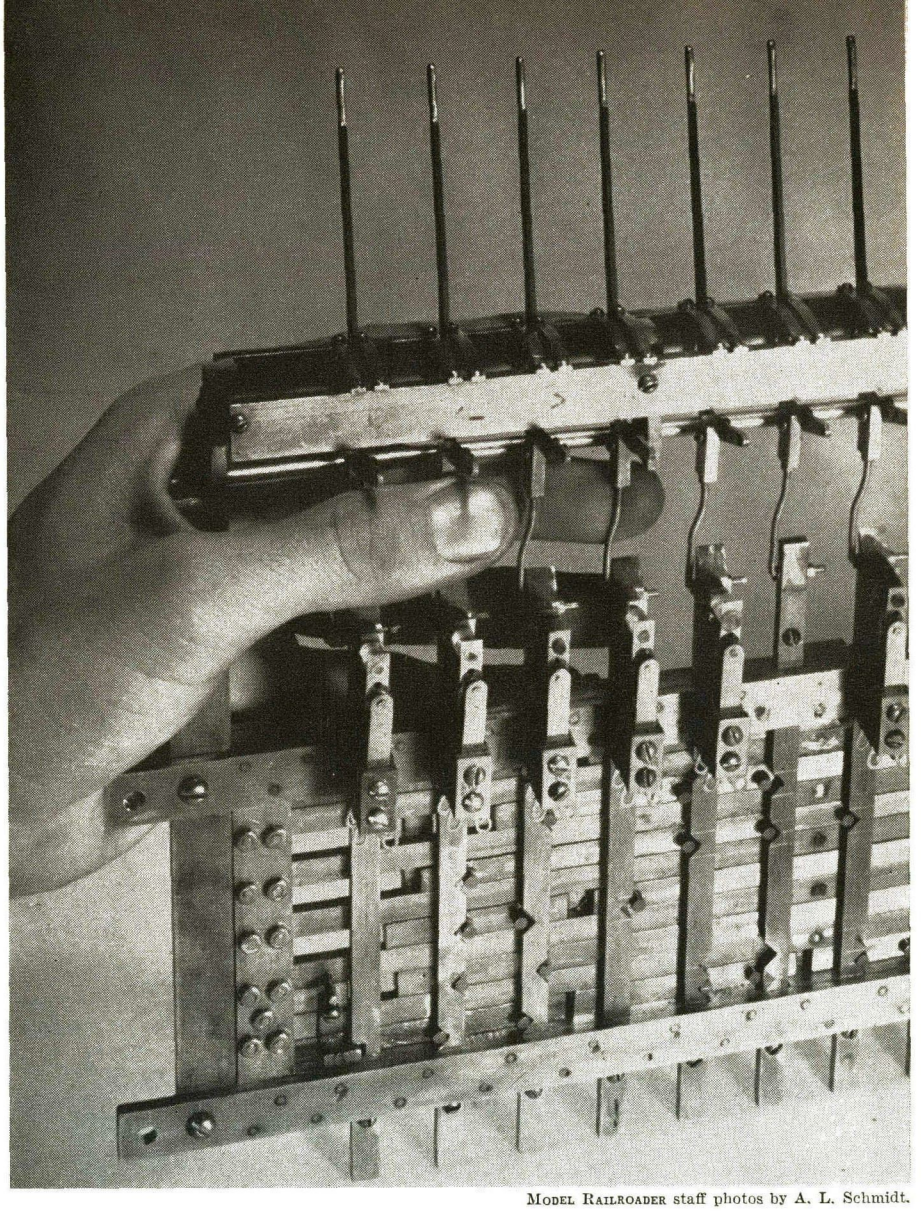
How to design your inter-locking frame

Theory of locking can be applied to any track pattern. Practical frame design can follow standardized parts arrangement

By Paul Larson
and Gordon Odegard

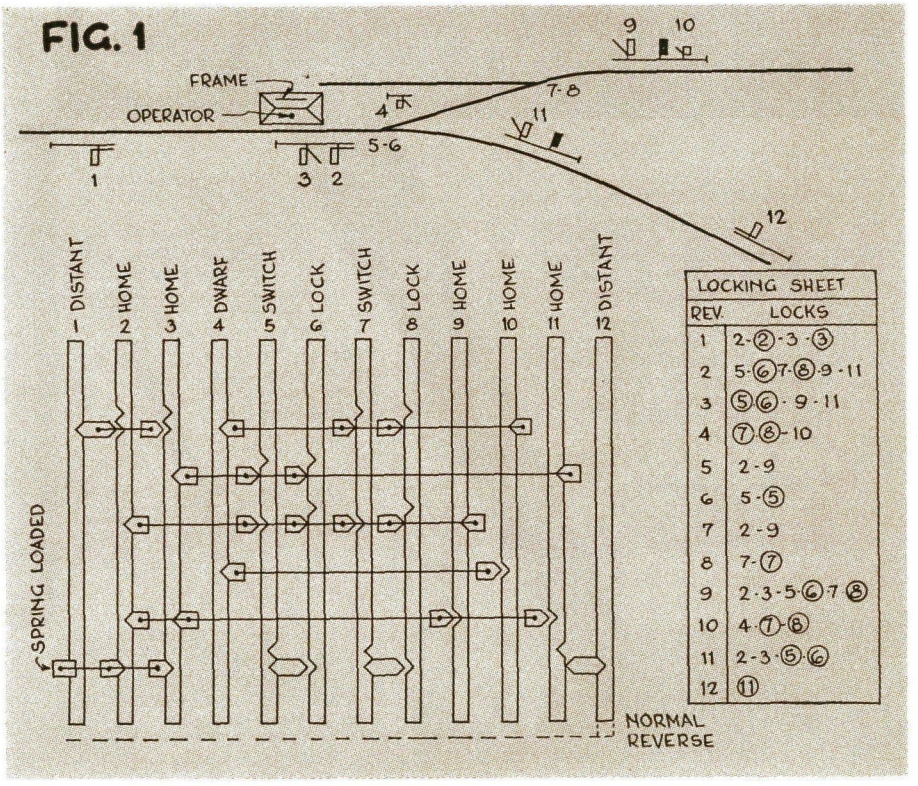


MODEL RAILROADER staff photos by A. L. Schmidt.

THE design of a mechanical interlocking frame is much like a mechanical puzzle, but once understood, the principles can be applied to any track and signal arrangement. In the frame are two sets of bars which interact with each other to prevent the operator from making dangerous moves. The main set of bars are the "tappets" and one tappet is connected to each lever. If the lever is pulled to clear a signal or move a switch, the tappet moves a short distance lengthwise at the same time.

Close behind the plane of the tappets are the locking bars. These can also move a short distance but at right angles to the tappets. The number of locking bars required depends on how many false moves must be prevented.

In the sides of the tappets are notches with sloping sides, and the connection between the tappets and locking bars



consist of cams called "dogs." Two or more dogs are mounted on each locking bar. These slide into and out of the notches in the tappets as the tappets are moved, locking and unlocking them.

Here's how the scheme works: Suppose the operator pulls the lever to clear a particular signal. This also pulls the tappet connected to the particular lever and forces any dogs seated in the notches to the side, thus moving one or more locking bars. The dogs on the other ends of these locking bars are thus forced into notches in other tappets. By this scheme, pulling one signal to clear locks all the other switch and signal levers in safe positions until the first signal is again restored to normal.

Interlocking signals are normally at stop or "red" position, and a lever must be pulled to "clear" the signal. This is not necessarily to green, however, for in some situations only a yellow indication is given to a train to let it into the "plant."

