CAVEAT EMPTOR

Not discussed today will be the history of such machines, nor where they were used, nor the advantages or disadvantages of the various styles (Style A, Improved Saxby & Farmer, English Type, etc.).

Also not discussed will be the electrical hook-ups required necessary to operate switch machines or signals (relays, pressure switches, wiring, etc.) – all I’m dealing with is the homemade mechanical machine itself, generally nicknamed an “Armstrong” machine (based on one’s needing a strong arm to physically move the prototype’s levers, although in many cases it was more in the wrists and knowing where and when to apply the appropriate pressure).

I do not profess to be an expert in the field. Once upon a time I was an interlocking tower operator on a railroad where such machines existed. All to be discussed here is how I would go about building a simple Style A mechanical machine for a model railroad application. Of course, if you want an expert on mechanical interlocking, you might try contacting Union Switch & Signal or some other manufacturer of interlocking machines, but don’t hold your breath waiting for a response – we’re talking about 19th Century technology here. Anyone there who knows anything can be assumed to be either retired or dead.

SPEAK ENGLISH, PLEASE

First, let’s get some items out of the way. In this we’ll include some technical terms, possibly a term or two that I created, and how the mechanicals function to make the whole thing work.

An interlocking machine’s levers are color-coded. These colors appear to be standard worldwide (at least with American and British applications – and the British applications also apply to former colonies and members of the British Commonwealth). Very basically (and not to be accepted as Gospel):

1. **RED** – Indicates a lever controlling a signal (either a Home signal or a Rear Home signal).
2. **BLACK** – Indicates a lever controlling a switch or derail.
3. **BLUE** – Indicates a lever controlling a lock (an electric lock, a facing point lock, etc.).
4. **YELLOW** – Indicates a lever controlling an Approach signal (used in Manual Block territory).
5. **GREY** – Indicates a spare lever, not controlling anything. Maybe it did once upon a time, but not now. Some railroads painted spare levers white.

In addition to the preceding, for American applications, a white horizontal stripe halfway up the lever generally indicates an electrical connection to the appurtenance (switch points, signal,
whatever) as opposed to a pure mechanical connection. As mechanical interlockings were subsequently modified or upgraded, in many cases the switch points may or may not have retained their mechanical connection to the interlocking’s levers while the levers controlling signals or electric locks were connected via electrical relays. Not to confuse the issue, but on British-style Controlled Manual Block applications, a lever with a white stripe meant that it was tied in to an adjacent tower. Then, too, are alternating black-and-white striped levers, also British, which indicate a mechanical device that places track torpedoes (they call them “detonators”) on the track at a Stop signal. We’re not going anywhere near there – our English is hard enough to understand.

Terminology? We’ll try to keep that simple. The **levers** controlled **locking bars** which, in turn, moved **tappets** (more commonly known as **dogs**) which interlocked with other locking bars, preventing their movement when opposing levers were moved (or thrown). Thus, when Lever A, controlling an eastward signal, was moved, its locking bar forced a dog into a notch on Lever C’s locking bar, controlling an opposing westward signal, thus preventing both signals from being cleared in opposition to one another at the same time. The same lever, Lever A, also forced a dog into a notch on Lever B’s locking bar, controlling a set of switch points, thus preventing the points from being moved once the signal was cleared off. See Figure 1.

![Figure 1](image)

Another is **Normal** and **Reversed**. The **normal** position for a Signal is Stop (or the most restrictive position). The **reverse** position for a Signal would be anything other than Stop (or the most restrictive application). The **normal** position for a Switch is generally straight, with the **reverse** position being a diverging route. Of course, depending on the interlocking’s traffic patterns; it’s perfectly conceivable that the opposite could be true in certain applications. The **normal** position for a Lock is unlocked, while the **reverse** position is locked. And, for the interlocking machine’s levers themselves inside the tower, **normal** is generally away from the operator, with **reverse** being pulled towards the operator.

Getting a little bit more complicated is **provisional** interlocking, more commonly referred to as **when** interlocking. Why **when**? Well, that has to do with the **provisional** part of the interlocking sequence. **When** Switch B is Normal, then Signal Lever A will only interact with certain appurtenances (such as an opposing signal (Signal C) on Route Normal), and **when** Switch B is Reversed, then Signal Lever A will only interact with other appurtenances (such as an opposing signal (Signal D) on Route Reversed). How can they do this? No, it’s not magic. It’s done with a sliding cam on the switch’s locking bar that moves into or out of place to permit
the signal lever’s tappet action to continue past the switch in order to lock other locking bars. See Figure 2.

