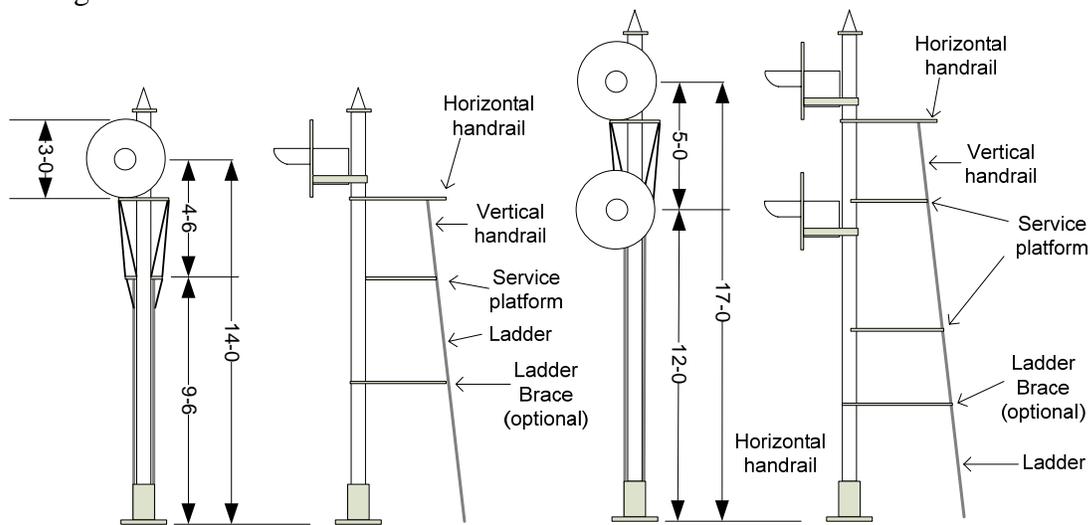


Building Signal Structures

So you would like to have a working signal system on your layout? There are a number of ready-made signals and signal kits on the market. However ready-to-run signals tend to be expensive, in the 30-50 dollar range, while kits are available in the more reasonable 10-15 dollar range. However it is possible to make your own, highly-accurate, signals at a much lower cost. This clinic describes the steps to make type SA signals, also known as searchlight signals using K&S brass stock parts and T-1 bi-color (red-green) LEDs, or Type D signals using red, yellow and green LEDs. The signal mast structures for either type are almost identical. The only difference is the target assemblies. I have given some dimensions in millimeters (for HO scale) which I find easiest to work with or scale feet. Figure 1 shows drawings of a single and double Type SA target signal. These signals are easily made for HO and larger scales. N scale presents more difficult problems to keep the signals to a reasonable scale.



Type SA Signal

Figure 1: Type SA Signal (Union Switch and Signal Design)

Assembly Jigs

Assembly jigs can greatly simplify the process of assembling small parts particularly when soldering them together. Figures 2 and 3 show basic assembly jigs that can be used to hold and locate parts for assembling SA signals. They may be constructed from most types of wood. Hardboard is good because it stands up well under heat, but pine or basswood are also acceptable. Plexiglas will also work if it isn't subjected to heat for long. Avoid softer wood such as balsa. You must modify the given dimensions proportionally when working in a different scale.

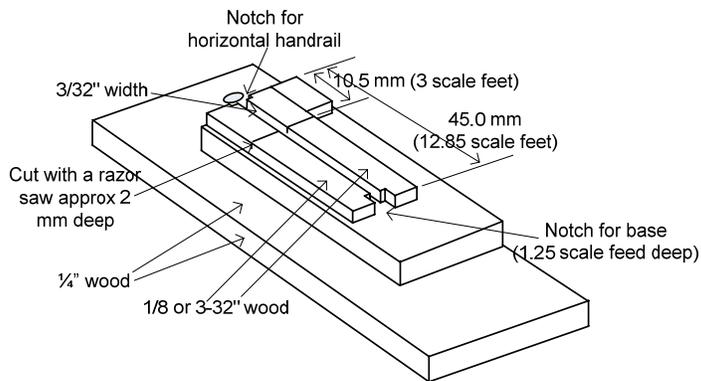


Figure 2: Basic Assembly Jig

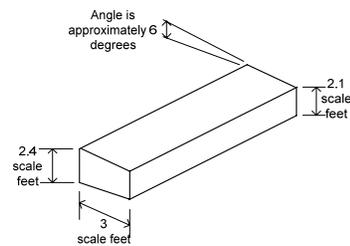


Figure 3: Handrail and Platform Locating Jig

Basic tools.

As always, before starting, assemble the basic tools you will need. Appendix A describes a basic tool set. In addition you may need larger metal shears, a electric drill or a drill press and the following drill sizes: 1/8, 3/32, 5/32 and AWG #34. Round tip needle-nose pliers are also helpful for bending rounded shapes. Toothpicks are also a useful soldering aid.

Type SA Target Assembly

For Type SA signals begin by making the signal targets. Union Switch & Signal SA targets are three feet in diameter. Drill or punch (if you have a punch) a 1/8" (HO) hole in the center of a scale four-foot square piece of .010 brass sheet (approximately 1/2" square for HO). Use a drawing template or a small compass to scribe a circle around the hole so that the hole is centered. The template circle should be approximately 11 mm for HO. (10.5 mm is 3 HO scale feet) The scribed circle will be slightly smaller than the template. Carefully trim the brass around the outside of the scribed circle so that it is approximately round. Mount several targets on a #10 machine screw as a mandrel using two nuts to secure them tightly. Mount the screw into an electric drill, run it at slow speed, using it as a lathe, and file the perimeter of the targets until they are perfectly round.

