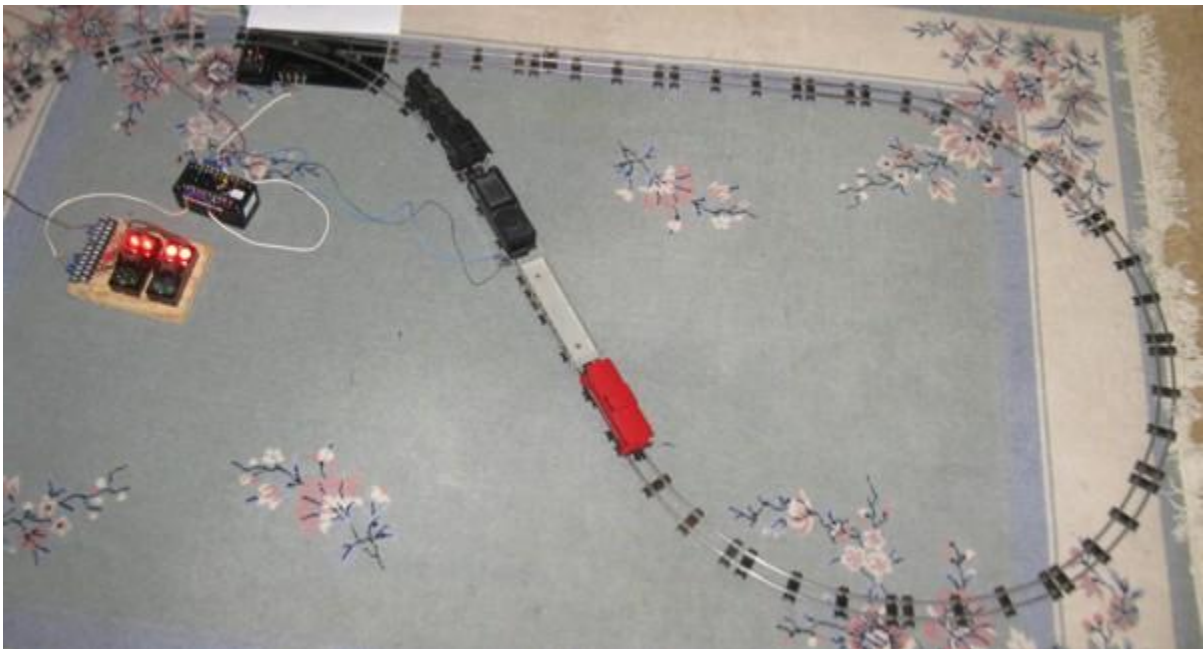


# Reverse Loops with American Flyer Trains

Norbert Doerry

Version 1.0 of March 2014



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<http://doerry.org/norbert/train/AFtrain.htm>

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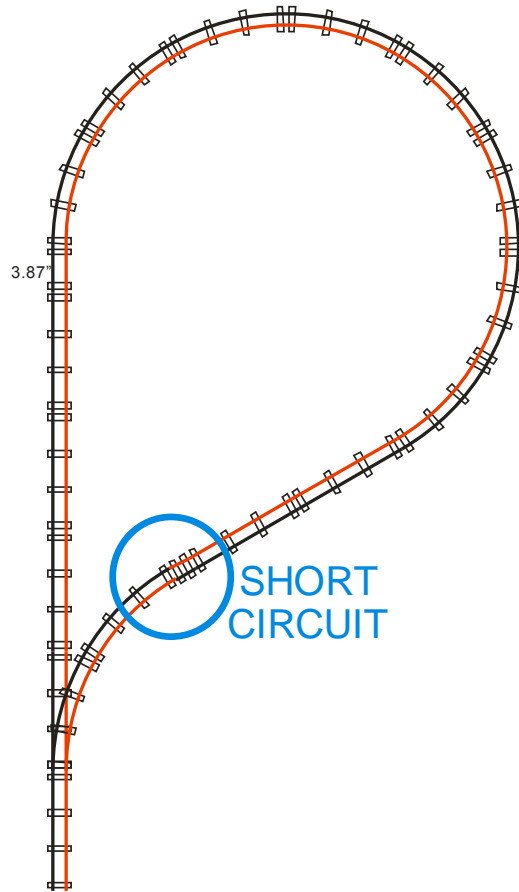
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## History

Version 1.0: "Reverse Loops with American Flyer Trains" March 2014 by Norbert Doerry: published <http://www.doerry.org>.

## 1. Introduction<sup>1</sup>

Reverse loops are a special case of a track layout that require careful consideration in powering the track in either AC or DC operations. A reverse loop exists whenever a train traveling in the forward direction can traverse the same piece of track in opposite directions. Figure 1 is a typical example of a reverse loop and highlights its problem. Unless special precautions and controls are implemented, a reverse loop will result in a short circuit. Each rail of the loop connects the right and left rails of the track entering the loop as indicated by the black and red rails connecting to each other in the circle.



**Figure 1: Reverse Loop**

This document version only addresses reverse loops and does not directly address wyes which also exhibit similar electrical problems as reverse loops. I will leave addressing wyes for a future revision.

Please contact the author if you find any errors. Also, feel free to suggest improvements or additions to this document. Revisions will be produced as needed to correct errors and add more material.

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<sup>1</sup> *American Flyer* and *A.C. Gilbert* are trademarks of Lionel Trains, LLP. This document is neither authorized nor approved by Lionel Trains, LLP.

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## 2. Reverse Loops in AC Operations

For AC operation, one may be tempted to solve the short circuit problem by simply inserting 2 insulating pins as shown in Figure 2 (a). While this eliminates the short circuit when a locomotive is not present, it does not work because the track pickups on the locomotive tender (or a diesel engine) generally connect to at least two wheels and are staggered. As shown in Figure 2 (b), when one of the tender trucks crosses over the insulating pins, the two wheels will create a short circuit. Typically this short circuit will be of short duration as the locomotive coasts forward a small amount. Then, as shown in Figure 2 (c), both track pickups are connected to the same polarity, hence the locomotive will have no power and will stop.

A simple solution is shown in Figure 3. A toggle switch is manually thrown to reverse the track power connections at roughly the same time the direction of the track turnout (switch) is changed. While simple to implement, it does require the operator to remember to do two things at the same time.

Figure 4 demonstrates how to use the American Flyer 695 reverse loop relay along with a remote switch to automate the reversing of track power in the reverse loop. With this configuration, the controller for the remote switch also controls the reverse loop relay so that the polarity of the track in the reverse loop is always correctly maintained based on the direction of the turnout.