To explain an interlocking in writing, one would create a locking chart, which tells you what lever locks what lever, and when. For this small interlocking, our locking chart would look like this:

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B (B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>(B)</td>
<td>D</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>(B)</td>
<td></td>
</tr>
</tbody>
</table>

First off, we see that the locking chart consists of three columns. The first column lists the locking levers, that is, what lever, when reversed, is going to lock what other lever or levers. The second column is for the provisional, or when, aspect of the equation. And the third column shows what lever or levers are locked, and in what position, by the lever listed in the first column.

- In the first row, we see that when the lever for Signal A is reversed, it locks the lever for Switch B in either Normal or Reversed positions (reversed is shown with parentheses). That’s all the lever for Signal A locks directly, nothing else. Don’t assume anything, don’t get ahead of me.

- In the second row, however, we have “when” locking coming into play. Here we see that if the lever for Signal A is reversed, and when the lever for Switch B is Normal, it locks the lever for Signal C in a Normal position. Does it lock the lever for Signal D? No, it doesn’t have to.

- In the third row, when the lever for Switch B is Reversed, now the lever for Signal D gets locked in a Normal position by Signal A’s lever. It’s sort of like a Yes/No logic chart, only this predates modern computer logic charts by a century or more.

- In the fourth row, we see that reversing the lever for Signal C will only lock the lever for Switch B in a Normal position. There’s no need to show that Signal C also locks Signal A Normal when Switch B is Normal since that’s already been mentioned in the second
row. Unnecessary duplication is avoided; as in mathematics, it stands to reason that if A = B then B = A. Why repeat yourself if you don’t have to? And you now know why the lever for Signal A didn’t have to lock the lever for Signal D when Switch B was Normal – Switch B did that all by itself.

- Lastly, in the fifth row, we see that reversing the lever for Signal D can only be accomplished if the lever for Switch B is reversed (i.e., you can’t clear off the signal if the switch isn’t lined up for it).

When drafting up a locking table, one can first include all possible variations without worrying about duplication. Once everything is thought out and entered and double-checked, then the unnecessary duplicate entries can be deleted (e.g., Rough Draft: “A locks B, B locks A”; Final Draft: “A locks B”).

So, with a bare-bones interlocking, we’ve discussed the basics of how things work. It can indeed get more complicated than that, but then again I’m not writing a book.

OUR MODEL INTERLOCKING PLANT

For our construction of a mechanical machine for model railroad applications, we’ll first construct a fictitious interlocking plant and surrounding territory.

Looking at the interlocking and surrounding area, nothing really looks overly complicated. The unmarked signals on the diagram are automatic block signals.

The first thing we’re going to have to do with this interlocking plant, in order to build an interlocking machine for it, is to create a locking sheet, showing what locks what and when. And here it is:
Signal 1, being a Rear Home, will affect the Home signals opposing it at the interlocking plant, depending on how the plant’s switches are aligned. Looking at the diagram, Switch 8 Normal will affect Signal 9, whereas Switch 8 Reversed will affect Signal 10. If Switch 6 is reversed, of course, neither Signal 9 nor 10 will affect Signal 1.

Lever 2 is a spare. It would not normally be included on the locking sheet – it was included here just to show that we hadn’t overlooked any levers.

To clear off Signal 3, we see that both Locks have to be reversed (i.e., locking the switches they control), and Switch 6 has to be Normal. We wouldn’t want to clear off the signal only to have the train spring Switch 6 in a reversed position! With Switch 8 Normal, the opposing signals on that route are blocked; Reversed is likewise with the other route.

Signal 4 is basically the same as Signal 3, only coming off an adjacent track.

Lock 5 locks Switch 6 either Normal or Reversed; likewise Lock 7 locks Switch 8.

You’ll notice no entries for Switch 6 or 8. We could have Switch 6 lock Switch 8 (or vice versa), but all that does is add an unnecessary piece to the puzzle. The signal levers have already taken that into account – with a reversed trailing point switch in front of them, the appropriate lever cannot be thrown.