If you are making multiple signals, I recommend punching or drilling multiple holes in a brass sheet before scribing and cutting them. If you locate your holes accurately, you should be able to get 8 targets in a row in a four-inch wide brass sheet for HO. When milling the targets, I also recommend ganging them up to 8 or more at a time on the mandrel.

Target Housing

There are two options for mounting the bi-color LEDs. The first is to mount them from the rear and the second is to mount them from the bottom. Which method you select will determine how you make the rear housing. I prefer bottom mounting because a rear mount will show LED light from behind the signal unless you paint the back of the LED to mask the light. Both hood options use 0.005 brass sheet. The bottom mount also has a more prototypical appearance.

1. Bottom mounted LED target housing.

Scribe a piece of 14 x 14 mm (4 x 4 HO scale feet) 0.005 brass sheet as shown in Figure 4 and using small metal shears cut along the indicated lines. I also tin the inside of the housing with solder first to provide silvered reflecting surfaces. Otherwise the reflected light will yield a yellower color on the illuminated signal. You may cut the target hood either before or after shaping the housing, but I have found it easier to cut first and make the bends last. Using a 1/8" brass tube as a mandrel, bend the sheet into a "U" shape, Figure 5, then using a 3/32" brass tube, bend the hood into a smaller "U" shape. Finally make a 90-degree bend on the back piece to enclose the housing.

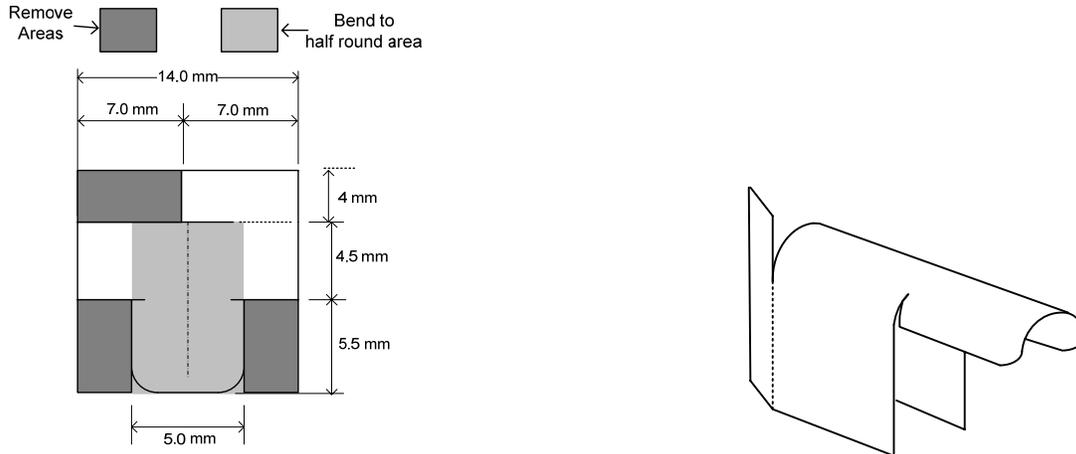


Figure 4: Bottom-mounted Target Housing Layout

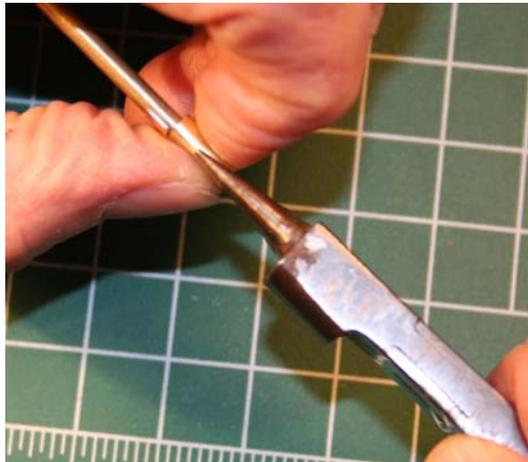


Figure 5: Bending the Target Housing using a brass tube for a form and round-tip needle nose pliers

2. Rear mounted LED target housing

Scribe a piece of 10 x 14 mm 0.005 brass sheet as shown in Figure 6 and form it into a "U" shape as described above. The difference is that the housing has a bottom instead of a back. Bending is approximately the same as for the bottom mount except there is a fold across the bottom instead of across the back.

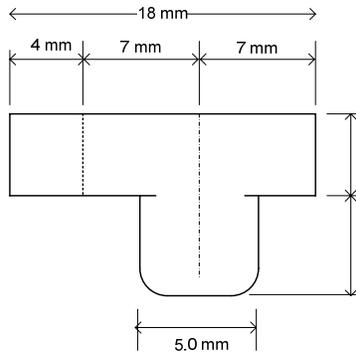


Figure 6: Rear-mounted Target Housing

Target Assembly

When the housing is formed trim and bevel the hood, if it has not already been done and insert the hood through the 1/8" hole in the target. If it doesn't quite fit, bend the hood to a smaller radius. Ensure that the housing is flush against the back of the target, add a little flux and solder. I use a simple 1/4" piece of hardboard with a 1/8" hole drilled in it as a soldering jig. I insert a nail or a wood dowel, slightly smaller than 1/8" diameter into the hole, to keep the hood snugly aligned with the top of the target. The nail should not solder-bond to the target assembly unless you use excessive heat and solder. It should take only a few seconds to apply the solder which should make a well-formed bead around the edge of the housing as in Figure 7. Bend the back wall 90 degrees so that it encloses the housing and solder to the opposite wall and trim it.



