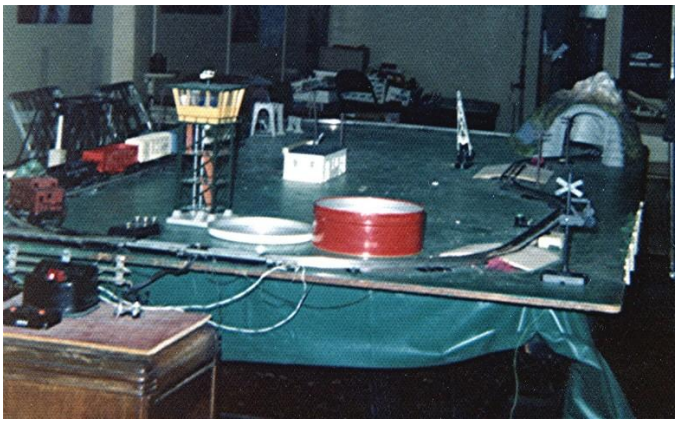
TONY'S TECH REPORT

(A Rocket Scientist's View of Toy Train Operating)

"Getting Started in New Mexico"

Let me take a moment to introduce myself and present my credentials. I'm Tony Porzio - long-time toy train operator, aerospace engineer, and electronics designer. I've been running 3-rail "O" gauge toy trains since the age of 10 and have been a member of the TTOS since 1986. The pinnacle of my toy train "career" was being honored as the TTOS Operator of the Year in 1998.

Over the years, I've added just about anything you can think of to a layout. From relay logic to computer interfaces, I've tried almost everything to make my layouts more interesting. I also think I've become a bit of an expert in how to build reliable layouts that won't frustrate the operator with nagging little problems. And here, I hope to share many of the things I've learned to help you build the best layout possible.



My First Layout (1972)

The great thing about any hobby is that there's nothing you MUST do. Well, that's not really true. If you're going to collect toy trains, all you need is a place to put them. But, if you're going to operate toy trains, you need a place to run them. Also, there are three things you must have – track, wire, and a power supply. Also, as your layout gets more involved, you need things like electrical switches and connectors. We all know where to get trains and track at the TTOS Swap Meets, but how about those other things?

My Current Layout (in progress)

One of the best things about living in Albuquerque is that we have access to a cheap source of toy trains necessities. It may not be a hijacked shipment of O72 curves, but as far as I'm concerned, it's just as good. I'm talking about the surplus store on east Central Avenue - Surplus City.

The store we all must take a few hours to go see is Surplus City. The store is east of Eubank on Central and is open during usual business hours and on Saturday. *The store is an utterly unabashed conglomeration of the cast-offs of our technological and consumer-obsessed society* (how's that for modern prose?). There isn't a category of middle-class American stuff that isn't given some floor space. Clothes, furniture, fixtures, plumbing, hardware…it's hard to imagine something that isn't there in some form.

Surplus City (east of Eubank on Central)

There are two main sections – the store and the yard. In the store, there are long aisles with unlabeled lots. Here you'll find shelves of treasures. And if they're not on the shelves, they're in the

hundreds of bins stacked around the place. Don't try asking the clerks for specific items, but they can always point you in "a general direction".

Down an Aisle (lots of capacitors on your left)

In the yard, you can find large items. Most of these are along the lines of storage cabinets and equipment racks. But if you need a high horse-power motor, you can probably find one too. Old chairs and work tables can also be found there.


In the Yard

For the toy train operator, there are two things you must see. First, near the back of the store are the wire racks. What do you need? 12 gauge? 20 gauge? Single conductor? Multi-conductor? If you're willing to get a little dirty and climb around the spools, you'll probably find that ideal reel of wire to hookup your track or switches. And you won't find a better price anywhere, especially for multi-conductor cables. They also have a large selection of lacquered wire for rewinding armatures and solenoids.


Wire – All You Need.

The second section you must see is near the front of the store where there are hundreds of bins of electrical components. In these bins you'll find terminal strips, switches, connectors, and high-power resistors, just to name a few.


Just a Few Bins – Some Can Motors

If you're not too tired after going through these two sections, I also recommend a stroll through the meter aisle (volts, amps, etc.) and then a tour of the 600-Volt electrical equipment. And let's not forget the relays and old computers.