Signals 9 and 10 are shown only affecting the switches and locks in the interlocking. Any interaction with opposing signals has already been addressed earlier. As previously stated, we don’t need to clutter up the locking sheet or machine itself with unnecessary duplication.

Lastly, Approach Signals 11 and 12 will only clear off if their corresponding Home signal is cleared off for a current-of-traffic routing (i.e. if Signal 9 is showing a Medium Clear or Medium Approach, or if Signal 10 is showing a Clear, Approach Medium, or Approach. If Signals 9 or
10 are showing Restricting, an Approach indication on Signals 11 or 12 will bring the oncoming train down to an acceptable speed for the impending Restricting aspect.

Boy, armed with all that knowledge about our plant and what our machine will and will not do (it won’t, for example, take out the trash or wash the windows), it’s time to roll up our sleeves, get out the cutting torch (just kidding), and start building a machine.

PLOTTING IT ALL OUT

The first thing we’re going to do is scribble up a diagram of the machine, similar to that shown in Figure 2 a few pages back, based on our locking chart. Right now we won’t concern ourselves with measurements, although our machine’s measurements will be based on the diagram that we draw. First things first – draw the diagram, and then figure out what the exact measurements are going to be. Our initial dog chart will look like this:

I used ¼” graph paper with a ¾” spacing between vertical locking bars. Based on our 12-lever locking sheet, our initial diagram will have 12 columns of locking bars, and 14 rows, one for each line on the locking chart. We do it this way to make sure we don’t miss anything. We also do it this way so that we can see what rows can eventually be combined with what other rows without overlapping the locking functions and eliminate wasted space. On a grown-up, professional-grade interlocking machine, overlaps are routinely accomplished, but we’re not going to go nuts with miniature machining and all that stuff.

The locking bars, running vertically, have been colored in to highlight the locking portions of the diagram. The locking bars ends have also been color-coded to show what type of function they represent – signal (red), spare (dark grey), lock (blue), switch (black), and approach signal
(yellow). This is also how the actual control levers on the machine would be colored on many railroads (your particular favorite might be different). Each line from the locking chart is matched up with its corresponding line on the dog chart. Now we can start eliminating the riff-raff and placing two or more actions on a single line in order to reduce space. There’s no need to make the machine any bigger than it needs to be. Right now it measures 15¼” across and 18½” down. Can’t do much about the width, unless we cram the levers closer together (and it is possible), but we can reduce the vertical height.

Oh, also note that when the locking bars move from Normal to Reverse, they move downward one-half inch. Since the dog bars are on one-inch centers, any further movement of the locking bars in excess of that one-half inch might allow for an error to be made. Pulling the levers towards you shoves the locking bars down. As the locking bars move downward (or back upward), the cams for the “when” locking also move into or out of position as appropriate. Of course, if you desire, you could plan your machine to have the locking bars move upward. It’s your choice – they both work. Now, back to our diagram….

To reduce the machine’s size, first we eliminate the lines for 2, 6 & 8, since they do nothing; everything below moves upward. We then move lines 7, 11 & 12 upward to fit into unoccupied spaces, and we now look like this:

![Diagram of the machine layout](image)

Yes, the machine’s layout could even be consolidated a little bit more, but that would require some real micro-machining, and even I’m not that crazy. I think we’ll go with this plan. The original plan was 18½” tall, and this reduced version is only 13½” tall, so a 27% reduction in size is good enough.

**BITS AND PIECES**

The base for our machine is made from a chunk of Formica® or similar brand laminated material. It’s the stuff they make kitchen countertops out of (no, we’re not going to use imported Italian marble!). The plastic laminate top gives a smooth, flat, friction-free surface for our dog bars to
ride one, plus, will hold wood screws well. Our countertop material will also be easier to attach it to the top of your model railroad layout with wood screws, and, will be sturdy. The overall size depends on the size of the machine being built, which, in turn, depends on the size of the interlocking being modeled. A chunk of this stuff ought to be available dirt-cheap as leftover material from a kitchen cabinet/counter refurbishing outfit. And, if the price is right, it really doesn’t matter what color it is.

Of course, you could also use a piece of ¼”-thick Plexiglas® or other brand of acrylic sheeting for the machine’s base, but you don’t want anything thinner than ¼” - you want something that will not be affected by temperature or moisture changes.

