Tortoise Turnout Bellcrank Installation

William Crocca

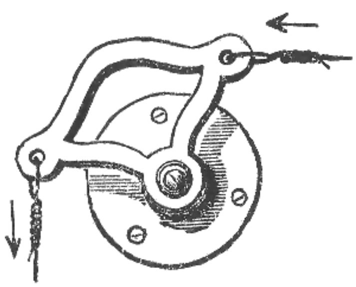
Introduction

The Rochester Model Railroad club's HO layout is decades old, largely built before the debut of the Circuitron Tortoise Switch Machine[1]. During the early construction of the current layout the mainline turnouts were fitted with twin-coil machines, and a number of siding and secondary track access turnouts were fitted with ground throws. Retrofitting many of these early installation with Tortoises proved challenging.

Two examples of difficult retrofit arrangements are (1) existing, scenicked trackwork and (2) where there is no room underneath a turnout's throw bar for a Tortoise to fit, typically because a benchwork brace is in the way. In these cases, we have been using an installation technique we call the "bellcrank method." It is extremely flexible; indeed, in one case the tortoise is over two feet under the turnout. Unfortunately, very few know how to implement a bellcrank linkage, so my purpose here is to explain how it's done.

Bellcrank Definition

So, what is a bellcrank? A **bellcrank** is a type of crank[2] that changes motion through an angle. The angle can be any angle from 0 to 360 degrees, but 90 degrees and 180 degrees are most common. The name comes from its first use, changing the vertical pull on a rope to a horizontal pull on the striker of a bell, used for calling staff in large houses or commercial establishments.[3]



Bell-crank.

Overview of an Installation

The installation method recommended by Circuitron involves drilling a large hole directly underneath the center of the turnout's throwbar, and then mounting the Tortoise directly underneath the turnout with a rod going through that hole and connecting the Tortoise arm to the throwbar. As noted earlier, the Circuitron method cannot always be used. The bell crank method, however, is dramatically more

[1] http://www.circuitron.com/index_files/tortoise.htm
[2] https://en.wikipedia.org/wiki/Crank_(mechanism)
[3] Illustration from 1908 Chambers' Twentieth Century Dictionary. Bell-crank, n. a rectangular lever in the form of a crank, used for changing the direction of bell-wires.

flexible in placing the Tortoise (or other style switch machine) because the modeler crafts a custom mechanical link between the turnout and the Tortoise where ever it may be located.

The basis of this flexibility is a crank that replaces the vertical motion of the Circuitron installation method with a horizontal motion that's underneath the layout. The Tortoise can then be mounted in any direction and at any convenient distance from the turnout. Making the crank assembly involves two rods:

1. to transfer the motion from the top of the layout to underneath the layout and
2. to connect the Tortoise to the crank.

Required Tools and Components

- Tortoise machine in good working order.
- Soldering iron or soldering station and rosin-core solder.
- Optional: rosin flux.
- Brass tubing. In this example K&S #8126, 3/32 x 0.014 round brass tube.
- Brass rod for the crank and the mechanical link. In this example, K&S #8186, 3/64 (1.19 mm) brass rod[4].
- Brass washers. In this example was used Hillman #6L brass washers. Choose a large enough washer easily to facilitate soldering the Tortoise Linkage rod.
- Small diameter tubing cutter, such as K&S tubing cutter.
- Diagonal cutter for the brass rod.
- Files and/or an abrasive such as steel wool, brass wool, or abrasive paper or cloth.
- Small screw drivers, Philips and slot.
- #4 round head sheet metal screws, ½” to ¾” in length for mounting the Tortoise.
- Superfine sharpie.
- Scale (ruler) for measuring rod lengths.
- ACC glue for fixing the brass bearing tube (Figure 3) in place.

Throw Rod Linkage and Bearing Tube

As noted, the standard Tortoise installation has the linkage from the Tortoise go up through a hole immediately under the turnout’s throw rod, and then through a hole in the throw rod itself. In comparison, the bell crank linkage goes up through a length of tubing, which acts like a bearing, set approximately 2 to 2.5 cm (3/4 to 1 inch) from the throw rod as shown in Figure 2. This distance is based on the travel distance of the Tortoise actuator, which is shorter than the slot in the housing. Should you be using a different switch machine, measure its throw length and use that in your calculations.