Surplus City is truly a treasure for the toy train operator in Albuquerque. In our hobby we NEED wire, switches, connectors, and hardware. Sure, you can find these things in new and pristine condition in the usual places, but what fun is that? Also, why

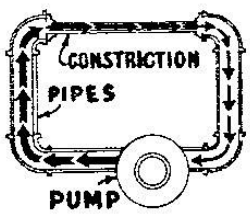
pay more when "used" is just fine for a toy train layout? My first bit of advice for my first article is this – do yourself a favor and take a couple of hours at Surplus City. Walk around, take some notes, and start thinking about the things you can add to your layout.

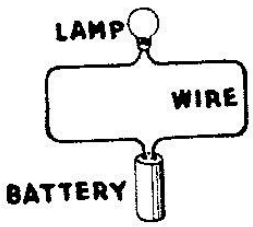
"The Facts of Life"

"Now I know you have some questions, and that's only natural. Well, you need to start learning some things and I'm hoping you'll come to me when you have some questions. But for now, there are things you need to know and I'm going to tell them to you." Sounds familiar? Maybe. However, I know that many of you still don't understand the "facts of life" when it comes to building a toy train layout. So this might seem very strange at first, but it's very natural and nothing to be ashamed about…..

I already mentioned some of the things that you MUST have to run a toy train layout. In this article, I'll go through some things you really should KNOW to operate a good layout. These things are VOLTS, AMPS, and WATTS. These are terms you've probably heard along the way, but still may not really understand. Fortunately, there has always been one way to describe these things that even the most non-tech types can understand. Think of water in a hose – VOLTS are like the water pressure in the hose, AMPS are like the amount of water flowing in the pipe, and WATTS are like how much the water can hurt you if you're at the wrong end of the hose.

Here's a drawings we've all seen before –





The constriction in the pipe resists the flow of the water in the same way the lamp resists the flow of electricity. The battery (or transformer) voltage, the current in the wire, and the lamp's ability to resist the current flow are related with this equation[1]:

$$V = I \times R$$

V is the battery (or transformer voltage), I is the amount of current in the wire, and R is the resistance of the light bulb. Resistance is measured in units called "OHMS". So, if the battery is at 10 VOLTS and the light bulb has a resistance of 5 OHMS, there will be 2 AMPS of electric current in the wire. And, please be calm, but here's one more equation:

$$P = V \times I$$

In this equation, P is power in WATTS, V is the voltage, and I is the current. Now, you might be saying, "So what?" Well I say, "Don't be so cynical – this is important!" Go to your layout (or to that box in the closet) and look at your transformer. Somewhere it is going to have words like "115 VOLTS – 60 CYCLES – 275 WATTS". Maybe you can see now how that equation relates to the real world. Your transformer is designed to deliver a set amount of power, and particularly, to deliver that power at about 14 to 18 VOLTS. But TAKE NOTE – the older transformers were rated for the power they take from the wall outlet. What they can deliver to your layout is less. Iron core transformers are great at producing heat as they operate. Of the 275 WATTS that an old ZW is rated, only 180 WATTS is available after several hour of operation. The classic values for the old transformers are:

Type	Current @ 15 VOLTS	Rated Power	Available Power
1015	2.5	45	37
1043	3.0	70	45
1033	4.0	90	60
LW	5.5	125	83
KW	8.0	190	120
TW	8.0	175	120
ZW	12.0	275	180

Well, if that's how much the transformer can put out, how much do you need? The two main things you need to remember is this – an engine takes 40 WATTS and a light bulb takes 4 WATTS. How about a crossing gate? How about a log loader? How about the milk car? An uncoupling

[1] My sincerest apologies to those of you with math anxiety, but there's nothing I can do about this….a little algebra won't kill you. Math is good. Math makes trains more fun.

track? It doesn't really matter – these loads aren't continuous (unless you have four or five crossing gates going down at once, then we're talking real power).

Now so far, I've just repeated what Lionel's been putting in their manuals since …well…a LONG time ago. However one thing they never went into detail on was what type of wire to use to make connections. You see, once we assume everything is operating at about 15 VOLTS (a reasonable assumption), power and current are directly related – the more power you need, the more current you need AND…the bigger wire you need.