There are other basic rules. A turnout may have two levers, one to actually move the switch points, the other to lock the points. A signal cannot be cleared until all the related turnouts are properly thrown *and* locked. Such locks are nearly always used where the switch points "face" oncoming traffic. The lock insures that the points are thrown all the way with no chance that a wheel flange will snag on a partly thrown point. If the points aren't thrown all the way, the turnout cannot be locked, and in turn, the signal cannot be cleared. Generally, these locks on turnouts are called "facing point locks."

Figs. 1-6 show typical arrangements of track and signals. Each diagram is accompanied by a "dog chart," a list of the levers that show which other levers any particular lever will lock if pulled. The lines connecting the wedge-shaped dogs represent the locking bars at right angles to the tappet bars.

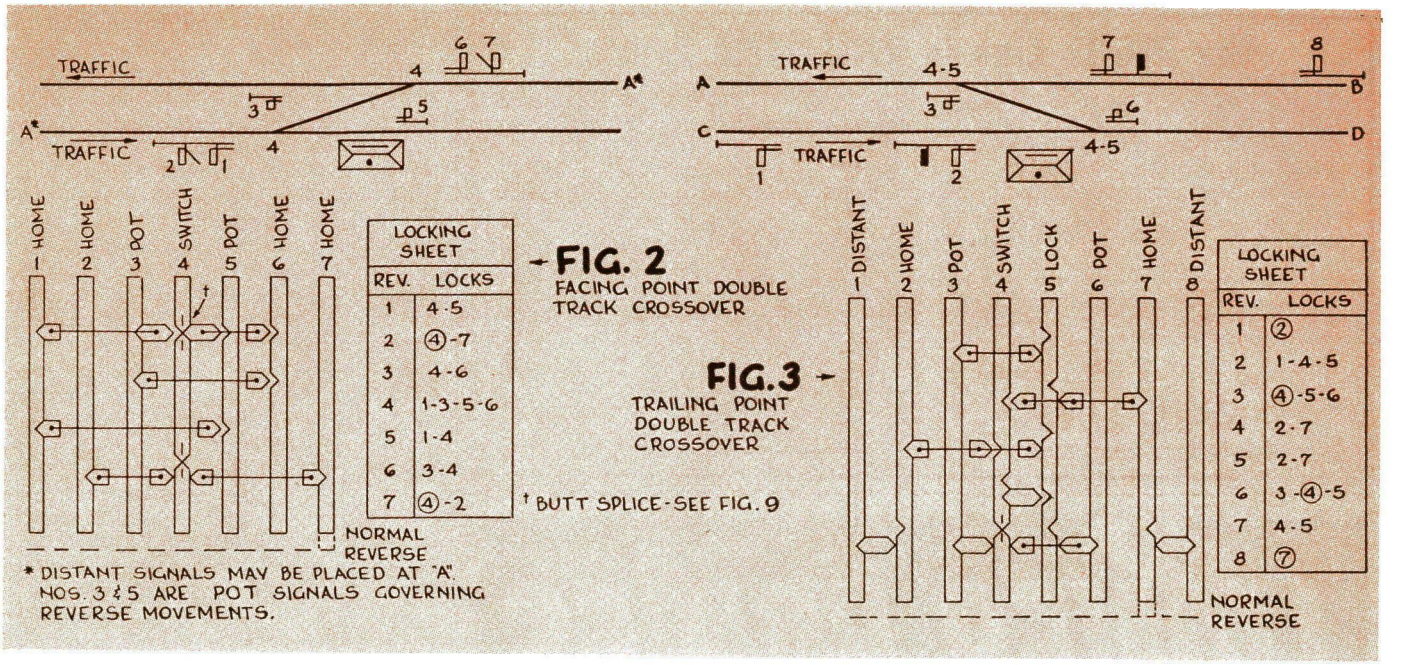
By studying the track-signal diagrams you'll note several other details. Derails — mechanical track devices that actually guide the wheels off the rails if a train passes a "stop" signal — are used in many instances. "Home" signals have two blades. The blacked-in blades indicate a fixed aspect — the blade does not move. As an engineer approaches the plant the position of the home signal is seen in advance when he passes the "distant" signal located beyond the limits of the interlocking plant. In some low-speed situations, the distant signal is fixed at caution. In other instances where there is no automatic block signaling, the distant has only green and yellow aspects.

So much for the prototype.

The interlocking frame we built at the MODEL RAILROADER workshop and then installed on Paul Larson's railroad follows the Fig. 1 scheme and is shown beginning in Fig. 7, page 65, and in the photos. Here's how it can be built.

Frame

The sizes of pieces needed for the interlocking frame are shown in the notes within Fig. 7, most of the bars being ⅛"



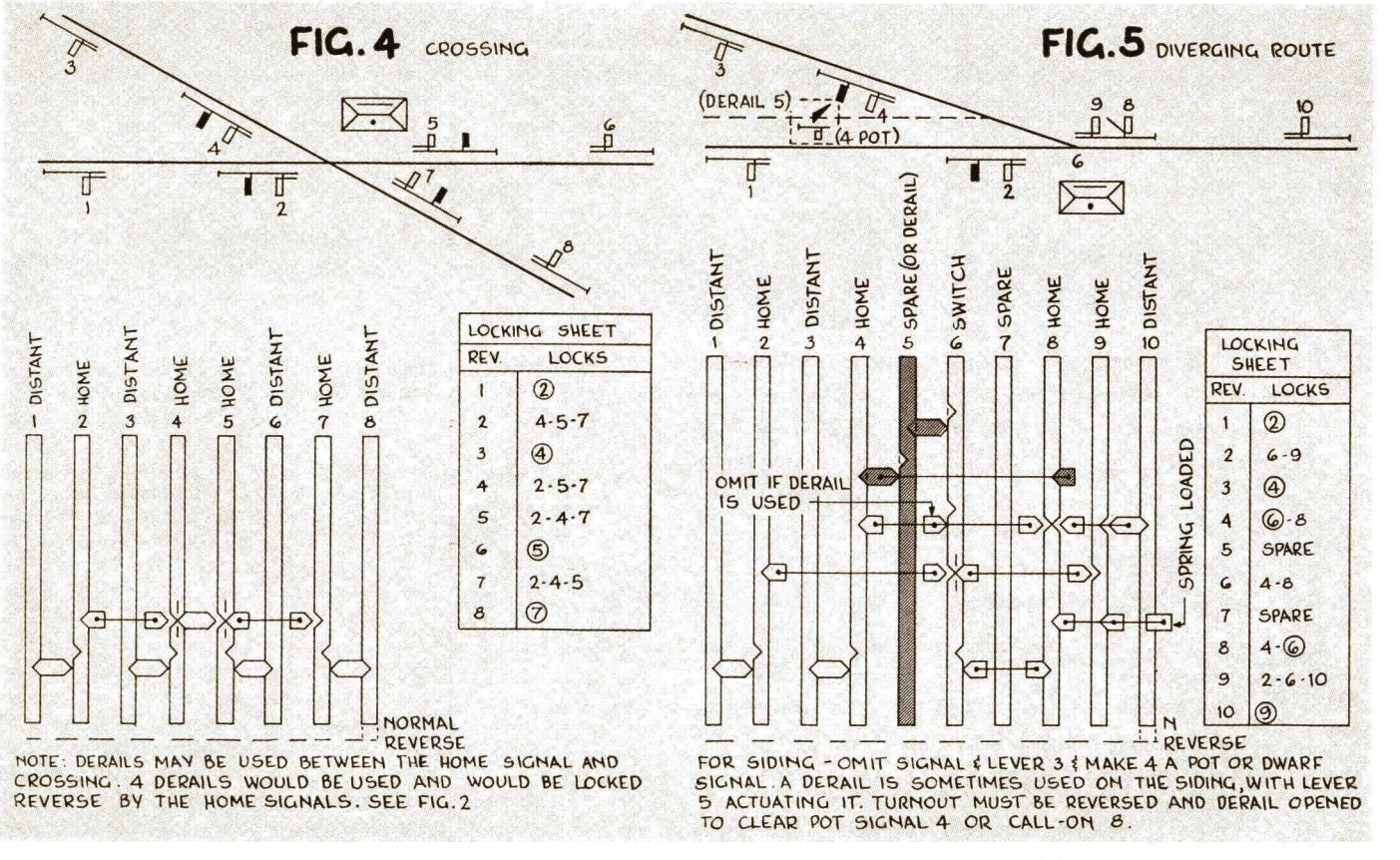
brass in ¼" and ½" widths. You may change the dimensions to suit a frame for more or fewer levers and locks as you wish. Our instructions assume you are building this particular frame, which is for a junction.