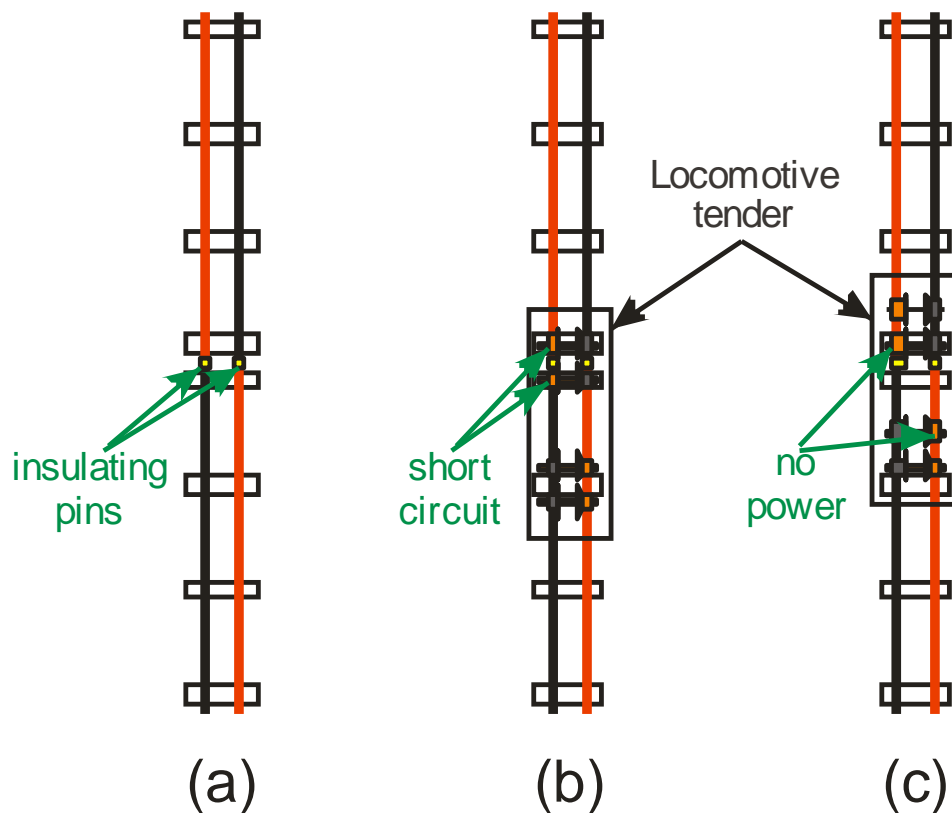
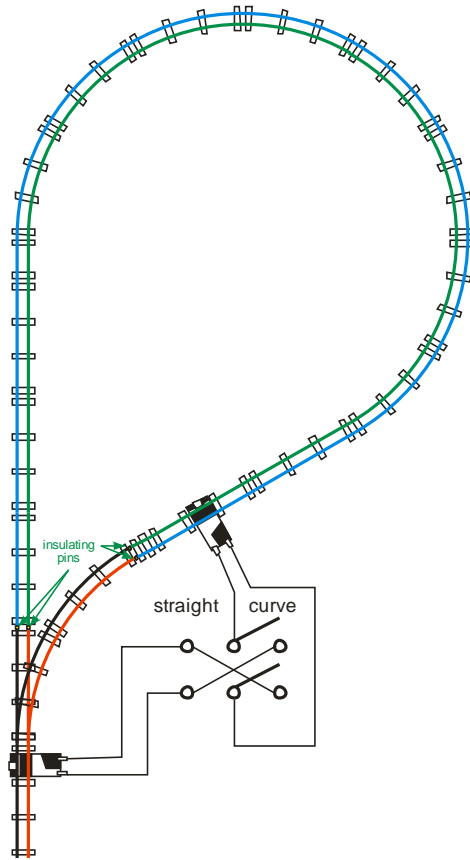
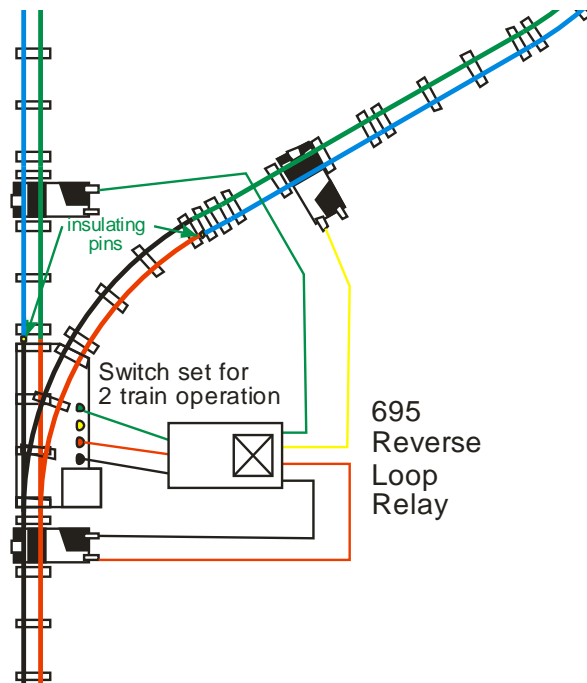


Figure 2: Reverse Loop Approach that doesn't work



**Figure 3: DPDT Switch solution for AC Reverse Loop**



**Figure 4: 695 Reverse Loop Relay**



While the 695 reverse loop relay works well, it also can be expensive. As an alternative the Atlas Snap-Relay 200 can be configured to emulate the 695 as shown in Figure 5 (a). An alternate solution for reverse loops shown in Figure 5 (b) does not rely on the contacts within the turn-out (remote switch) to power the "inside" rail and hence may have better reliability. One potential issue with the Atlas Snap-Relay 200 is that the rated current is not published. If you intend to operate the reverse loop with a high current locomotive such as a dual motor ALCO, the circuit shown in Figure 6 may be employed. This circuit consists of a 12 volt power supply (rectifier, filter capacitor, and voltage regulator) and a DPDT 12V relay with high current contacts that is controlled by the Atlas snap-relay 200. A picture of the snap-relay is shown in Figure 7.

