNLOAD" button is pushed, the left control rails and electromagnet are connected to the outer rails (COMMON!!!!!!) and the right control rails are connected to the center rail (HOT!!!!). This produces a voltage between the left and right control rails which makes items like the Milk Car and the Coal Dump Car operate. Since both sides of the electromagnet are connected to the outer rails (**COMMON!!!**), there is no voltage across it and it doesn't operate (0 volts – 0 volts = 0 volts).

So now that I've described this operation and you know the concepts of COMMON and HOT, what can we conclude? Well, if you haven't figured it out yet, I'll explain the UCS trick – you don't need four wires to make a UCS work, just two!

Since terminal #1 on the UCS track is connected to an outer rail, any COMMON connection for the controller will suffice. And since terminal #3 on the UCS is connected to the center rail, any HOT connection for the controller will do. And since the UCS is an "accessory", it is preferable to use an accessory or fixed voltage HOT source instead of track voltage. The next figure shows how this is done. Wire #1 from the controller goes to "U" on a ZW while wire #3 goes to a fixed voltage source (usually "B" or "C"). Wire #2 from the controller goes to UCS terminal #2 while wire #4 goes to UCS terminal #4. Now you only have to run two wires from your control panel to the layout for each UCS while making a short jump from the controller to your transformer with the other two wires.



Smart UCS Wiring

And if this isn't enough, here's one more trick – Since pushing either button on the controller connects wire #4 to HOT, you can use a tap from that wire for a control panel indicator light. Simply connect a light between wire #4 and COMMON and it will turn on when the UCS is activated. On a control panel track schematic, it can show you where the active UCS is!

OK – I think that's enough for now. Remember; let me know what else you want to see in these articles and what you would like me to cover in our coming TTOS/NMD clinics. If you have a particular wiring problem, I can probably solve it.