Next will be a collection of 2-56 machine screws in various lengths. Round-top and flat-top countersunk-style heads will be required. Of course, a 2-56 tap and the accompanying drill bits will be required (one size, whatever it is, to accept tapping, and the other, a little bit bigger, to accept the screw going through).

Lastly, the heart and soul of our machine is ½” x ⅛” brass or aluminum bar stock, readily available in most hardware stores. You’re going to have to cut it to size, and also drill and tap it. And all the little bits and pieces? Well, here’s a chart describing them and including their measurements. Everything is color-coded to make identification easier, I think.

Did I mention that there’ll be a whole bunch of bits and pieces of 1/8”-thick bar stock, some as small as 1/4” x 1/2”? Plus, they’ll need holes drilled 1/8” in from their edge? Sorry ‘bout that, but there are going to be a bunch of small pieces, and a small vertical drill press might help here. The Dog in the right-hand bottom corner of Figure 6 shows all the basic measurements necessary to do any of the pieces requiring drilling.
As we go over the various layers of our machine’s construction, you’ll see how all the parts come together.

**READY, SET, GO!**

Before we attack THE PROJECT, first I’ll show how the various subassemblies go together. We have two – the Locking Action and the “When” Action. These two mechanical activities are the bulk of our mechanical interlocking. Here’s the first:

**ASSEMBLING THE LOCKING ACTION**

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Onto our Base we’ll first put down Dog Bar Guides</td>
</tr>
<tr>
<td>2</td>
<td>Then we’ll put in the Dog Bars</td>
</tr>
<tr>
<td>3</td>
<td>On top of the Dog Bar Guides will go the Locking Bar Guides</td>
</tr>
<tr>
<td>4</td>
<td>The Locking Bars go on</td>
</tr>
<tr>
<td>5</td>
<td>And onto the Dog Bars will go the Dogs</td>
</tr>
</tbody>
</table>

Figure 7

And here’s the second:

**ASSEMBLING THE “WHEN” ACTION**

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>We start off with the Dog Bar Guides, Dog Bars, Locking Bar Guides and Locking Bars already installed.</td>
</tr>
<tr>
<td>2</td>
<td>Nest installed is either a Spacer or a Dog, as appropriate.</td>
</tr>
<tr>
<td>3</td>
<td>The When Dogs then go on top of these.</td>
</tr>
<tr>
<td>4</td>
<td>The When Cam Guides are then installed on top of the Locking Bars.</td>
</tr>
<tr>
<td>5</td>
<td>And we drop the When Cam into place.</td>
</tr>
</tbody>
</table>

Figure 8

Put the two actions together, let them breed like rabbits, and here’s a picture of the finished product to give you an idea of what’s being constructed.
Yes, it looks a little bit complicated right now, but it’s really just a little bit at a time. Actually, the hardest part is over with – figuring out what locks what when. The entire assembly will be topped off with a sheet of ⅛” Plexiglas®. First off, the When Cams are free-floating - they’re not held down in any way. Secondly, it serves as a dust cover. Even when mounted horizontally, the dust cover is a good idea.

Some of the pieces are hidden underneath other pieces, but all will be revealed as we go through the construction stages. You’ll note that all the pieces are held down by at least two screws – this will ensure the piece doesn’t wobble around any during use.

You may also note that the finished product, although similar, is not arranged exactly like the dog chart shown in Figure 5. Some rows had to be placed elsewhere so that the locking bar retainers did not interfere with the “when” locking. For example, the former Row 3 was moved up to Row 1 while the former Rows 1 & 2 became Rows 2 & 3, respectively. The rows on the bottom half of the machine were likewise shuffled around when it was discovered that the When Cam Guides interfered with the placement of the Locking Bar Retainers.
STEP 1

The first layer of our interlocking machine is the Base [ ]. We drill holes in it to hold the dog bar guides. If you’re using a countertop base, wood screws work fine. If you’re using acrylic plastic, however, you’re going to have to drill and tap the holes for 2-56 machine screws. The \( \frac{1}{4} \)“ graph paper lines keep everything in perspective. For the \( \frac{1}{8} \)” locations (screw locations), you’ll have to read between the lines.