[4] There are cases where the length of the rod is so long that 3/64” brass rod isn’t strong enough. In those cases, piano wire should be substituted. However, piano wire is more difficult to bend precisely. Sometimes it’s helpful first to make a prototype from brass, and then duplicate the prototype geometry in piano wire. However, piano wire doesn’t solder, so a mechanical method of affixing the washer/pivot would be needed when fabricating the Tortoise link (as opposed to the bell crank link).

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Figure 2 shows the bearing rod in place for this sample installation. However, as shown in Figure 1, there are six general locations where the bearing tube can be located, and the four locations outside the two rails can be at any suitable distance from the track, but always constrained at 2 – 2½ cm (3/4 to 1 inch) from the centerline of the throw rod. However, the effective length of the turnout's throw rod can be as long as needed. Alternatively, the throw rod length can be extended using the machine linkage underneath the layout. An advantage is that on top of the layout the throwbar extension must always be at a right angle to the straight route centerline, whereas underneath the layout, using the crank method, there is no similar restriction.

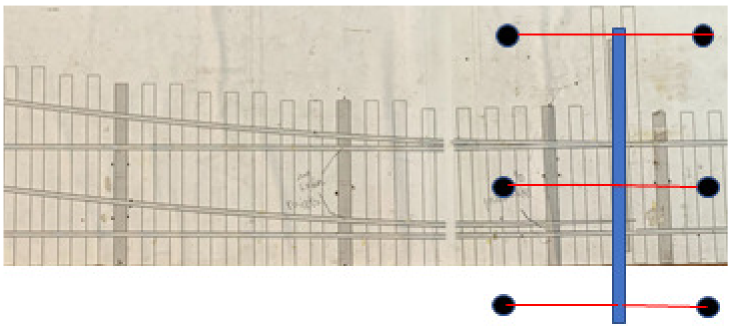

Figure 1, Six Possible Bearing Tube Locations

For demonstration purposes I built a small table with a clear Plexiglas top on which a turnout was mounted and then motorized with a Circuitron Tortoise using a bell crank linkage.

Figure 2 shows the points of an HO turnout with a brass tube imbedded in the roadbed just behind the second tie behind the throwbar. The brass tube serves as a bearing to let the crank rod pivot, and thus move the throwbar.

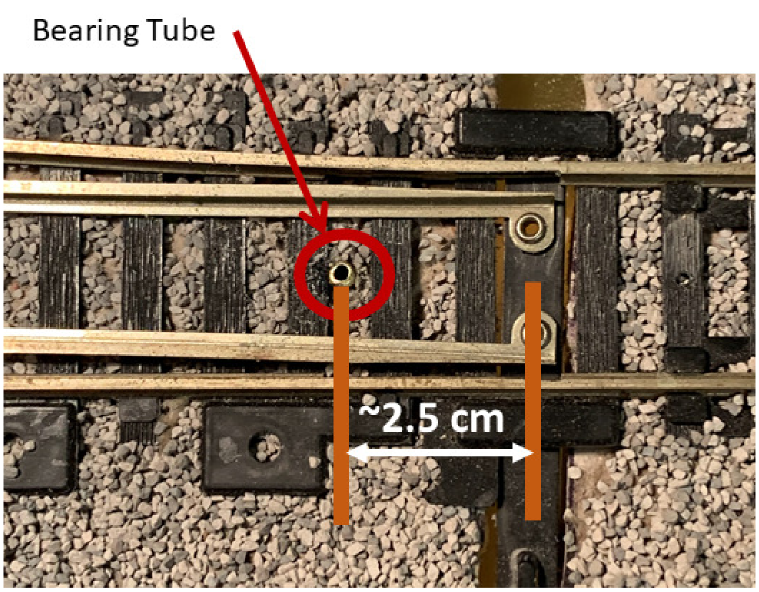

Figure 2, a tube inserted vertically into the roadbed

Figure 3, brass bearing rod underneath the subroadbed

The length of the brass bearing tube is equal to the thickness of the roadbed and subroadbed together *plus* the offset of the Circuitron actuator from its base. Figure 4 shows the offset to be roughly 2 ¼”. Generally, I find that using 2” for this figure gives a good result[5]. In the case of this demonstration platform, the thickness of the roadbed and subroadbed, the Plexiglas) is ¾”. Your subroadbed is likely to be plywood or foam board. But the method is the same.