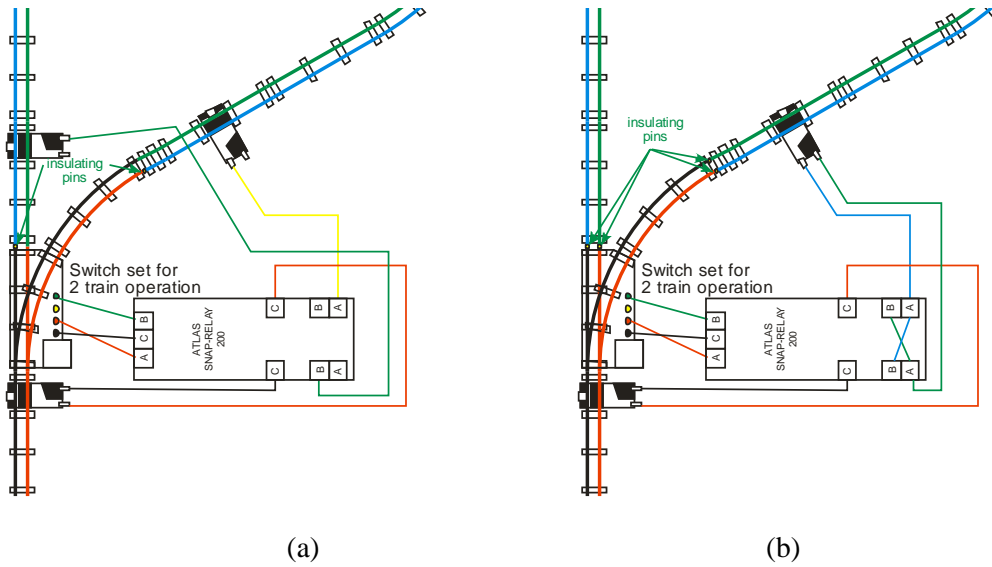


Figure 5: Atlas Snap-Relay 200 solutions for AC Reverse Loop

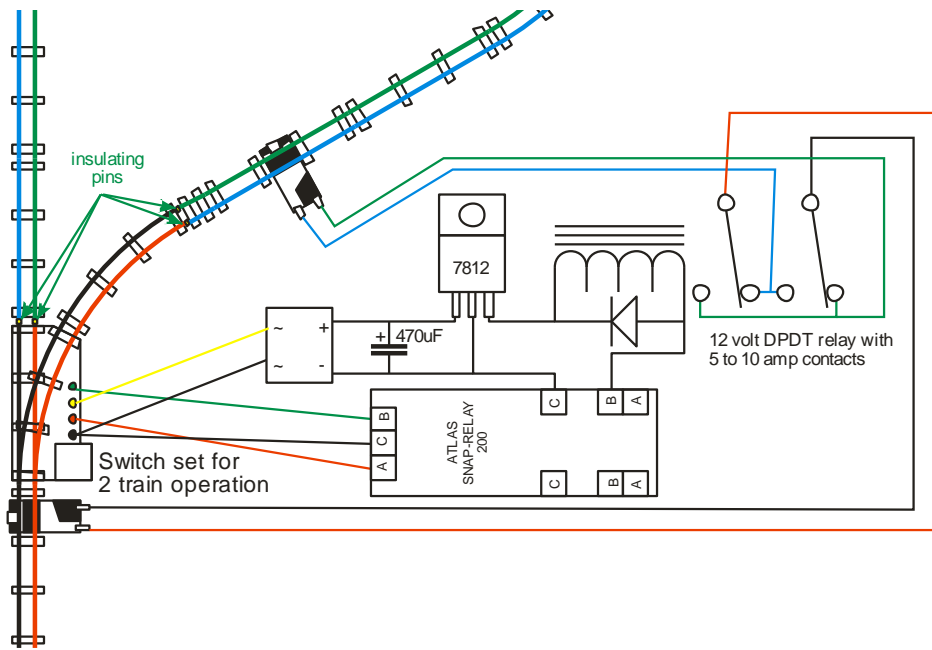


Figure 6: Atlas Snap-Relay 200 with high current relay for AC Reverse Loop

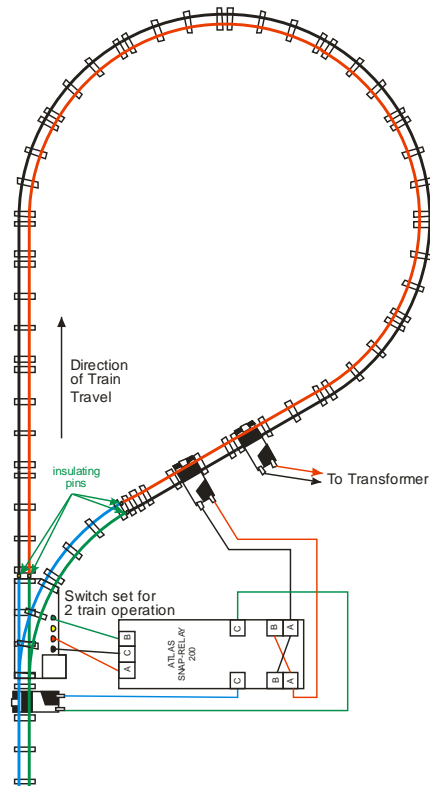


**Figure 7: Atlas Snap Relay 200**

One of the beneficial aspects of these AC implementations is that each reverse loop is an independently controlled subsystem. If problems are experienced, they generally can be localized and identified relatively easily.

### 3. Reverse Loops in DC Operations

Because train direction is determined by the polarity of the track voltage, different methods are required for DC operation as compared to AC operation. In DC operation an engine by convention travels forward when the rail on the right (when looking forward) is the positive rail. This means the polarity of the track leading to and from the reverse loop must switch while the train is in the reverse loop. The polarity of the track within the reverse loop can remain constant; the train will therefore always travel in the same direction through the reverse loop. Figure 8 shows how an Atlas Snap Relay can be used to switch the polarity of the track leading to the reverse loop.



**Figure 8: Atlas Snap-Relay 200 solutions for DC Reverse Loop**

A real layout generally will not have only one reverse loop; at least one other reverse loop (or wye) is needed to restore the original direction of the engine. Otherwise the reverse loop can only be visited once when a train travels only in the forward direction. Control of the polarity of the connecting single track can still be established with a single Atlas Snap Switch if the track switches for the two reverse loops are electrically connected to one another so that they both switch at the same time as shown in Figure 9. This configuration still requires the operator to change the direction of the switches while the train is in the reverse loop.

Note: The methods employed in this document for DC operation will also work for AC Operation. (However, the methods for AC operation will NOT work for DC)

One of the drawbacks to the DC implementations is that multiple reverse loops must be integrated to control the polarity of the track leading to the reverse loop. This additional complexity may complicate troubleshooting should problems be experienced.