As you can see, the only holes drilled on the Base are to hold the Dog Bar Guides (see Step 2). Any holes for attaching the Base to your layout would require enlarging the Base’s size a little and then drilling mounting holes. Again, the hole locations shown on the base are only for the Dog Bar Guides.
STEP 2

On top of the Base will go the **Dog Bar Guides** and between them, the **Dog Bars**. You’ll note the Dog Bar Guides, in addition to being screwed in on their ends, are also screwed down in their center. Yes, the ½” bar stock being used doesn’t bend much, but we want to ensure that it remains perfectly straight, giving parallel grooves for the Dog Bars.

All the **Dog Bar Guides** are identical, with the top, bottom and middle also having been drilled to accept Locking Bar Guides. If confused, refer back to Figures 6, 7 & 8 to see what I’m talking about and how and where the pieces go. The Dog Bars, sitting between the Dog Bar Guides, are only as long as they need to be, and are drilled and tapped to accept whatever it is that’s going to be placed on top of them.

At this point, the Dog Bar Guides are screwed to the Base once you are certain the Dog Bars will slide smoothly between them.
STEP 3

Here where it starts to get cluttered up. First we put the **Locking Bar Guides** on top of the **Dog Bar Guides**. Then we’ll be adding either **Dogs** or **Spacers** on top of the **Dog Bars**. And then we add the **Locking Bars**. Sounds simple, doesn’t it? If all the holes you’ve drilled so far line up properly, then you’re good to go.

The large Locking Bar Guides are secured to the Dog Bar Guides with flathead 2-56 machine screws going into countersunk holes. The small Locking Bar Guides, however, are not secured at this time, but merely set in place.

The Spacers are set in place, but all the Dogs (save two) are secured to the Dog Bars using roundhead 2-56 machine screws.

In case you’re curious, this step uses a grand total of 136 screws, but you’re just about done.
STEP 4

In this next-to-last step, we’ll be adding the When Cams [ ▢ ], When Cam Guides [ ▢ ], When Dogs [ ▢ ], Locking Bar Retainers [ ▢ ] and one Splice Plate [ ▢ ]. The When Cams are free floating, and are kept in place by the When Cam Guides. The When Dogs, which interact with the When Cams, sit on top of the Spacers or Dogs sitting on top of Dog Bars. It’s easier to visualize than explain. The Splice Plate is necessary since the notches on Locking Bar 6 are on both sides of the bar, effectively cutting it in half. The top of the Splice Plate also serves as one of the When Cam Guides. Not every design requires the use of a Splice Plate, but, unfortunately, this one does.

Note that all 68 screws used here are flathead screws in countersunk holes. Why flathead? Because roundhead screws would get in the way of the Plexiglas cover going on next.

If you don’t like the splice plate, adding an additional row to the machine would eliminate that requirement, but we wanted to make this machine as compact as possible, within reason.
STEP 5

This is the last step in the assembly process. Taking 12 roundhead machine screws with washers (don’t want to damage the Plexiglas), we securely fasten the top to the machine. And the finished product, all color coded, looks like this:

![Diagram](image)

Are we finished? Well, we’ve still got to connect the locking bars with their respective levers, and we’ve got to hook up some sort of electrical connections for the signals, but that’s someone else’s headache, not mine. Right now, this machine can be mounted either flat atop the layout or vertical against the edge of the layout.

ERGO, IPSO FACTO, AND A BUNCH OF OTHER LATIN TERMS

In the vernacular of the *hoi polloi*, “We be done!” The design shown here is a good representation of a Style A mechanism used in both all-mechanical and electro-mechanical machines. It may take time, exact measurements, and a small drill press for the vertical drilling, but it’s definitely do-able. A similar design was once written up in *Model Railroader* magazine.
back in 1961, but I believe it wimped out on attempting to do any “when” locking (that’s the kicker). And, I believe, it’s the “when” locking, or the lack thereof, that limits any reasonably-priced offerings of a working mechanical machine. An Australian concern, Modratec, does offer a mechanical interlocking machine, but it lacks “when” locking. This design, although do-it-yourself, accomplishes that mission.

I hope you’ve enjoyed today’s lessons. If anything, it can give you something to think about with your model railroad layout. Imagine, a working mechanical interlocking – you and your train layout will be the talk of the town, maybe.

If some of my terminology differs with yours, or the prototype’s, my apologies.

The author is a retired Army Transporter and ex-towerman. He started out his railroad career on an all-mechanical interlocking (Improved Saxby & Farmer design) on the New Haven Railroad.