Figure 7: Soldered Target assembly

There are two ways to attach the target and housing to the mast. Note that different railroads positioned the target closer to or further from the mast, so check drawings or photos of the prototype you are modeling. If the target is close to the mast, solder the housing directly to the mast.

1. Form a piece of 1/16" square brass tubing as shown in Figure 8. and solder it to the housing on the back of the target assembly. This looks a little more prototypical.

2. Cut and bend a “squared-U” shaped brass strip shown in Figure 9 and solder it to the housing on the back of the target assembly. This is easier, but doesn’t look quite as good.

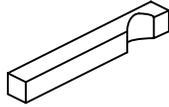


Figure 8 Solid Mounting Arm

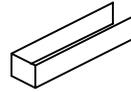


Figure 9 Open (U-Shape) Mounting Arm

Mast Assembly

The mast structure consists of 6-7 pieces:

1. The mast
2. The horizontal handrail
3. The vertical handrail
4. The service platform
5. The ladder
6. An optional ladder brace
7. The pedestal and base assembly

Cut a piece of 3/32” brass tubing approximately 22 scale feet long. File a notch between 6 and 7 scale feet from the top to enable you to pass #30 wire-wrap wire down through the mast. Make sure there are no burrs along the inside lower edge of the notch that will inhibit passing the wires through.

I highly recommend making jigs as shown in Figures 2 and 3 to hold the parts while you are soldering them.

Horizontal Handrail Assembly

The horizontal handrail is formed from flat brass wire as shown in Figure 10. The vertical handrail is formed from 0.010 or 0.0125 phosphor bronze wire as shown in Figure 11. You can either bend a single piece or make two identical pieces as shown in Figure 11. I find two pieces easier to work with and solder than a single piece. I recommend phosphor bronze wire over brass because brass tends to break when bent to a sharp angle. The dimensions are given in millimeters for HO scale. To convert to scale feet, divide these numbers by 3.5.

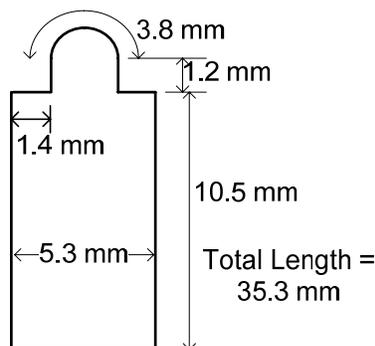


Figure 10: Horizontal Handrail

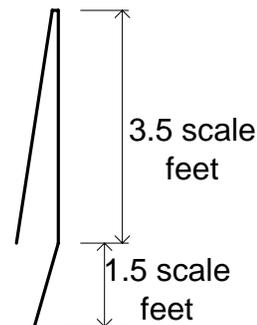


Figure 11: Vertical Handrail (Make 2)

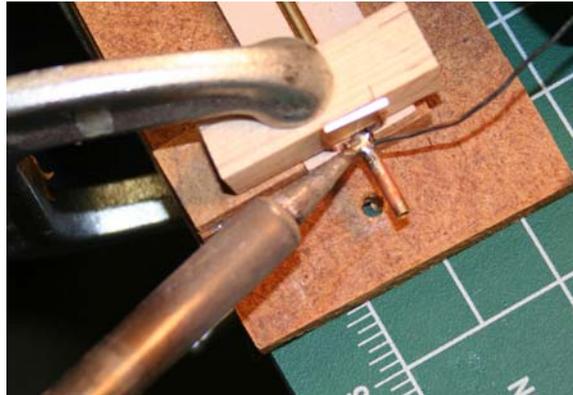


Figure 12 Soldering the Horizontal Handrail

To solder the horizontal handrail to the mast, position the rounded portion of the handrail around the mast approximately 4 scale feet from the top of the mast, place the mast in the jig and position the handrail so that it is square with the mast using the handrail jig and solder. Ensure that the wiring notch is oriented toward the back. Refer to Figure 14.

Service Platform

Form the service platform from 0.010 sheet brass or substitute brass mesh stock if available as in H 12. K&S sells various sizes of etched brass mesh in square and diamond patterns. While this isn't exactly prototypical, it does look better than a solid platform. Make two cuts about 2 mm long and $\frac{3}{32}$ " apart in from the end and centered. This will provide a platform extension forward to the front of the mast and will greatly facilitate positioning the platform as in Figure 13. The platform attaches to the mast 3 scale feet below the horizontal handrail. The ends should slide into the right angle slot you cut into the assembly jig. Push into this slot until the bent tab is snug against the mast, align it with the horizontal handrail. This will automatically center the platform and hold it firmly in place (if you haven't made the cut too wide) while you solder it. Ensure that it is oriented squarely with the vertical handrail above. If you are making a double target signal, make a second platform long enough to extend from the mast to the ladder and solder it 5 to 6 scale feet above the upper platform.