When cutting the pieces, dress the ends smooth, and square with a smooth file or sanding disk. Start with the right-hand piece "B," ⅛" x ½" x 3¾", soldering it to the lower piece "A" of the same material but 12" long. Let exactly 1" of "A" extend beyond "B" and use a square to check your angle to exactly 90 degrees.

Now lay 12 pieces of ⅛" x ¼" cut 5¾" long side by side but separated by 12 pieces of the same material ½" sq. This gives you the spacing for locating the left-hand piece "B." Compress the assembly when you make the mark to show the location for "B." Solder this second "B" to "A" at right angles. There should be 10" between the two parallel members and each should be 1" from an end of the long piece.

Cap this assembly (with spacing bars in place) with a ⅛" x ½" x 10" bar. Tack-solder all the ½" sq. pieces to the 10" and 12" members. These will be drilled and tapped later on.

Now cut five ⅛" x ¼" x 10" locking bar spacers (which run horizontally). Position these using six intermediate temporary ⅛" x ¼" spacers and locate the upper 12" bar "A." Solder it and the five locking bar spacers to the frame. Now place 12 pieces ½" sq. on this edge as we did before and space them with the 5¾" long "tappets," as they are called. Cap with a ⅛" x ½" x 10" bar and tack-solder in place. Cap the locking bar spacers with two ⅛" x ½" x 3¾" directly under



the first two "B" pieces. Remove all the loose spacing bars.

Mark and center-punch all the holes required for screws to hold this assembly together. See Fig. 7. Placement of these holes is not critical, but they should be located so that the centers are about ⅛" from any edge. Drill all No. 50 and counter-drill all except the "A" pieces size 43. Tap the "A" pieces 2-56.

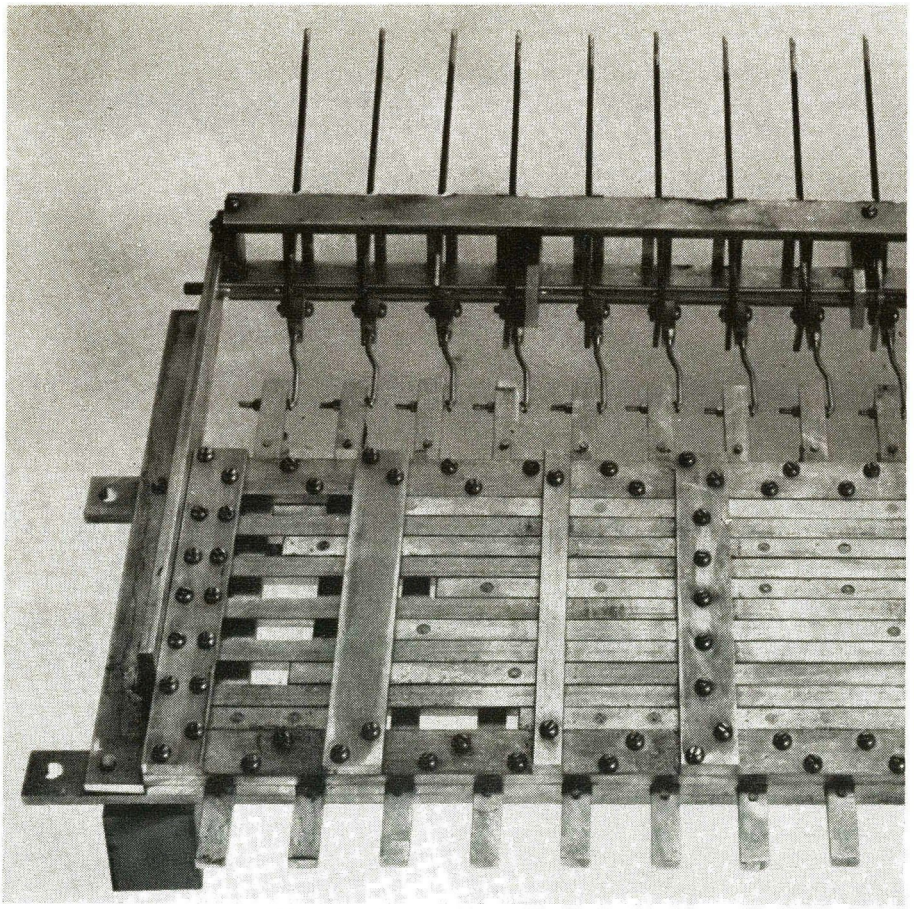
Now unsolder and disassemble the frame except for the two 12" and the first two 3¾" bars ("A" and "B" pieces), which are soldered together. Either lay the components aside in proper order or code them with numbers and letters so they may be replaced in their proper positions. Dress all surfaces with a file, cleaning off all solder and drilling burrs.

Drill 20 No. 47 holes in the upper piece "A" as shown in Fig. 7. Tap these 3-48 for mounting the electrical contact later on. Note 6 and 8 lock levers don't require holes for contacts.

Now reassemble the frame, using 2-56 x ½" roundhead steel screws and nuts. Put the 12 tappets and some ⅛" x ½" locking bar spacers in the frame to help align all the components before you tighten the screws. Be sure the tappets are not pinched by a twisted ½" sq. spacer. As an anchor for the spring lock, insert a ⅛" x ¼" x 1" bar in the lower left corner of the frame as shown in Fig. 7. Drill a No. 43 hole through the pieces and secure with a 2-56 nut and screw. Drill two No. 50 holes, one in the insert and one in the locking bar spacer directly above it, and tap 2-56. Number all the tappet bars before removing them so they can be replaced in the same slots. Remove all other loose pieces and file the edges of the basic frame smooth. Cut five pieces of ⅛" x ½" brass bar stock 3¾" long. These are supporting members for the short locking bars. Locate their positions in Fig. 7 and drill No. 43 to match the corresponding holes in the frame. Cut off excess screw lengths and file flush with either frame or nut. Drill four No. 19 and four No. 28 holes in the 12" long "A" pieces. Locate the position from Fig. 7.

Tappets and locking bars

Draw-file No. 1 tappet to a smooth fit in its respective slot and square the ends. Break the end corners with a slight 45 degree chamfer. Drill a No. 50 hole 1¼" from one end and tap 2-56. (See Fig. 7.) Put a 2-56 roundhead screw into the hole, cut off the excess threads and file flush with the underside of the bar. To find the other stop screw position, insert the tappet into the frame and hold the screw head tight against the frame edge. Scribe a line across the bar on the other end of the tappet, ¼" plus half the diameter of the 2-56 screw head (about 5/64") away from the frame edge. Total distance is about 21/64". Tend to make this dimension slightly undersize so you can file the screw head to get exactly ¼" tappet movement. Drill a No. 50 hole, tap 2-56 and insert a roundhead 2-56 screw as you did on the first end. Drill a No. 47 hole crosswise through the tappet at the position shown in Figs. 7 and 8. Repeat



The back side of the frame: Entire assembly is fastened together with 2-56 screws. Frame is made of ⅛" x ¼" and ⅛" x ½" brass bar stock. Frame must be absolutely square to work properly.

these drill and tap operations for each of the tappet bars.