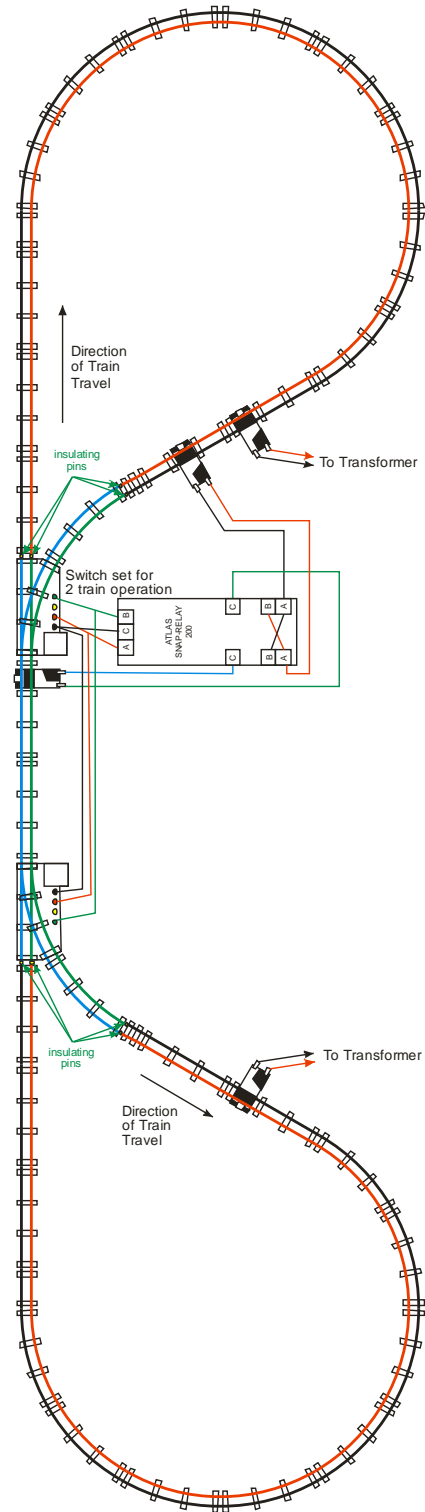


Figure 9: Atlas Snap-Relay 200 solutions for two DC Reverse Loops

## 4. Automating Reverse Loop and Switch Control

In the previous section, operation of the train through the reverse loop required operator action. This section details how operation of a reverse loop can be fully automated; the train operator need only to watch and enjoy the trains. Figure 10 depicts a block diagram of the automated control. The previous sections provided solutions for "Switch Position Detection" and "Reverse Loop Track Power." This section will add the functionality of the track trips and switch controller.

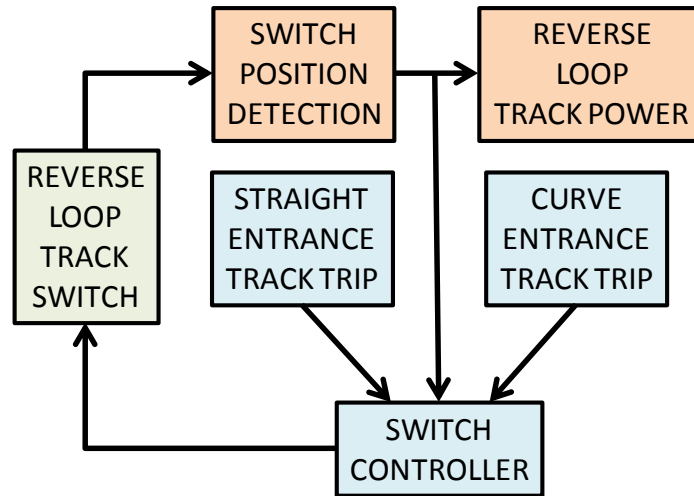


Figure 10: Automatic Reverse Loop and Switch Control Block Diagram

### 4.1 AC Operation

Figure 11 illustrates how operation of a reverse loop can be fully automated. The reverse loop track power polarity is determined by the position of the track switch (turn-out). The switch is automatically thrown to the proper direction based on the current direction of the switch and the activation of the appropriate track trip. Figure 12 provides the logic flow diagram for the control of the track switch.

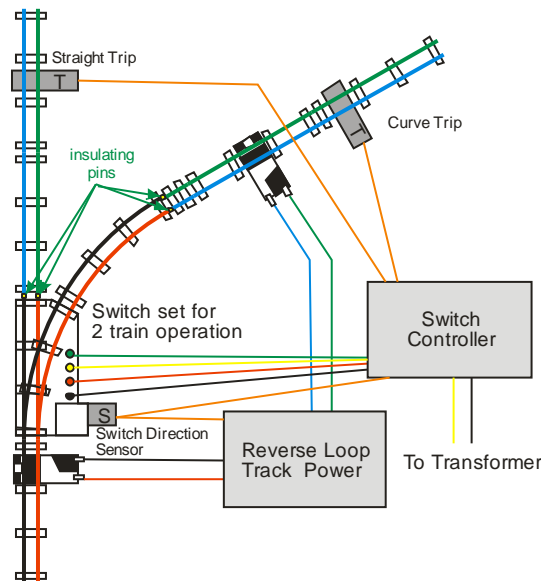
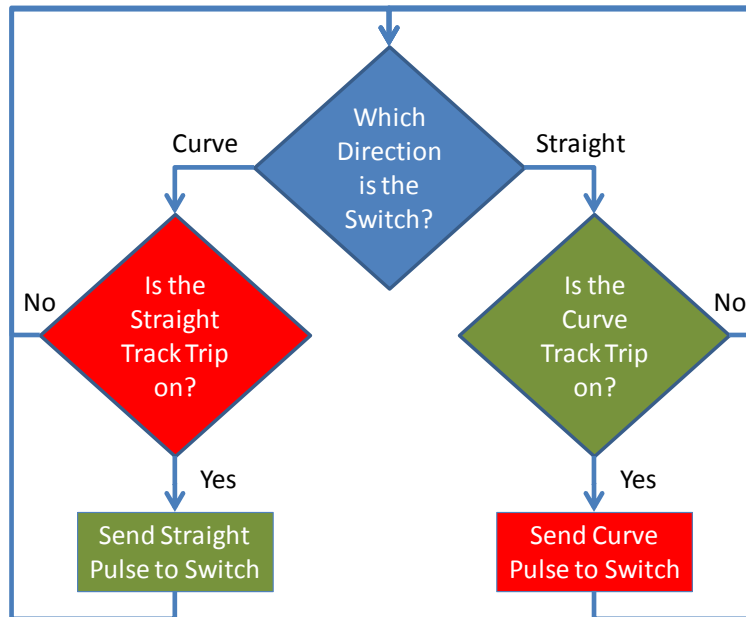


Figure 11: AC Operation Automatic Reverse Loop and Switch Control



**Figure 12: AC Operation Switch Control Logic Flow**

Figure 13 and Figure 14 are schematics of a circuit that implements Figure 11 and Figure 12. The NOR gates implement the decisions of the logic flow of Figure 12. The two 555 timers create the pulses for throwing the track switch. The two relays in Figure 14 energize the switch coils based on the pulses generated by the 555 timers. The relay in Figure 13 implements the Reverse Loop Track power block from Figure 11.

Appendix A provides more details on the different types of track trips available for sensing the presence of a train. Appendix B provides different methods for implementing the switch direction sensor.