To measure the total thickness of the roadbed and subroadbed, insert the bearing tube into the hole just drilled for it until the top is even with the roadbed. Mark the exit underneath the subroadbed. Measure 2” from there. Cut the rod to that length. I use the K&S tube cutter for this operation. Pull the bearing tube up a way, coat the visible part of the tube with ACC glue and push it back into the hole. Figure 2 shows it inserted. Figure 3 shows it extending 2” below the subroadbed.

[5] In one case we have an installation where the length of the bearing tube is nearly two feet. In this situation we had to use a length of heavy piano wire for the crank as the brass rod would twist rather than transmit the torque over that length.

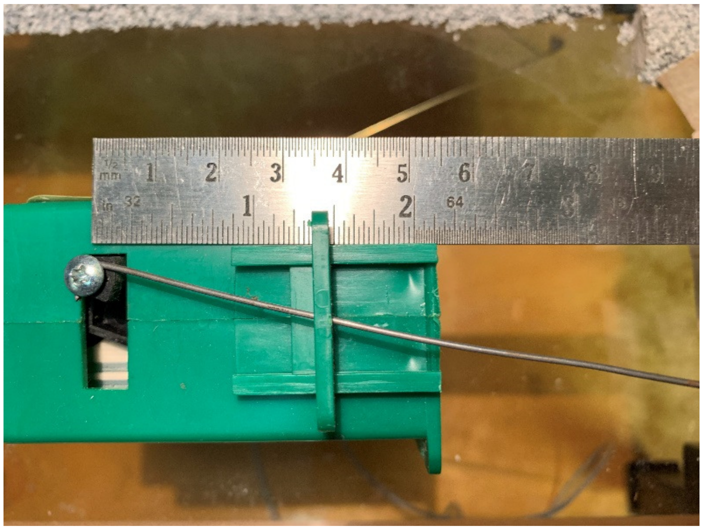

Figure 4, measuring the actuator offset from the base

Locating the Switch Machine

If you're using this method to actuate a turnout, then you need to figure out where to locate the tortoise and how to orient it with respect to the turnout points. Figure 5 shows this process for the demonstrator. As you will see in this example, the crank rod has been located in between the rails. But it also could have been located far away, underneath a building or other scenery. This is done by extending the turnout's throw rod to whatever length is necessary. There are lots of ways to do this such that the extended rod will be completely camouflaged. Alternatively, the crank rod can be located as shown here and the Machine Linkage extended underneath the layout to connect with the Tortoise.