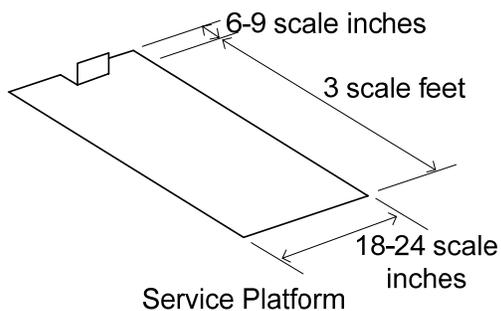


Figure 13: Service platform

Vertical Handrail Assembly

Cut two pieces of 0.010 or 0.0125 (HO) or 0.020 (O) phosphor-bronze wire approximately 9 scale feet long. (Brass wire will probably break when you attempt to bend it into a sharp angle.) Bend the wire approximately 3-1/2 scale feet from one end against a metal strip (such as a scale rule) to the approximate angle shown in Figure 14.

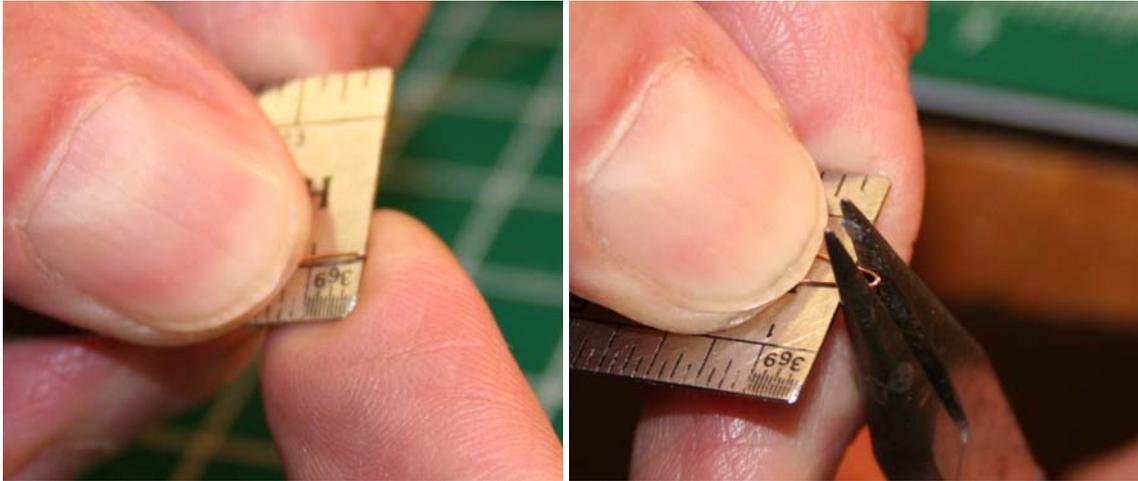


Figure 14 Make the first bend. The angle will probably not be sharp enough, so hold the wire firmly against the metal to hold it in place and complete the bend as shown above.

Position one vertical handrail against the sloped face of the handrail jig, with the tightly bent ends looped over the horizontal handrail, and solder where the handrails intersect. You can probably hold the vertical handrail in position with your finger while you solder it by touching a solder-loaded tip against the joint as in Figure 15. This should require about a half-second and the wire will probably not conduct enough heat to burn your finger. (If it does, use a small piece of paper towel as an insulator.) Refer to Figure 1 and note that the vertical hand rail will be positioned between the front and rear bends of the horizontal hand rails so that they are in the same plane as the ladder. Solder the second vertical handrail, mirror-image, in the same way. If the handrails are not perfectly aligned after soldering, you can now bend them into the correct position.



Figure 15. Soldering one vertical handrail

Ladder

Signal ladders are generally narrower than ladders mounted on freight cars, but you could probably substitute wide stock, if necessary. Tomar is currently the only known supplier of HO brass signal ladder stock, Part #H-899, available from Walthers. A package contains 24 inches of ladder stock, sufficient for a number of signals. Cut a 9.5 scale foot section (or longer if you are modeling a taller mast), leaving enough extension at the top to solder to the bottom of the service platform. The ladder should reach the base and pedestal of the mast. Bend the vertical extension beyond the top rung about 86 degrees and tin with solder. Also tin the underside of the service platform. Using a jig to position the ladder, press the tabs against the underside of the service platform and solder as in Figure 16. Again, you can probably use your finger to hold the ladder in position. At this time also solder the two inside vertical handrails to the service platform.