To each tappet except 6 and 8, solder a 1/16" x ¼" x 5/16" piece of brass and file to the tapered shape shown in Figs. 6 and 8. These will serve as lifting pads for the electrical contacts.

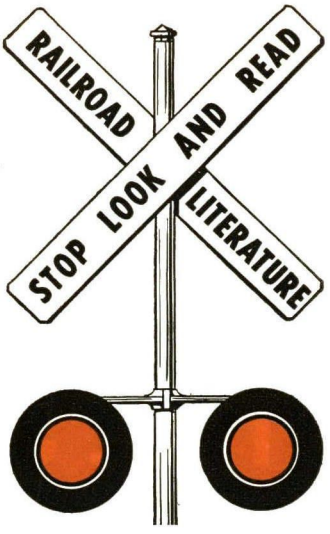
Fitting the locking bars and making the locking pieces is a rather tedious job since stop screws, tappets and locking bars must be removed and replaced many times. As the work progresses the frame and moving parts become a sort of Chinese puzzle where several pieces must be removed before the part you are working on is accessible. A little extra work here will pay off with a smooth, snug-fitting machine when you are finished. Each completed locking bar should remain in place as the work progresses to insure snug fitting.

The order of fitting is not too important. However, we started with the first row of bars and worked our way back. Since the same method of shaping and fitting the dogs and notches is used throughout, we will only describe the construction of one locking bar. Figs. 7 and 8 give all pertinent dimensions. All the bars are cut from ⅛" x ¼" brass. The lengths of each piece are listed at the bottom of Fig. 7. Bar "C" is 2¾" long. Draw-file the edges, square up the ends and put a slight chamfer on the edges so they will not snag in the frame.

Fig. 8 gives the dimensions for locating the dog-pin holes. Center-punch and drill the No. 31 hole 7/16" from one end of the bar. Chuck a length of ⅛" dia. drill rod into a drill press or some similar turning device and while it is rotating file the end square and then file a slight taper ⅛" long. Cut the piece about 9/32" or 5/16" long and drive it into the No. 31 hole drilled in the locking bar. File the bottom edge flush with the bar and the top ⅛" above the bar. This dog will engage a notch to be cut in tappet 3.

Place the locking bar in proper position and insert tappet 3. Scribe a line through the center of the pin and across the face of tappet 3, parallel to piece "A." See the drawings for the shape of the notch. Scribe V-shaped lines on the bar and rough out with either a hack saw or a cutting disk in a hand power tool. We used the latter equipped with a carborundum disk about .020" thick and 1" dia. fitted on a ⅛" dia. mandrel. Such disks are very handy for cutting and shaping small parts. File to a smooth finish. A Barrette Swiss pattern file is handy since its triangular shape with only one cutting face will allow you to work a surface without marring an adjoining one. Endeavor to get the notches as much alike as possible. The notch should have a smooth finish so that the steel dog will slide easily over it. Assemble the parts in the frame and test the sliding action of the mating pieces. All matching surfaces should be checked frequently and mated on a cut and fit basis.

Chuck a 2" or 3" piece of ⅛" dia. drill



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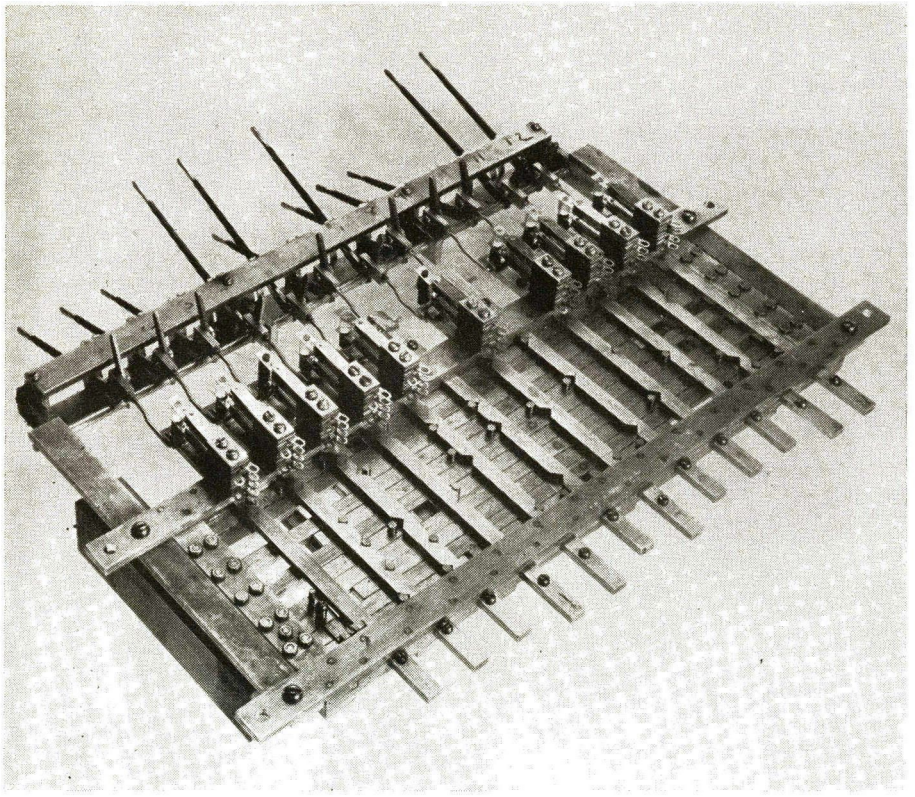

The front side of the frame: To reduce friction, MR's staff used ⅛" drill rod for the dogs. Later experimenting showed that wedge-shaped dogs would work as well in model as in prototype.

rod in a drill press or electric hand tool. Fashion a sharp scribing point about 3/64" long on one end, using Swiss pattern files. This tool can also be made with a lathe. This scriber need not be hardened since it will be used to scribe only about 30 short lines across the locking bars. If it becomes very dull, the point can easily be dressed back to shape. Of course you may harden the tool if you wish.