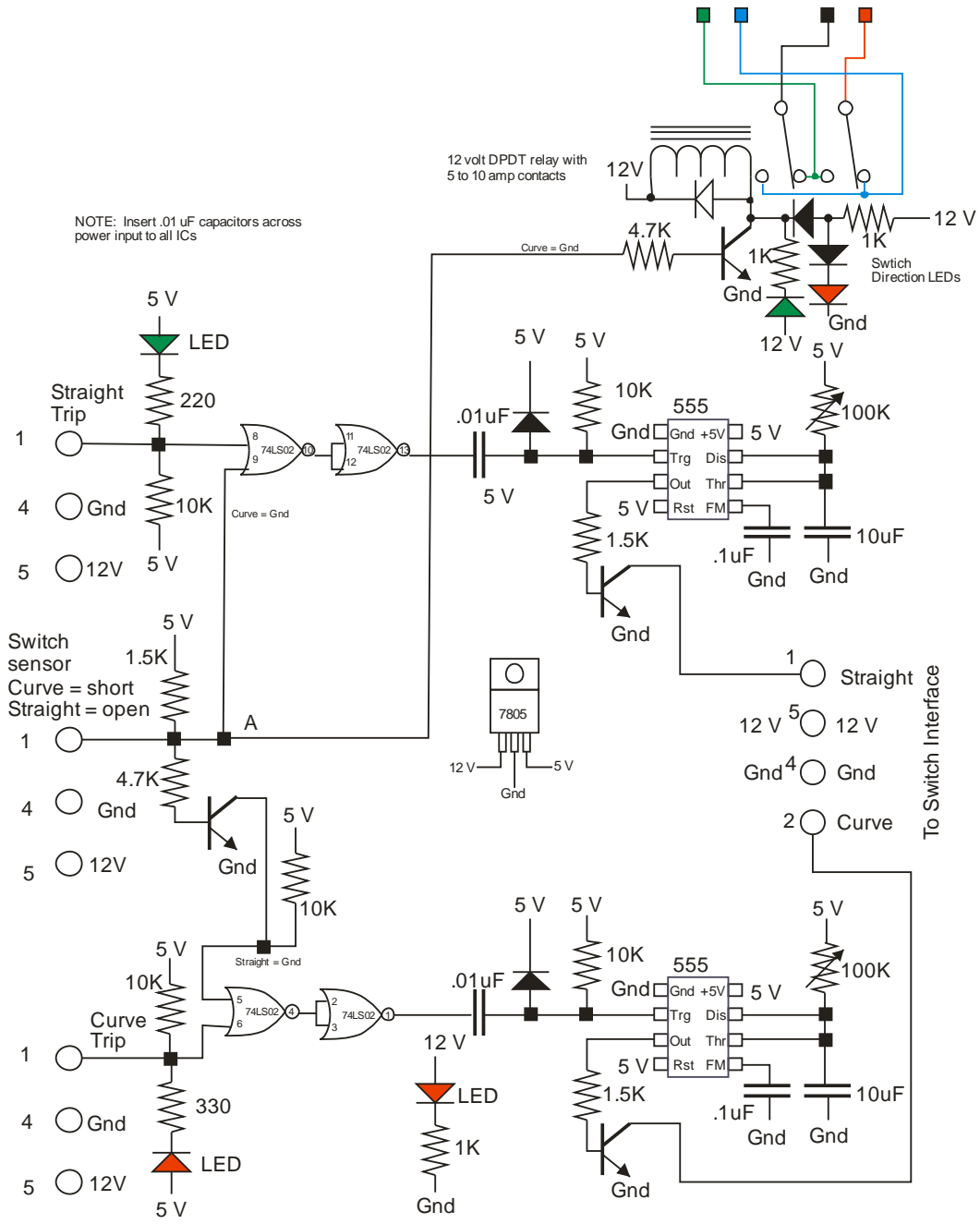
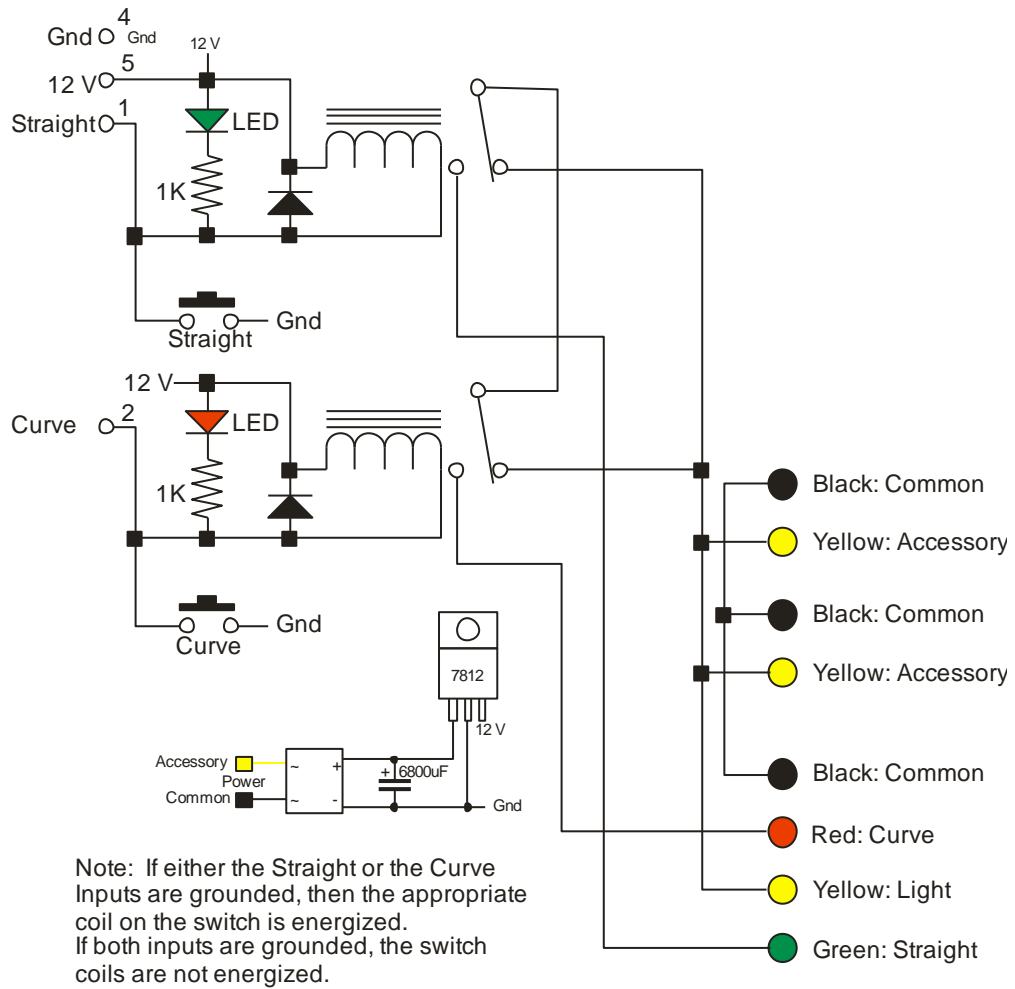


Figure 13: Reverse Loop Control Schematic (Part 1)



**Figure 14: Reverse Loop Control Schematic: Switch Interface (Part 2)**



## 4.2 DC Operation

Figure 15 illustrates how operation of a reverse loop can be fully automated with DC. The same circuits for the AC operation can be employed, but the location of the trips and the connections to the track are somewhat different. Note that Figure 15 addresses two reverse loops at the same time. Also note that only the upper track switch is sensed; the lower track switch is slaved off of the upper switch. If the direction of the lower switch is not the same as the upper switch, the train will stop upon entering the lower reverse loop.