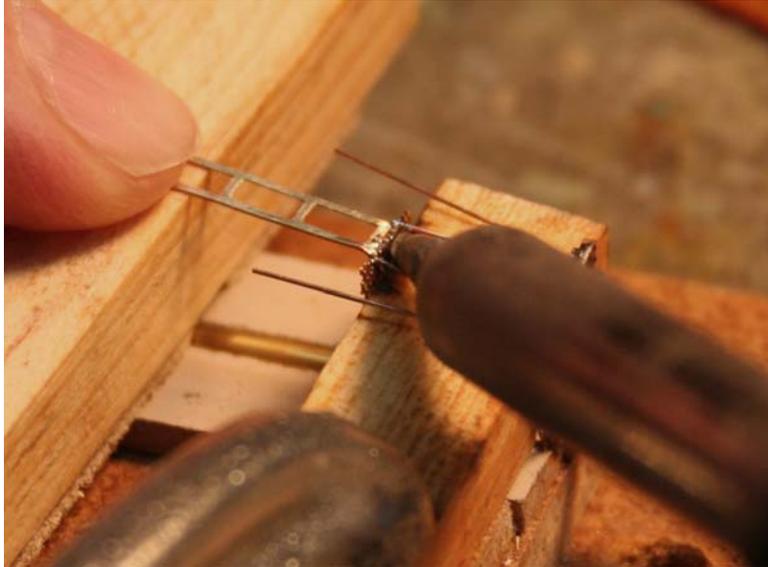


Figure 16: Soldering the Ladder

Now make the final bends to the outside vertical handrails so that they are parallel. Make second bends where these rails are at the level of the service platform so that they intersect the ladder at the first rung below the top, as in figure 17. The outer post of the handrail may or may not touch the platform

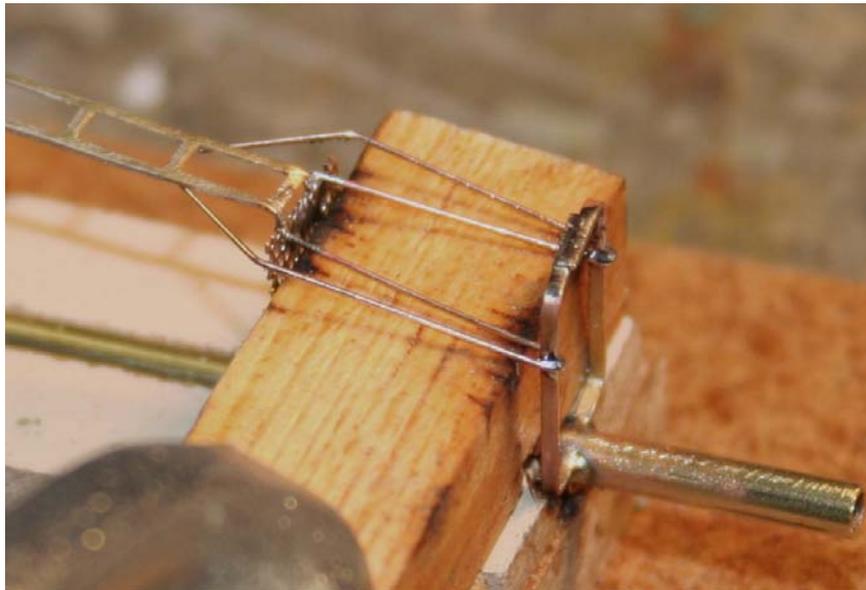


Figure 17. Bending and Soldering the Vertical Handrails to the Ladder

The mast assembly is now almost complete. However you may optionally add a ladder brace. Bend a “U” shaped piece of flat brass to the diameter of the mast so that the two arms reach and touch the ladder. Position it so that it is perpendicular to the mast and solder it to the mast and both sides of the ladder. Trim any part that extends beyond the ladder.

Mounting the Target to the Mast

Complete the target assembly by soldering a mounting bracket to the side of the light housing. Normally the target is offset to the left (facing from the front), but in tight situations you might want to offset it to the right. You can make the bracket as shown in Figures 8 or 9. The square tubing looks more prototypical, but the strip is easier to attach. Attach the target by placing the mast and the target assemblies into the jig. I find that with tubing bracket it is necessary to shim the target face upward so that bracket mates properly with the mast. Solder when it is correctly aligned, Figure 18.



Figure 18: Soldering the Target to the Mast

Base and Pedestal

The final mast detail is to add the base and pedestal. Cut the pedestal from 1/8" brass tube approximately 4 mm. (15 scale inches) long and file the ends square. Punch or drill a piece of 1/4' x 0.015 brass stock and trim to approximately 2 scale feet square with the hole centered to form the base. Slide the tube first, then the base onto the mast. Solder so that the base is flush with the bottom of the ladder and square with the orientation of the signal assembly. Refer to Figure 19