With both tappet and locking bar in position, reverse the tappet so that the steel dog rides on the edge of bar 3 rather than in the notch. Now insert tappet 2 and using the special scribers, scribe a line across the locking bar while it is held

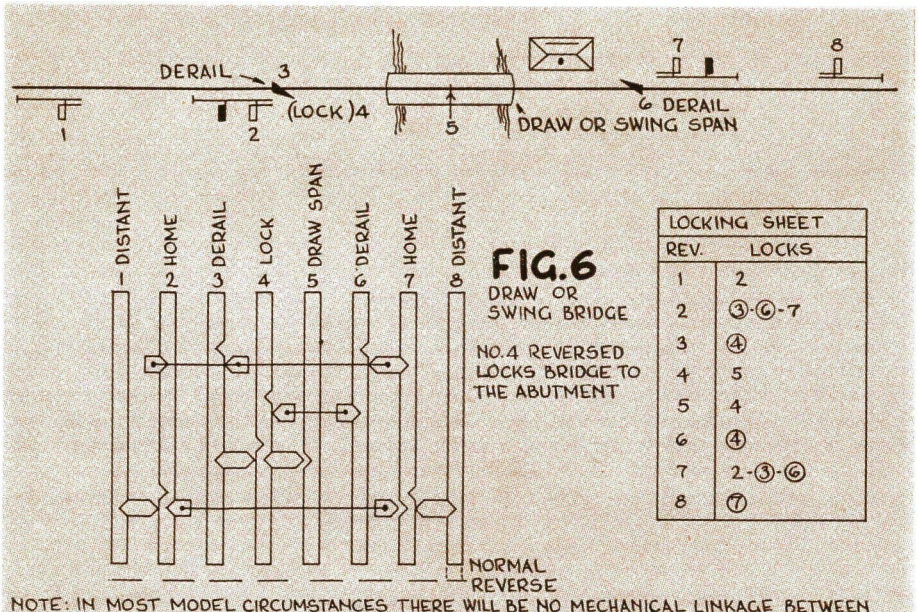

FIG. 6
DRAW OR SWING BRIDGE

NO. 4 REVERSED LOCKS BRIDGE TO THE ABUTMENT

LOCKING SHEET	
REV.	LOCKS
1	2
2	③-⑥-7
3	④
4	5
5	4
6	④
7	2-③-⑥
8	⑦

NOTE: IN MOST MODEL CIRCUMSTANCES THERE WILL BE NO MECHANICAL LINKAGE BETWEEN THE BRIDGE AND THE LEVERS SO THAT SOME OTHER MEANS MUST BE EMPLOYED TO ACTUALLY INTERLOCK THE SPAN TO THE SIGNALS. IF THIS IS NOT DONE, IT WILL BE POSSIBLE TO CLOSE THE DERAILS AND CLEAR THE SIGNALS WHETHER THE BRIDGE IS OPEN OR CLOSED. THE SIMPLEST METHOD TO INTERLOCK BRIDGE AND SIGNALS IS TO USE LEVER NO. 5 TO OPERATE THE BRIDGE. IN NORMAL POSITION THE BRIDGE IS CLOSED AND THE END LOCK CAN BE CLOSED AND THE SIGNALS OPERATED. IN REVERSE POSITION THE SPAN OPENS AND THE LOCK AND SIGNALS ARE LOCKED NORMAL.

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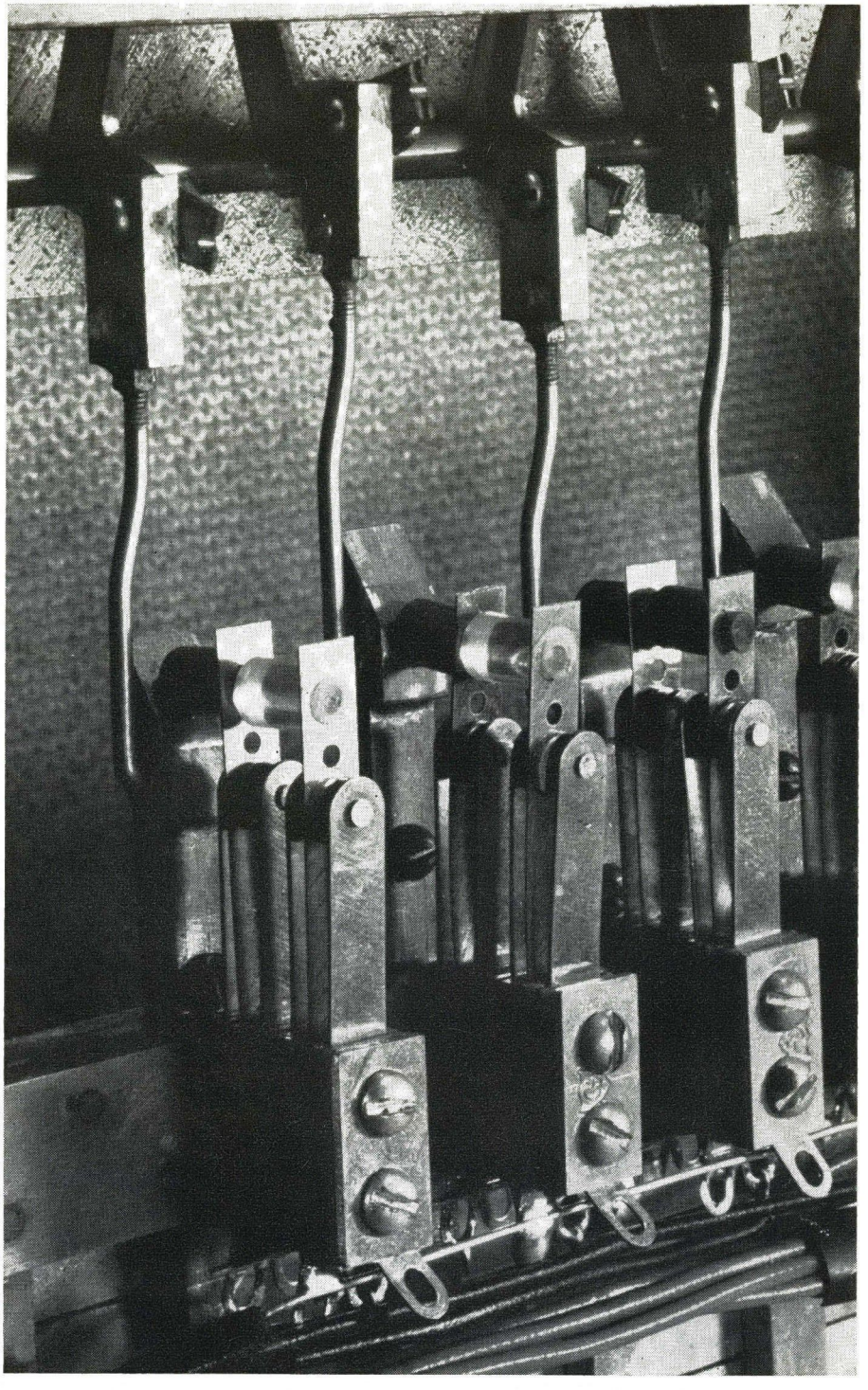
snug against bar 3, using the edge of bar 2 as a straightedge.

This will give you one of the required centerlines for the next dog. Find the center of the locking bar, center-punch and drill a No. 31 hole. Now fashion and install a steel pin as you did before. The next step is the cutting of a notch in tappet 2 to receive this dog. All the other dogs and their respective notches except one are made by this same basic method. The procedure is the same as for tappet 3. Refer to Fig. 7 often when laying out these notches to be sure you are putting them in the right place. A mistake can be quite a disappointment.

When the plan calls for a tappet to be locked in its reverse position be sure to move the bar to the reverse position before laying out the notch. It will save a lot of patching, relocating and cutting.