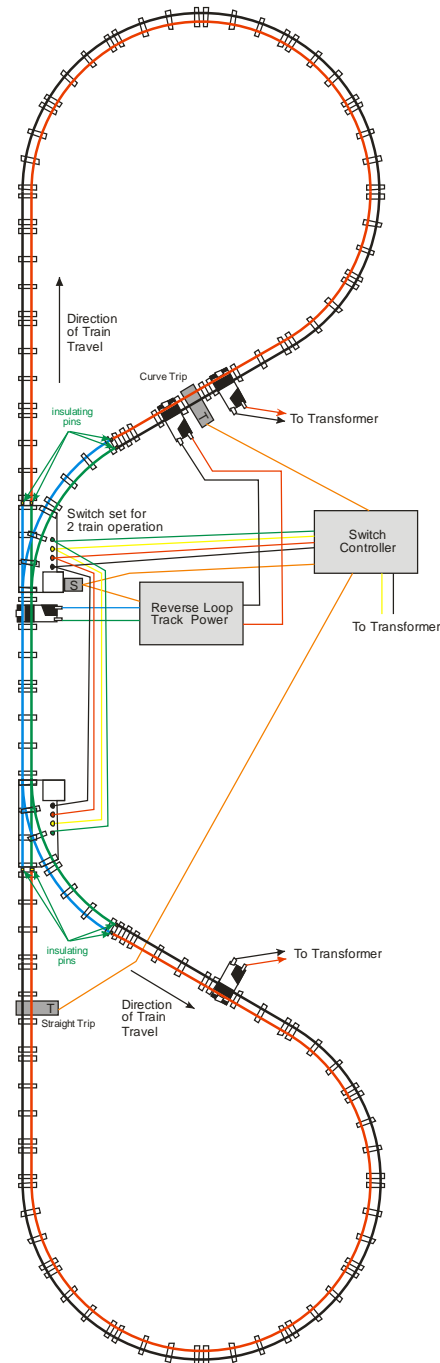
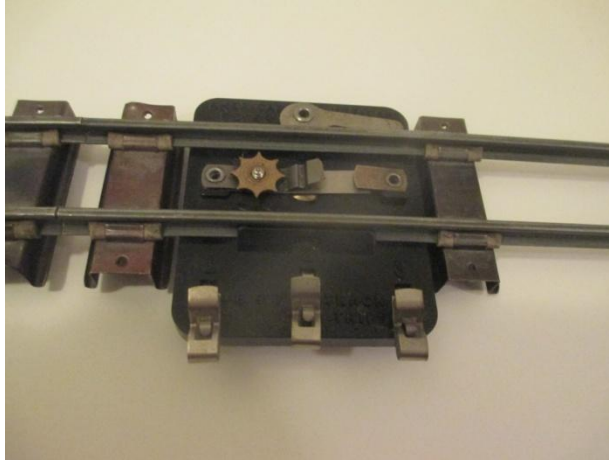


Figure 15: DC Operation Automatic Reverse Loop and Switch Control

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## Appendix A: Track Trips

### A.1 Pressure Trips (AF 697)



**Figure 16: Pressure Track Trip #697**

The 697 pressure track trip is activated by weight. It can be adjusted to activate by the weight of the engine, or by the entire train. When the trip is not activated (no train present) the circuit is closed between contacts number 1 and 2 and contact 3 is disconnected. When activated the circuit is closed between contacts number 1 and 3 and contact 2 is disconnected.

The "star" wheel on the trip is used to adjust the activation weight. Turn the wheel counter-clockwise to reduce the pressure required to activate and turn the wheel clockwise to increase the pressure required to activate.

Because the contacts are electrically isolated from the rails, the 697 trip can be used to directly control the circuits in this document: use contacts 1 and 3.

If used on a layout, it is important not to solidly fasten the track for several sections on either side of the track trip; the track must be able to freely move up and down. This restriction may make the use of this trip on a layout not practical.

## A.2 "Shoe" Trips (AF 696)



Figure 17: Shoe Track Trip #696

The 696 shoe track trip is activated by the wheels of the engine and cars pressing down on the shoe. When the shoe is depressed, the circuit is closed between the one contact and the rail adjacent to the shoe.

If you are sure that the 12V supply for the control system is electrically isolated from the secondary of the transformer used to power the track, you can directly use the 696 trip by connecting the control circuit to the one contact on the 696 trip and to the rail adjacent to the shoe (using a 707 or 690 track terminal for example)

If you are not sure if the 12V supply will be electrically isolated from the secondary of the transformer used to power the track, you should use an isolation circuit. Figure 18 is an example of such an isolation circuit. The "Trip In" is connected to the 696 trip connection and to the track rail opposite from the shoe. This trip isolation circuit will only activate when there is voltage applied to the track and the shoe is depressed. It will work for either AC or DC operation.

Figure 19 shows how to make the track connections with and without the isolation circuit.

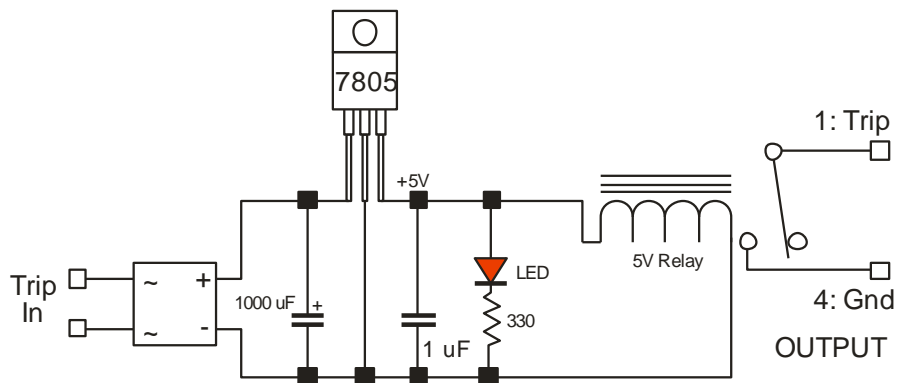
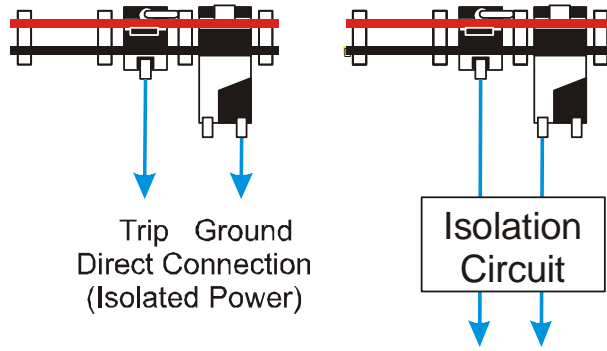


Figure 18: 696 Isolation Circuit



**Figure 19: Track Connection for 696 Track Trip**

One potential issue with the 696 trip is that for some steam locomotives, the pilot wheels are not heavy enough and tend to derail when they hit the shoe. This can usually be rectified by adding a lead weight to the pilot wheels.