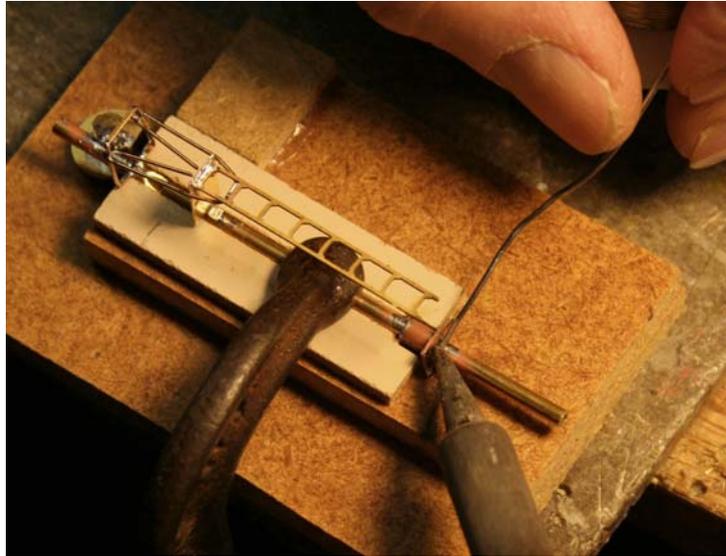


Figure 19: Soldering the Base and Pedestal

Final assembly

There is one more option: soldering a short piece of 1/8" square tubing below the base of the pedestal. This will enable you to insert the signal into a 5/32" piece of square tubing inserted into your roadbed at the signal location. This will keep your signal properly oriented to the track. You may also add an identification sign(s) to the front of the signal below the target. Signs typically include a mile marker and/or grade or absolute lettering. Consult your favorite prototype for location and numbering standards. Your signal is now complete except for installing the LED. If you have a supply of Oregon Rail Supply pointed ends, insert one into the top of the mast. Otherwise trim a small brass brad, insert it into the top of the mast and solder or cement it into place. Figure 19 show completed and installed single and double Type SA signals

Installing the LED(s)

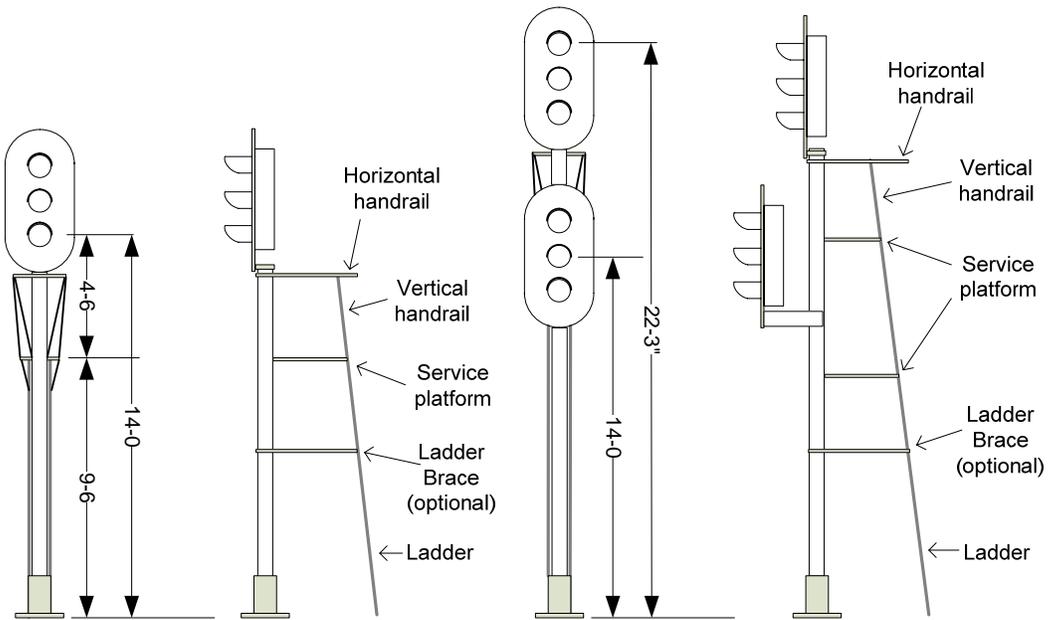
The signal mast will accept up to six #30 wire-wrap wires. You need only three for a single target signal. Solder wires to the red, green and cathode leads of the LED as close to the body as possible, cut the LED leads as short as possible and insulate the joints with heat-shrinkable tubing or liquid tape, then feed the wired through the notch just below the target down through the mast and connect them to the appropriate electrical source. Ensure you make the wires long enough to reach this source.

Congratulations, your signal is now complete, ready to wire into a signal controller, and go into service. The assembly may seem complicated, but I have found that with good jigs, assembly may be completed in about an hour. Figure 20 shows completed and installed single and double Type SA signals.



Figure 20 Completed Type SA Signal Structures

Type D Signal Assemblies



Type D Signal

Figure 21 Type D Single and Double target Signals

Figure 21 shows modified drawings for General Railway Signal Type D signals.

The mast assembly for type D signals is almost identical to that for Type SA signals, except for the target mounting. For HO scale signals, rather than attempting to make your own three-light targets, I recommend using Oregon Rail Supply targets. You will need to make your own for other scales. The Oregon Rail Supply targets come in individual visor or hooded styles and in two and three-light configurations. You can mount them to the mast using the supplied plastic brackets, which are fragile, so I recommend that you can make your own brass mounting plate as shown in Figure 22. Cut a 0.010 brass plate approximately the size of the back of the plastic target and drill three holes large enough in diameter to accept an LED snugly and aligned with the LED holes in the target. The Oregon Rail Supply targets space the lights 15 HO scale inches apart (2.8 mm or 0.11 in). For T1 LEDs, I recommend using a #34 drill, then enlarging the hole with a round jeweler's file so that each LED fits snugly into the hole. Solder the target mounting plate to the top of the mast as shown in figure 22.

The General Railway Signal drawings for a two-target signal show the green light of the lower target positioned 14 feet above the ground. The Oregon Rail Supply targets are larger than those drawings, so I have shown the yellow light of the lower target centered 14 feet above the ground. For the topmost target, solder the mounting plate to the top of the mast using the solder tab as shown in figure 23.