Tappet 1 requires a spring loaded locking dog and must be unlocked by either No. 2 or No. 3 levers. Move tappets 2 and 3 to the reverse position. Hold locking bar "C" tight against the edge and scribe a line across it where the left edge of tappet 1 meets it. Mount a positive locking dog flush with this line and cut a matching square notch in tappet 1. See Figs. 7 and 8. Take a block of brass 1/8" x 1/4" x 5/16" and secure it to the locking

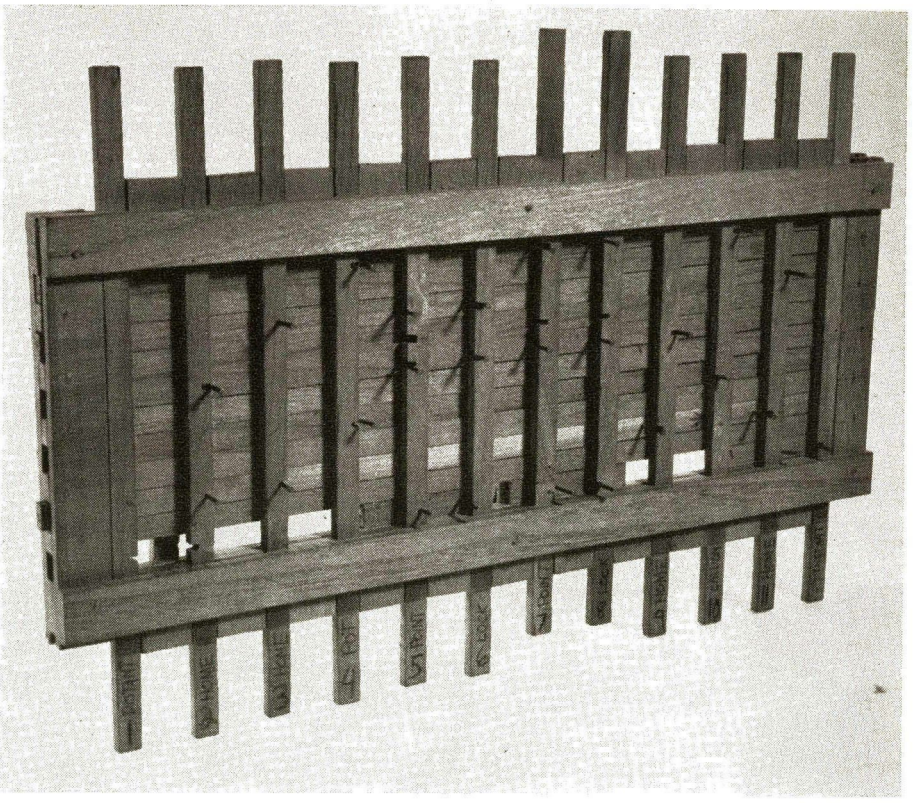


MR's frame was not rod-connected to turnouts and signals, hence the contacts moved by the bars.

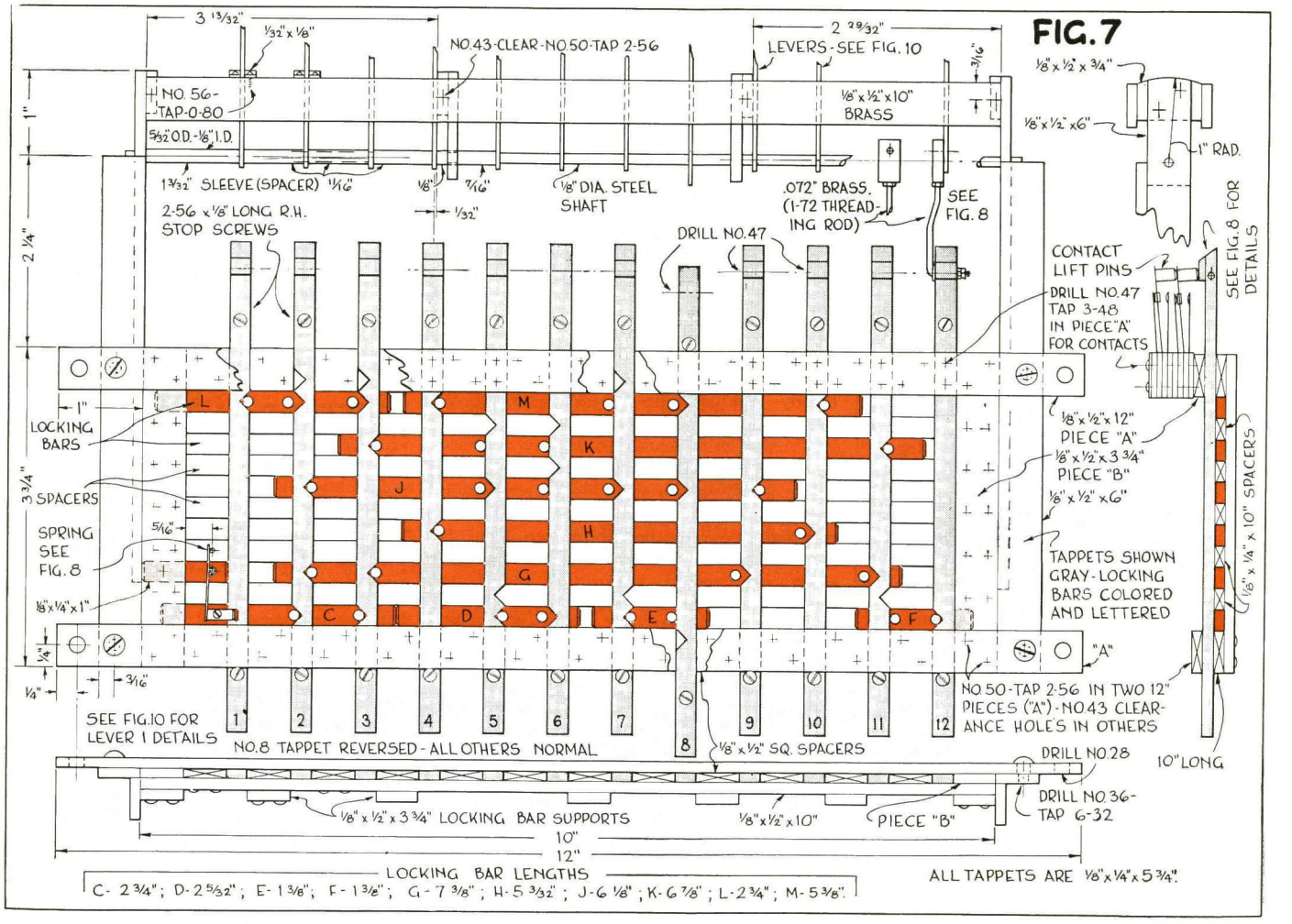
bar with a 1-72 x 3/8" flathead screw. Solder the dog to the bar and file off any excess screw portions or solder. Taper the side faces so that the dog will tend to be guided into the notch. Form a dog spring from .020" spring wire to the dimensions shown in Fig. 8. Use a 1/16" rod as a core for winding.

Attach the spring to the frame with a 2-56 x 1/2" roundhead screw and put a lock nut on the bottom side (see drawings and photos). Run another 2-56 x 1/2" screw through the adjacent hole to serve as a stop. Put it in from the underside and turn it up tight. This spring should keep the square dog in the notch in tappet 1, and either tappet 2 or tappet 3 reversed should release it. Check the alignment and movement carefully, as these pieces must work very freely. Now make the other locking bar assemblies in the same manner.

If you have the same luck we did, you will no doubt have a notch or two in the wrong place, or you may have some sloppy fits. Here are a few tips which can help you remedy some errors. You will have to decide which correction will best fit your needs. Loose locking between tappets can sometimes be remedied by putting an oversize dog pin in the locking bar. If the locking is a little too tight you can file the diameter of the pin slightly, being careful to keep it as nearly round as possible. The flat edge bearing surface can also be filed slight-



This is the wood mockup of the frame used to check out the locking action. The dogs are small brads that slip into slots in the tappet bars. In this mockup, it's necessary to move the dog-bars manually before a tappet can be moved. A mockup can also be made of cardboard.



ly or one or more notches may require a little filing to deepen them. A notch that is too deep can be fixed by soldering some shim brass of appropriate thickness to the notch bearing surfaces. If you happen to put a notch in the wrong place you can solder a piece of ⅛" thick scrap in place and file it flush with the bar surfaces, and then cut a new notch in its proper position.