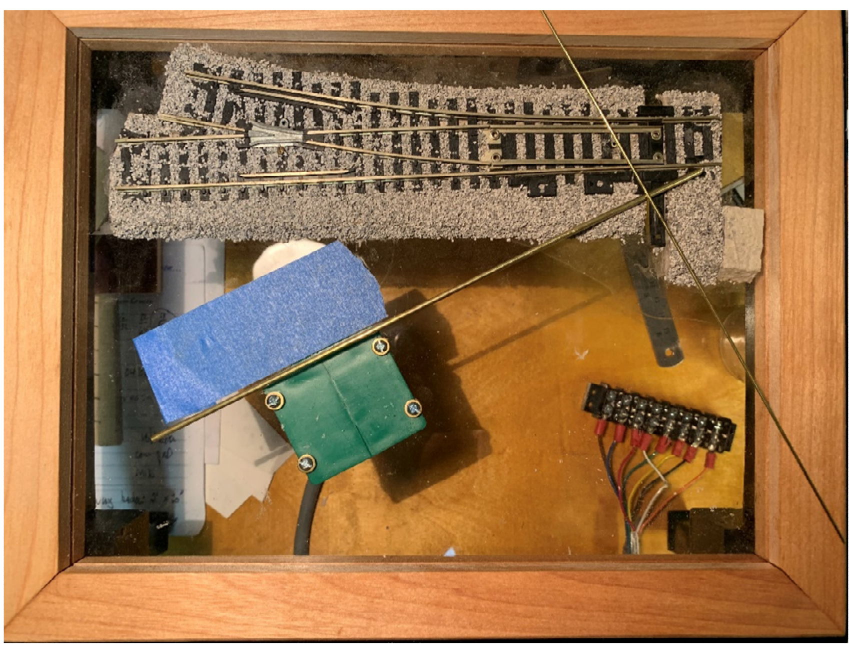

Figure 5, orienting the Tortoise

I decided to locate the Tortoise out in the open, but away from the turnout to illustrate that it can be distant from the points, and to allow easy viewing of the mechanism. The tube and rod are oriented to allow the crank to be operated at right angles to the direction of throw of the Tortoise actuator. In turn, the Tortoise is oriented to keep its actuator aligned with the throw rod. To see this geometry, refer to Figure 5 where the tube and rod are oriented as they will be installed. Note the underneath crank rod is bent such that it operates at right angles to the Tortoise motion when the points are at center position. The underside of the crank rod is also approximately 2 cm (3/4 to 1 inch) in length. Remember that the 2 cm (3/4 to 1 inch) comes from the Tortoise's actuator throw length. Should you be using a different machine, measure its throw length and use that distance in your measurements.

The Crank Rod

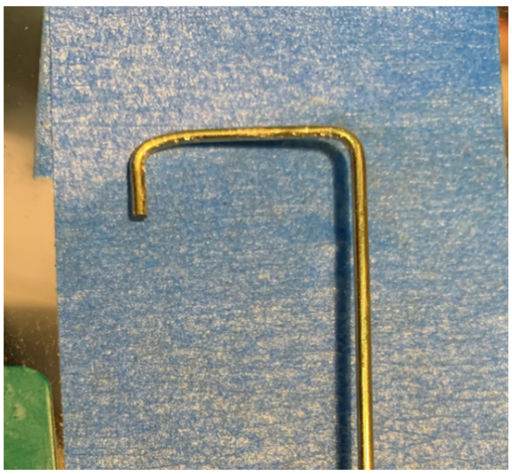

Figure 6, Upper Bend on Crank Rod

Figure 6 shows the first bend you will put in the crank rod. It should be bent such that when the rod is inserted into the bearing rod, the bent tip will fall into the hole in the turnout's throw rod. To test for proper fit, manually move the points with the crank rod inserted to be sure the points move freely. If there is binding, it's likely because the hole in the throw rod is too small to accommodate the difference in the crank's length between center point vs snuggled to either closure rail. Technically one should put a slot in the throw rod to fix this, but the movement is so short that minimally enlarging the hole will suffice.

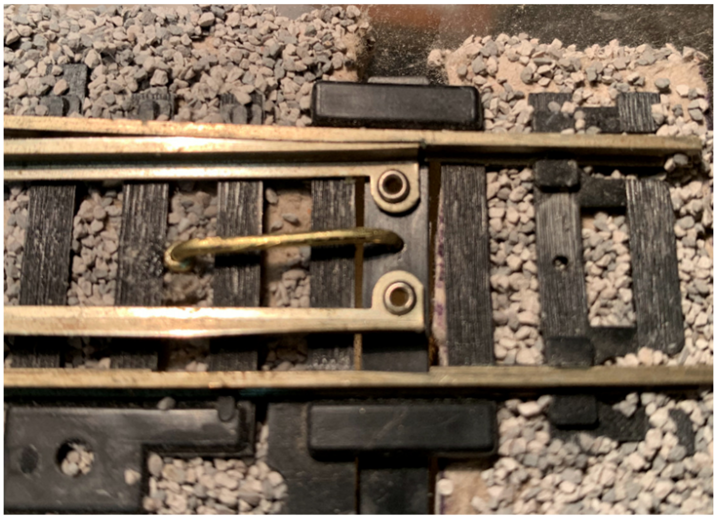

Figure 7, crank rod inserted in turnout

Figure 7 shows the upper bend inserted in the bearing rod and throw rod. The next operation is to bend the lower part of the crank rod. When you're bending the lower crank rod (see Figure 8), be sure to hold the top of the crank rod firmly down while making the bend else you will risk having the top of the rod too loose.