When making a two-target signal, the lower target may have only red and yellow lights, depending on the installation. In this case shorten the mounting plate and drill only two holes. For the lower target make an extension bracket from either 3/32" round or square tube stock. File one end round concave to fit snugly against the mast. Solder the square end to the mounting plate solder tab and the other end to the vertical mast. Again using a jig is most helpful. Figure 24 shows a completed structure ready to accept the LEDs and target housing.

Installing the LEDs

When the rest of the assembly is complete, push the LEDs through the holes in the mounting plate and slide the plastic target over the LEDs. You may also need to enlarge the holes in the target to fit the LEDs, but take care not to drill through the front of the target. You may also want to secure the target to the mounting plate with ACC. Note that prototype practice generally has green on top and red on the bottom. For HO, the 3/32 mast will accept no more than 6 #30 insulated wires. I recommend that you solder the LED cathodes together and solder that wire to the mast as the ground.

When soldering wire leads to the LEDs try to make the connections as close to the base of the LED as possible, observing the polarity. Make a small loop of bare wire as close to the insulation as possible, pull the loop tight against the lead and quickly touch a hot iron and good-quality electrical solder against the connection. The connection should be made in less than a second, and the brief application of heat will not damage the LED. When the connection is made, cut the LED lead as close to the connection as possible. Its always good to test the connection using a 3 volt power supply after completion. Figure 25 shows completed Type D signal structures.

For a more detailed explanation of how to prepare LEDs for installation refer to the clinic *Using and Wiring Light Emitting Diodes (LEDs) for Model Railroads*

Other Scales

If you are working in N, S or O scale, I am not aware of any commercially made targets. N scale provides a particularly difficult challenge, but a hooded type might be easy to make and would more easily disguise the oversized LEDs. For O scale you could make your own by cutting visors from brass tubing and soldering them onto a brass target. Other possibilities include making targets from Plastruct or Evergreen styrene sheet and tubing. An assembly jig made with wood dowels would simplify this process. In O scale you could also use a 1/8" tube for the mast which would be a more correct size.

Scale-size ladders would also be a challenge in any scale other than HO, but freight car ladder stock, although wider than that used for signals might work well.

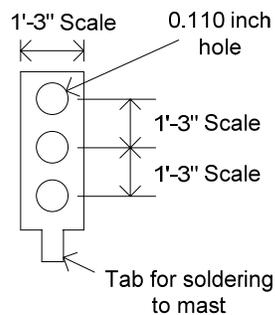


Figure 22 Type D Target Mounting Plate

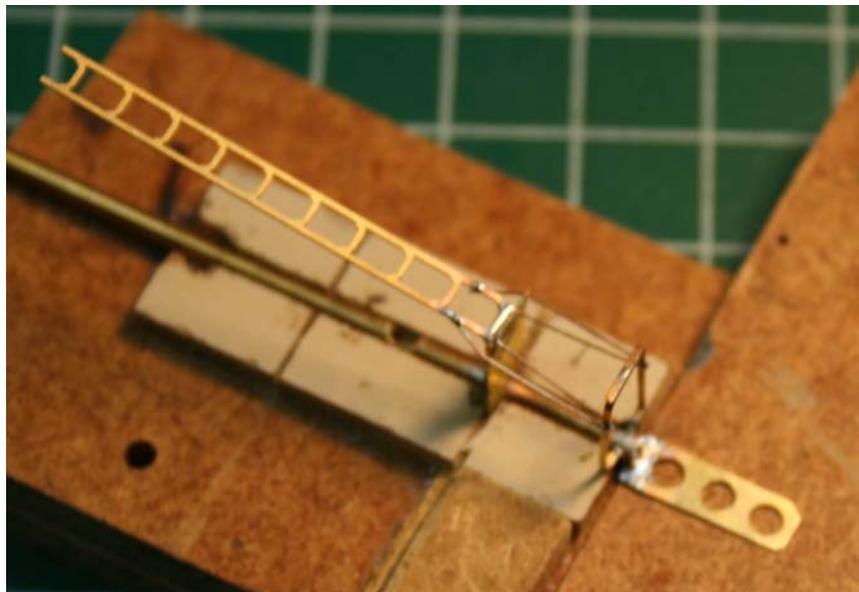


Figure 23 Partially assembled Type D signal mast showing the attachment of the target plate to the mast.