Butt joints

Butt joint locking was not used on our frame, although it could have been. The principle is useful and in certain installations will simplify frame construction. It is used with a given number of levers where any one reversed will lock all the others. The idea is to divide a locking bar at some midpoint so either end can move away from the other as shown in Fig. 9. Small vertical marks in Figs. 2, 3, 4 and 5 indicate butts. In Fig. 2, for instance, pulling lever 1 will lock not only 4 but also 5 and 6 through the butt joint. We have shown redundant locking bars in the next two spaces in this diagram. No harm is done and sometimes positive locking is desirable in addition to the butt locking.

The construction of the intermediate tappets is shown in Fig. 9. The bar has a weak section caused by two notches exactly opposite one another. Note that such notches must be rounded at the bottom so the bar will have some material to hold it together. Cut all notches and install all dogs which are directly connected with the butt joint. Make all necessary adjustments and then cap the section with a piece of 1/16" x ¼" x ¾" brass for added strength. It can either be soldered or attached with 00-90 screws. The dog pins are approximately 9/64" from the mating ends of the locking bars. This dimension is not critical in itself, but the sum of the distances from the ends of the bars must be such that the pins will align themselves as shown in the plan view of Fig. 9.

Levers and support brackets

The levers we used were of British manufacture and unfortunately no one knows anything about them except that they were purchased from a Kansas City hobby dealer who doesn't remember where he got them! Perhaps they are still made, but a careful scrutiny of British catalogs has failed to locate more.

Fig. 9 shows two styles of levers which can be made from 1/16" brass stock. The right-angle type like those we used is more difficult to make, while the straight style requires a horizontal mounting somewhat different from the type shown in our drawings. If you decide to use the straight lever you will have to design your own cabinet housing.

Saw and file 12 levers to the shape shown in Fig. 9. Drill and tap the required holes. The distance between the two holes should be exactly ⅜". Break all corners and edges with a file and file the handle portion of the lever to an oval shape. You may add dummy latch handles if you wish.

Prototype levers are often painted different colors according to the function

they perform as follows: signals, red; switches, black; locks, blue; derails, blue/black (top half blue, bottom half black); movable frogs, yellow; and spare levers (for use if the plant is enlarged) white. Sometimes a space is left for a spare lever but the lever itself is omitted. This is a generally accepted painting scheme with variations on individual roads. The handles of mechanical levers are never painted.

We used Floquil model railroad paint with a small amount of diesel gloss added and baked the finish with a heat lamp to increase its durability. Baking can be done in an ordinary oven at 150 to 200 degrees for about 15 minutes.

Cut the pieces for the lever supports from 1/8" x 1/2" brass. Make a right- and left-hand assembly from 6" pieces soldered together at right angles. See Fig. 7 for dimensions and arrangement. Attach a 1/8" x 1/2" x 3/4" brass piece to the top of each assembly with solder and two 2-56 roundhead screws. File the tops to a 1" rad. and drill 1/8" dia. holes 1" down from the top. Position these two brackets on the frame as shown in Fig. 7 and attach with 6-32 roundhead screws. Now construct two intermediate bearings from 1/8" x 1/2" x 3/4" and 1/8" x 1/2" x 1 1/4" brass and drill and fashion them to conform with the top portions of the support brackets. These will be placed between levers 4 and 5, and 8 and 9, positioned as shown in Fig. 7.

Cut two pieces 1/8" x 1/2" x 10" long for the lever stop bars. Refer to Fig. 7 and attach the pieces to the ends of the curved parts on the lever support brackets with 2-56 x 1/4" roundhead screws, one to a joint. Attach the intermediate bearings the same way. Position these very carefully. The bearing bracket should be drilled No. 50, tapped 2-56, and the stop bar drilled No. 43.

Mounting the levers

The lever pivot shaft is a 10 1/4" length of 1/8" dia. steel rod. Brass tube 5/32" o.d. x 1/8" i.d. is used to space the levers. Cut 15 pieces to the following nominal sizes: one piece 1 3/32", two pieces 1/8", two pieces 7/16", one piece 21/32", 9 pieces 11/16" long. It is best to make these slightly larger than indicated so they can be individually fitted. Fig. 7 shows the relative positions of these spacers.

Begin with lever 1. Slip the 1 3/32" spacer over the rod following lever 1. If it is not exactly over the center of the tappet below it, file a little off the end of the spacer until it fits. Do this with a file and with the spacer chucked in a drill press or electric hand tool so the end will be cut square.

Now slip an 11/16" spacer over the rod and position lever 2. Proceed along with levers and spacers, custom fitting each in place to assure a snug fit.

Form 24 lever guides from 1/32" x 1/8" brass to the dimensions shown in Fig. 8, upper right. A pair of these will straddle each lever at right angles to the stop bar, and help to hold the lever in a vertical position. Drill No. 51 holes 1/16" in from each end.

Locate the position of the mating holes in the stop bar, drill No. 56 5/16" deep and tap 0-80. Use a cutting oil or compound

to avoid tap breakage. Attach the guides with 0-80 x ¼" roundhead screws.

The 12 connecting links are fashioned from ⅛" x ¼" x ½" brass pieces and .072" dia. rod. The .072" brass rod is specially made for 1-72 threading. Some of the larger hobby shops handle this material. We got ours from E&H Model Hobbies, Room 10, 160 W. Chelten Ave., Philadelphia 44, Pa. See Fig. 8 for all necessary dimensions.

Attach the link to the tappet with two No. 1 flat brass washers and two 1-72 hex nuts. See Fig. 7, lever 12. The block is fastened to the lever with a 2-56 x 5/16" roundhead screw. Move the lever to normal and reverse positions to see if the tappet is moving its complete throw. The lever should rest against the stop bar when the tappet has reached the limit of its travel. The length of the link can be adjusted by unfastening the block from the lever, loosening the 1-72 lock nut and turning the block up or down to the desired length. Replace the fastenings and lock nut. If the lever does not have enough movement to actuate the tappet, slight notches can be filed in the stops. If the lever throw is very much too short or long, remake the lever and increase or decrease the ⅜" dimension to fit. Paint the outer exposed areas of the frame, above and including the lever stops, black. (See photo of finished plant).

Electrical contacts

Our machine is not actually mechanically connected to the switches and signals as were the prototype installations. A system of rods is difficult to install and maintain, especially in the smaller scales. So we attached electrical contacts to the interlocking machine and controlled electrically operated signals and switch machines with them. In the latest of prototype mechanical installations this method of control was often used to operate distant signals and sometimes other apparatus.