### A.3 Current Trip: Electric Track Trip (AF 670)

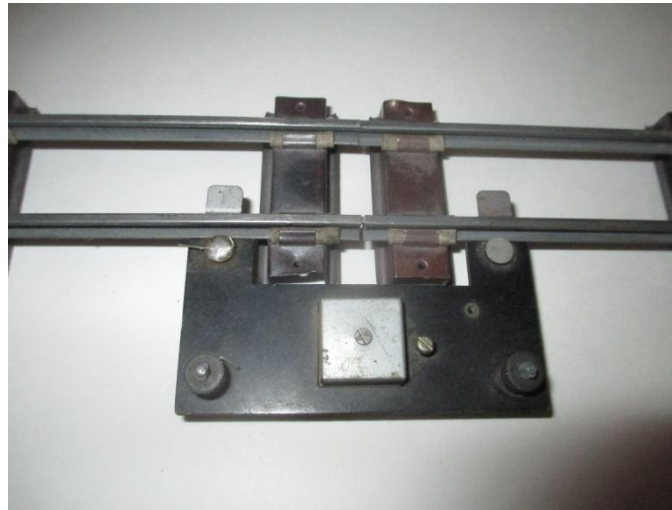


Figure 20: Electric Track Trip #670

Electric track trips work by connecting a relay in series with the train engine on a control section of track. The relay coil is designed to have a low voltage drop and be able to handle the current draw of an engine. The 670 electric track trip, shown in Figure 20 is an example of an electric track trip. As shown in Figure 21, the 670 electric track trip is connected in series with an isolated control section of track (between the insulating pins); when power is drawn from the control section of track, the relay closes the connection between the two terminal on the trip.

Because the contacts are electrically isolated from the rails, the 670 trip can be used to directly control the circuits in this document.

One issue I have experienced with these trips is that occasionally the contacts will stick. Some variants of this trip have an adjustment screw that can be used to improve reliability.

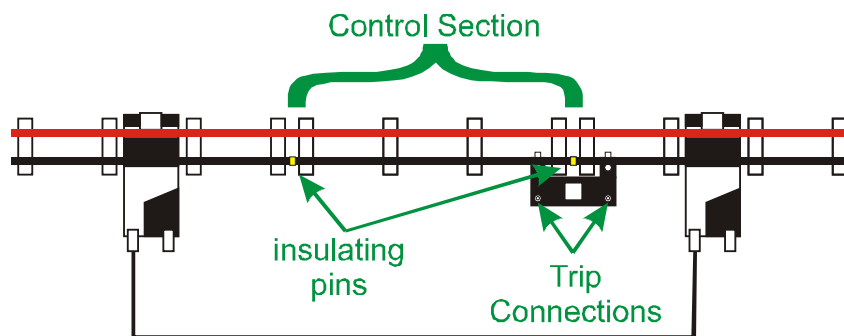


Figure 21: Using the #670 Electric Track Trip

The No. 26671, No. 26672, and No. 26673 Electric Track Trips operate in a similar way as the 670, however instead of having isolated contacts, these trips have only one contact which will connect to the rail not in the isolated control section. See Figure 22 and Figure 23 for the typical connection of the 26671 and 26672 electric track trips. Because the contact is not isolated from the rail, it must be treated

similar to the 696 trip above. If you are not sure if the 12V supply is isolated, the isolation circuit depicted in Figure 18 may be used.