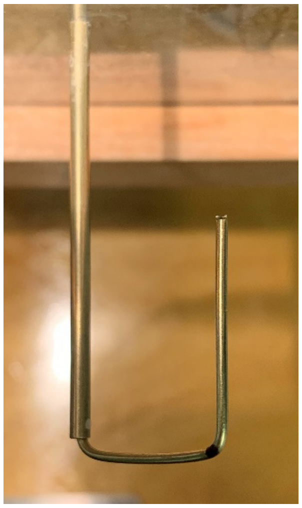

Figure 8, lower crank rod bend

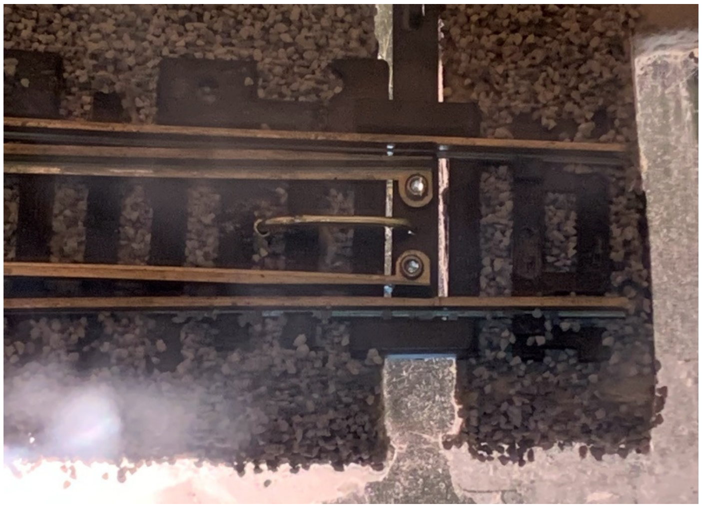

Figure 9, points at center while lower crank gets first bend

Referring to Figure 9, with the points being held in the center position, bend the crank rod to be parallel to the brass rod placed over the entrance to the bearing tube (Figure 8). Then mark off a distance of 2 cm (remember 2 cm (3/4 to 1 inch) is throw length of the Tortoise actuator) and bend the crank rod up as shown. Test operation by moving the crank rod from underneath to verify the points are moving freely and as expected, i.e., contacting the closure rails in both the straight and diverting positions.

The Machine Linkage

The last step is to link the Tortoise actuator to the crank rod. Here is where some fabrication and soldering are required. As the link rod pushes and pulls the crank rod, and the point moving from side to side, the crank rod will be turning in the bearing tube and therefor relative to the machine linkage. So the connection between the crank rod and the machine linkage has to be another bearing. To fabricate this bearing cut a short length of bearing tube. Then wrap the end of a piece of brass wire (the same kind of wire used to make the crank rod) around that short piece of tube and solder in place. When you're done, it should look similar to Figure 10.

Figure 10, short bearing tube on one end of the machine link

Note that the length of the pivot tube is arbitrary. Too short and the tube might bind rather than pivot, or even pop off the end of the crank. Too long and it could be difficult to install. Experience to date suggests that ½" is a good length. There are some older installations on the club layout where the crank length is fairly short, necessitating a "Z" shaped machine linkage. While these work, they have a tendency to pop off the crank. In these cases, some way of restraining the pivot tube from popping off is needed. Bending the crank works but could break off if the linkages have to be disassembled too often. Other installations have small retainers affixed to the crank. One sort of retainer is a small section of thick-walled tube, drilled and tapped for a small set screw (e.g., 00-90).

The final step is to connect the other end of the machine link to the Tortoise. This end too will be pivoting relative to the center of the Tortoise actuator. Therefor a second bearing will be needed.