Six sets of Guardian 200-M3 4p-dt contact kits are required. These are available at radio parts stores and mail order houses such as Allied Radio, 100 N. Western Ave., Chicago 80, Ill. Assemble 10

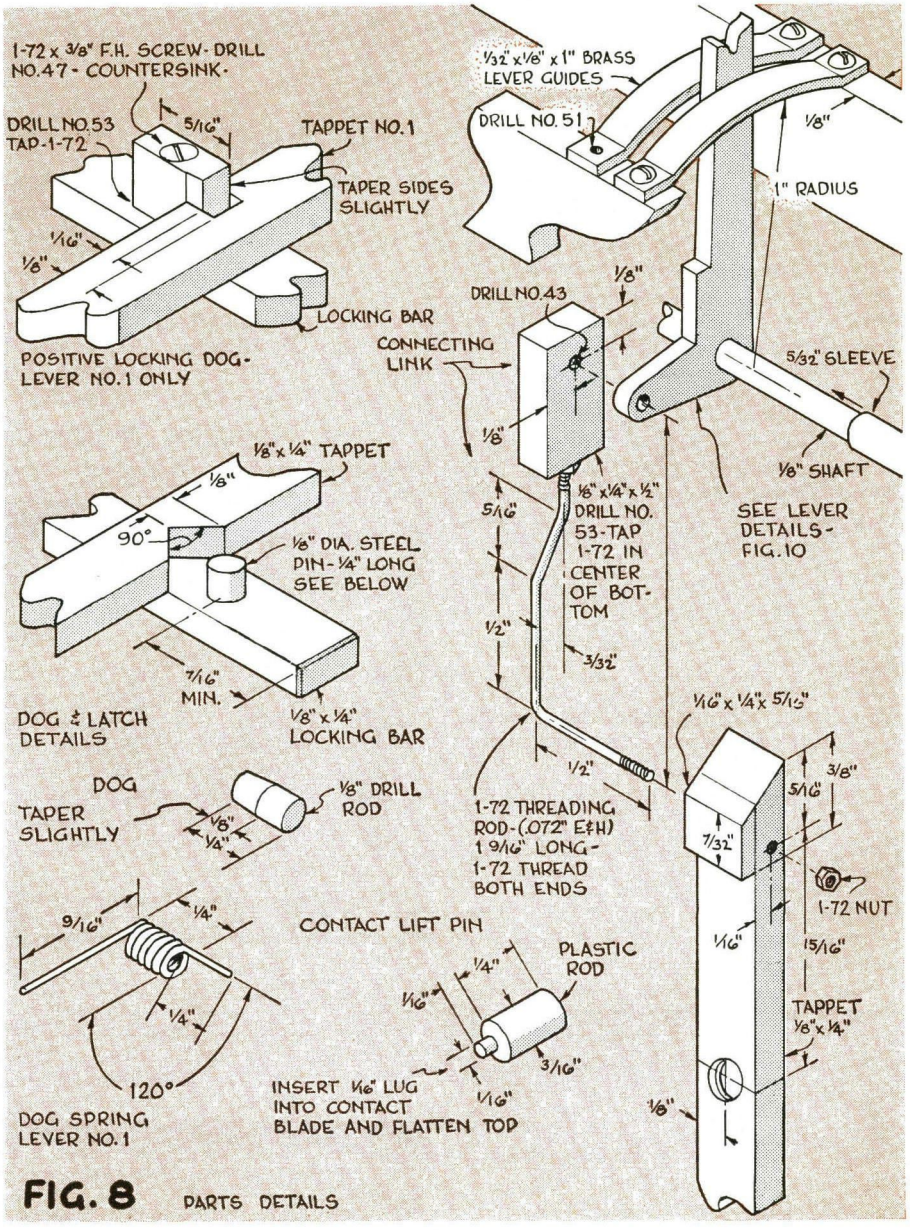
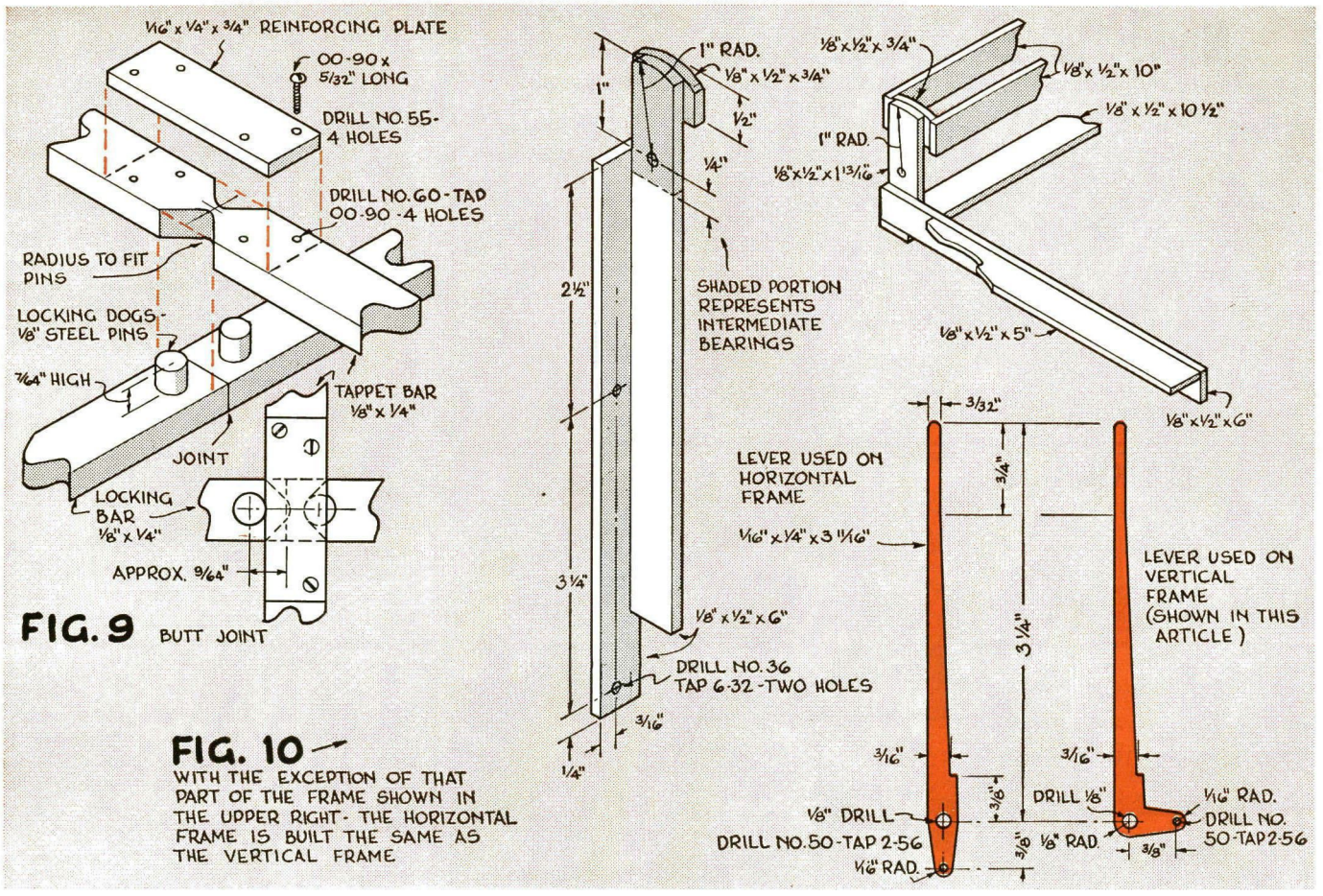


FIG. 8 PARTS DETAILS



dp-dt sets according to the instructions furnished, with the following component arrangement. Starting at the bottom: fiber spacer, short blade, spacer, long blade, spacer, short blade, spacer; repeat and position metal cap.

Twenty insulated lift pins are needed so eight additional ones will have to be turned from 3/16" dia. plastic rod. Use a lathe if you have one, or a hand operated or electric drill can be used to turn the fiber while you fashion it with a file. See Fig. 8 for dimensions. Affix the lift pins by inserting the lug through the second hole in the contact blade. Rivet the tab with a warm soldering iron. The fiber pins furnished should be cut in length to match the dimensions in Fig. 8. The holes in the contacts will have to be drilled 1/16" to fit the pin lugs.

Attach each dp-dt assembly to the frame with 3-48 x 11/16" roundhead screws, utilizing the tapped 3-48 holes made earlier. Draw the screws up tight and check to see that they do not protrude through the 1/8" mounting bar and jam the tappets. Adjust the contacts according to the instructions furnished with the kits.

Next month we will build the cabinet.