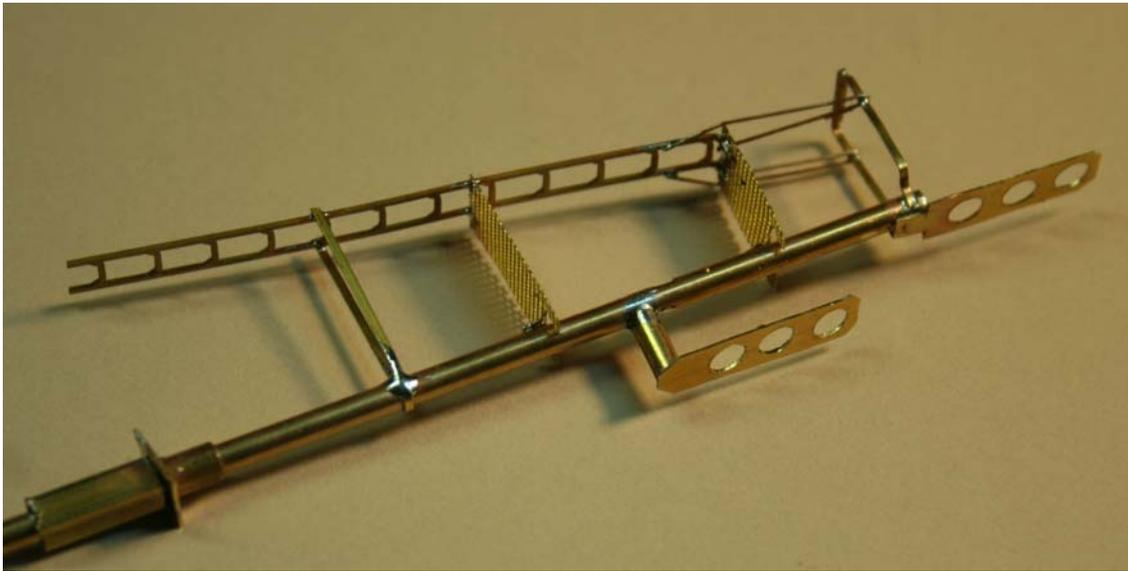


Figure 24 A two-target signal assembly before adding the LEDs and targets

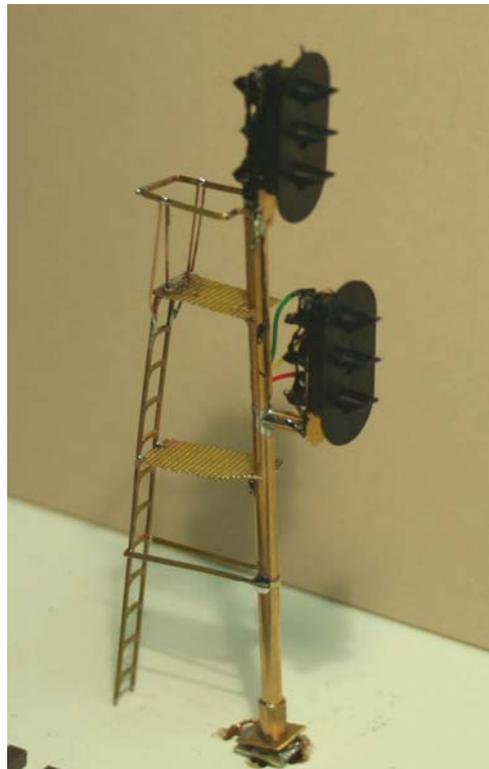


Figure 25 Completed Single and Double Target Type D Signals

Mounting Socket

You may drill a $\frac{3}{32}$ hole in your roadbed to insert your signal, however I prefer to make a mounting socket from square tubing to prevent the signal from rotating out of position. Cut and about $\frac{1}{2}$ inches of $\frac{1}{8}$ square tubing that will nest with the signal mast. Slide it up against the base pedestal and solder it. Cut another length of $\frac{5}{32}$ square tubing to

nest over the 1/8 tube. Make a collar for it by drilling a hole into a small piece of brass and filing the hole square to fit snugly over the square tube. Solder the collar flush with the end of the tube. Drill a hole in your roadbed so that the socket will fit into it without rotating ensuring that this hole is vertical. If the hole is too large you can fill around the socket with wood putty or white glue. If the LEDs are grounded to the mast, this socket can also be grounded provide an electrical connection. Figure 23 shows a socket arrangement with a ground wire soldered to it that is just visible.

Appendix A: A Basic Tool Set for Building Signals.



Figure 25 A basic Tool Set for Building Signal Structures

These tools include, top to bottom and left to right:

- Jewelers files: round, flat, square and oval shapes
- Close-cutting diagonal wire cutters
- Good quality wire strippers for #30 through #24 electrical wire Small needle nose pliers
- Scriber
- Small metal shears

These tools are available from Micro-Mark.

Appendix B: Table of conversions

mm	inches	Scale feet	Scale Inches
0.69	0.094	0.20	2.4
1.20	0.047	0.34	4
1.40	0.055	0.40	4.8

2.00	0.079	0.57	6.84
3.18	0.125	0.91	10.9
3.50	0.138	1.00	12
3.80	0.150	1.09	13.1
4.00	0.157	1.14	13.7
4.50	0.177	1.29	15.5
5.00	0.197	1.43	17.2
5.30	0.209	1.51	18.1
5.50	0.217	1.57	18.8
6.00	0.236	1.71	20.5
7.00	0.276	2.00	24
7.36	0.290	2.1	25.2
10.50	0.413	3.00	36
14.00	0.551	4.00	48
18.00	0.709	5.14	61.7
33.25	1.309	9.50	114
45.00	1.772	12.86	154.3
49.00	1.929	14.00	168

Appendix C: Bill of Materials

Brass Sheet 0.005	K&S	For Type SA target hoods
Brass Sheet 0.010	K&S	
Brass Tube 3/32 Round	K&S	
Brass Tube 1/8 Round	K&S	
Brass Tube 1/16 Square	K&S	Optional
Brass Tube 1/8 Square	K&S	Optional
Brass Ladder Stock	Tomar	#H-899
Phosphor Bronze Wire 0.0125		For vertical handrails
Flat Brass Wire	Detail Associates	#2524 (for horizontal handrails and ladder braces)
Type D Targets	Oregon Rail Supply	#104 Triple light targets
Etched Mesh	K&S	Various sizes (Optional for service platforms)