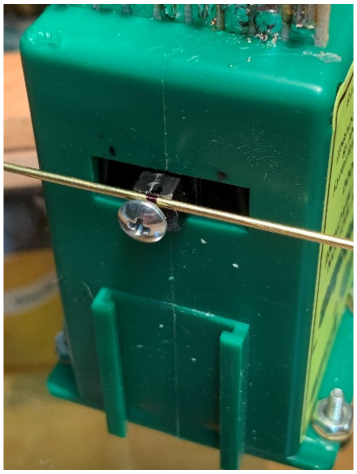

Figure 11, laying out the pivot washer location

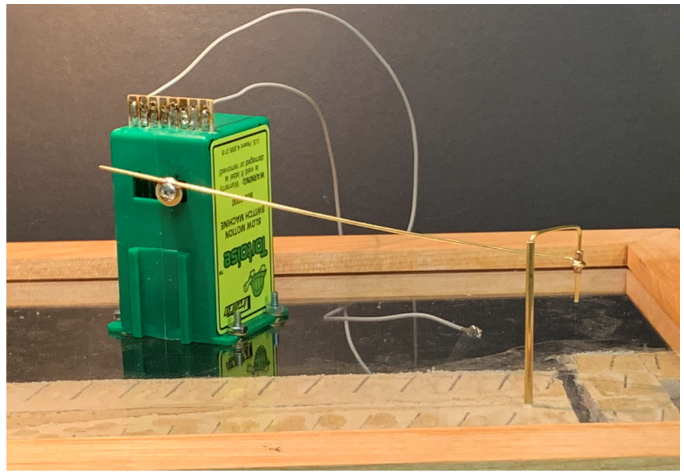

Figure 12, Machine Link Installed

With the pivot just fabricated (as shown in Fig 10) placed on the crank rod (see Fig 12), the Tortoise actuator moved to its center point, and the turnout points held in the center of their motion (see Fig 9), mark the location on the Machine Link that corresponds with the center of the screw in the Tortoise actuator. Using a Sharpie (see Fig 11) will give a clear indicator mark. Then at that location solder a brass washer to the machine link, being sure that the Machine Link is on the outside of the washer, i.e., away from the Tortoise case. Then screw the washer to the Tortoise actuator, but not too snugly as the washer will have to pivot as the Tortoise moves through its range.

As you test a new installation, note that the overtravel of the linkage in each direction introduces some twist in the crank. That twist provides the spring force which keeps the closed point snuggled tightly against its closure rails. Essentially, while in over travel, the vertical stem of the bellcrank doubles as a torsion spring.

An Alternative Linkage Method

There is an interesting alternative to fabricating the machine link: using a bicycle break or gear-shift cable. Using a cable in place of the machine linkage just presented will offer even more freedom in locating the Tortoise as there doesn't have to be a straight line between the Tortoise actuator and the points crank. However, using a cable requires arranging brackets at both cable ends, which is more work and a tad more difficult than using the brass wire. Also, the cable approach introduces friction, so if a cable link is used, keep it as short as possible. Our club layout currently has no instances of a cable linkage.

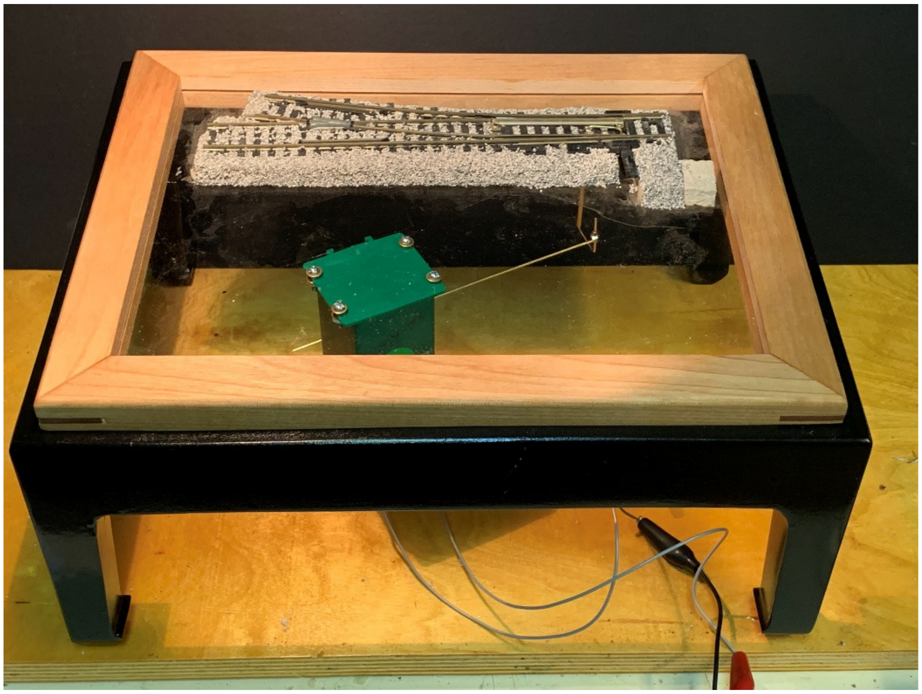

Figure 13, Completed Installation

At this point the mechanical linkage between the Tortoise and the turnout is complete. See Figure 13. For the demonstrator, only the Tortoise motor wires were connected; wiring to the built-in DPDT (**D**ouble **P**ole **D**ouble **T**hrow) switch was omitted.

The demonstrator uses clear Plexiglas as the sub-roadbed, which allows both the trackside and the underside to be seen simultaneously. Additionally, the demonstrator allows the Plexiglas plate to be turned over, so the underside of the installation is facing up.