Making a mistake on wire sizing can be the most dangerous mistake you can make with toy trains. Not only can it lead to poor performance, it can also lead to a fire hazard. Looking at the last table, we see that the ZW is designed to deliver 12 continuous amps. In order to keep the transformer safe to use, it has a circuit breaker that opens at about 15 amps. So what do you think would happen if you hooked a ZW to a track using very thin telephone wire and the train derailed and caused a short circuit (those bright blue sparks you see sometimes when a truck derails)? Since phone wire (24 gauge) can only carry about 2 amps, the available power of the ZW would quickly heat the thin wire to the point where it would burn before the circuit breaker could kick in. Instead of the circuit breaker operating to protect the wire, the wire would burn up in order to protect the circuit breaker! This is why the wire you use should be able to carry the full load that the circuit breaker is rated for.

So what size wire do you use? Although some opinions do vary based on application, a good rule of thumb I use is "14/15" – 14 gauge wire carries 15 amps. Going up and down the gauges by 2, go down and up the amps by 5. Therefore, 16 carries 10, 18 carries 5, 12 carries 20…and so on. Now this rule is very conservative, but you'll never go wrong. However, in the next table, you can see "handbook" values for wire gauges that are used in electrical and electronic design with complete safety –

Wire Gauge	Single Wire Capacity (amps)	Wire in Cable or Conduit Capacity (amps)
10	55	33
12	41	23
14	32	17
16	22	13
18	16	10
20	11	7.5
22	7	5

Now, if that's still a little too much to digest, here's a more practical list of applications that I use on my layout –

Application	Wire Gauge
Wiring from transformer to a main wiring bus bar (ground/common)	12
Wiring from transformer to a main wiring bus bar (supply voltage)	14
Connecting transformer or wiring bus bar to a single section of track	16
Switches, UCS tracks	18
Accessories, Single Lights	20

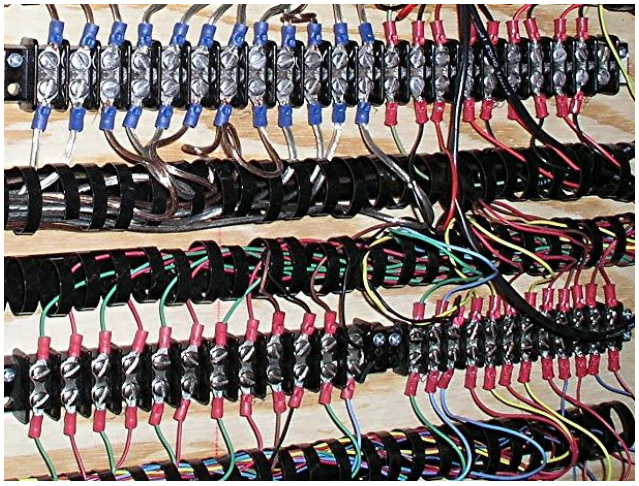
So what's a "bus bar"? This is a handy piece of metal that you'll find in your home circuit breaker box. It is a bar of metal with several screw connections that make a convenient place to hook up several items to the same power supply (or more frequently, the same ground/common connection). Want one? Just go to the hardware store and in the "Electrical" aisle, look for a "bus bar" or a "grounding strip". Unfortunately, they are usually locked up with the circuit breakers and you'll have to ask somebody for help.

And PLEASE…don not confuse a ***bus bar*** with a ***terminal strip***. A bus bar is a solid piece of metal, a terminal strip is a collection of single point-to-point connections designed to make your wiring more accessible, reliable, and neat.

This is a picture of a BUS BAR on my layout (it is located on a 2 x 4 just under the deck) –

On this bus bar, 12 gauge wire is used to bring the common (ground) from the control panel to the layout. From the bar, connections using 16 and 18 gauge wire can be used to make connections to the outer rails on the track and various lights and accessories

And these are some TERMINAL STRIPS inside my control panel –



Across the terminal strips, 16 and 18 gauge wires are used to make connections between individual toggle switches on the control panel and individual track blocks (center rail connections) and accessories. Track turnouts are also connected this way. Why go to this much effort? Like I said, it makes your wiring reliable and neat. Also, it will provide secondary connections between accessories, switches, and the TMCC controllers (probably more on that in the future).

So those are the facts of life for now. I hope you're not embarrassed…but you have to learn these things sometimes. And if you can't be good, be careful.