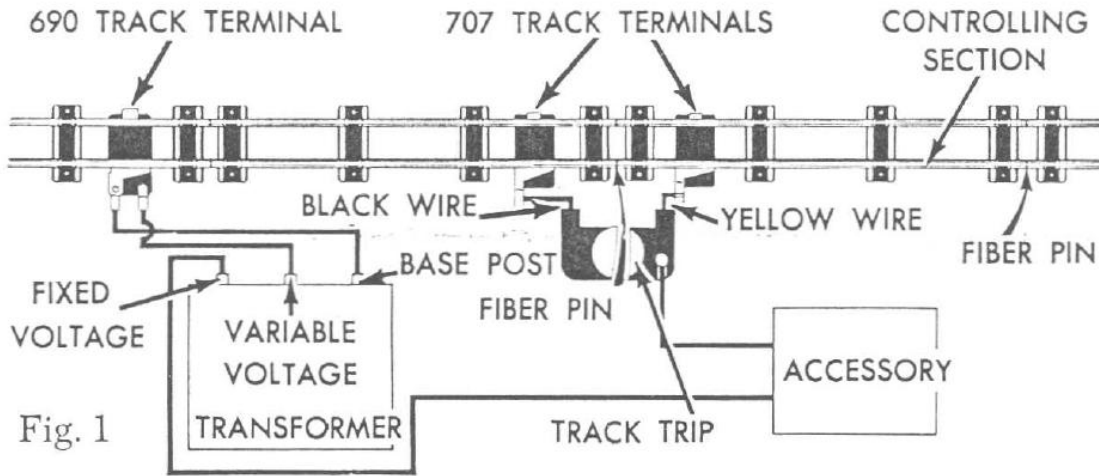


Figure 22: A.C. Gilbert instructions for no. 26671 Electric Track Trip

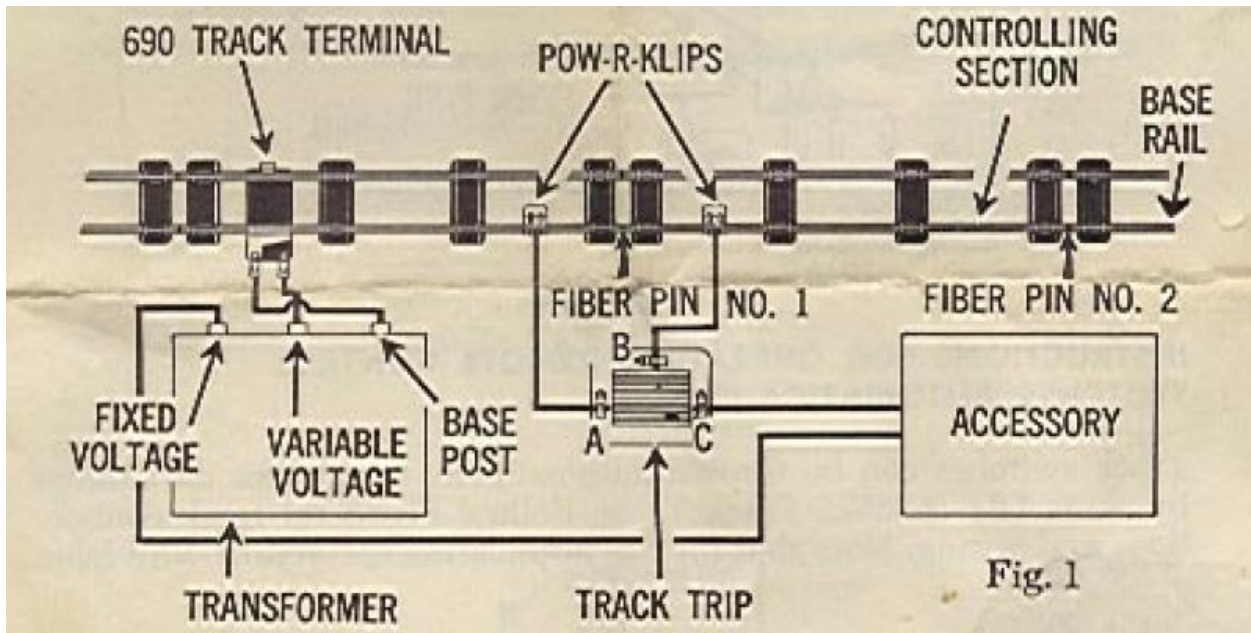
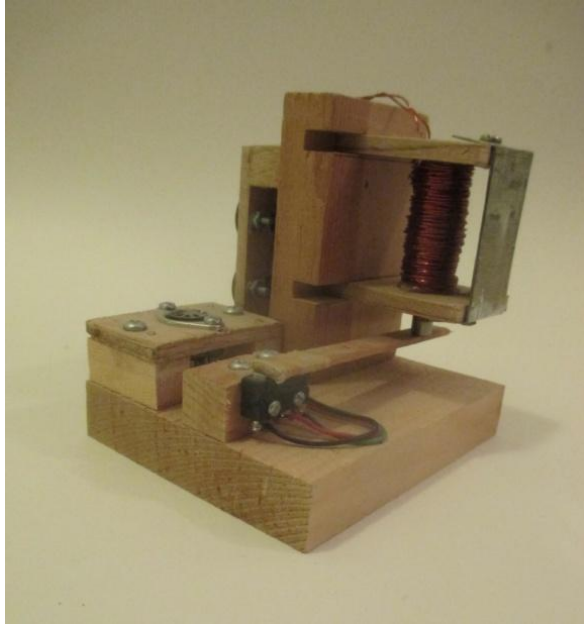


Figure 23: A.C. Gilbert Instructions for no. 26672 Electric Track Trip

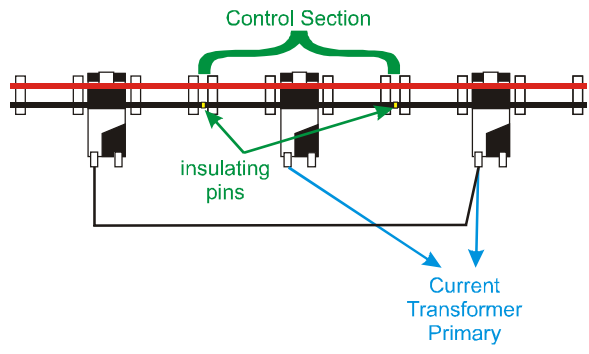
Note that it is possible to make your own electric track trip. See Figure 24.



**Figure 24: Home-made electric track trip**







**Figure 27: Current Transformer Connection to Track**

## A.5 Infrared Trip: Reflective

A reflective IR track trip works by sensing infrared light reflected by a passing train. The infrared LED emitter can be co-located with the infrared sensor as shown in Figure 28 (Two components on the black plastic bases). The reflective IR track trip can be easily installed in a track-side building as shown in Figure 29. Alternately, such as on a permanent layout, the emitter and sensor can be installed underneath the track pointing up; the circuitry can be hidden under the roadbed.

When using reflective track trips, be wary of stray sunlight shining on the sensor; sunlight (and even some electric lights) can activate the sensor. You may have to experiment with shielding the sensor from stray light and keeping unintended objects from reflecting light back to the sensor.

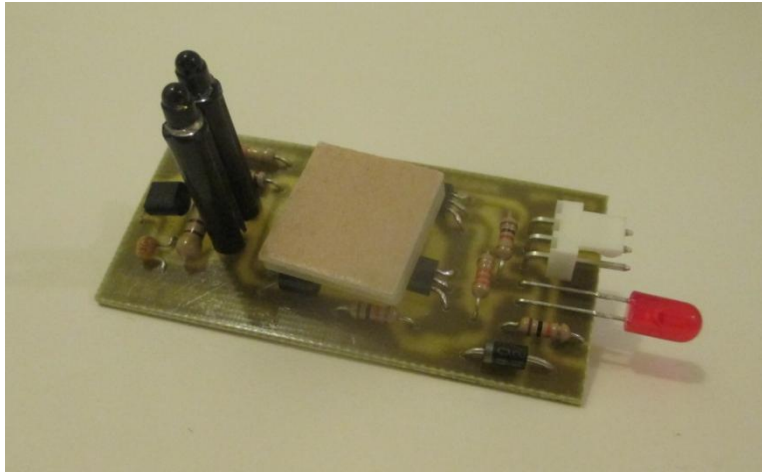


Figure 28: Reflective IR trip (Sensa-Trak II from TCH Technology)



Figure 29: Reflective IR trip installed in track-side building

## A.6 Infrared Trip: Beam Breaking

I have found the beam breaking IR track trip to be very reliable, second only to the electronic current sensor. Unlike the electronic current sensor, beam breaking IR track trips aren't sensitive to whether you operate your layout with AC or DC. This type of trip works by detecting when a beam of infrared light is interrupted. Since the location of the source of light is well known, the IR sensor can be easily shielded to only respond to the IR LED and not to stray light. Additionally, an IR sensor can be chosen that only responds to IR light that is pulsed at a given frequency, typically around 30 to 40 kHz. Steady sources of IR light, such as the sun, can be filtered out if there is sufficient shielding to avoid completely saturating the receiver. Figure 30 is an example of a beam breaking IR trip. The IR LED is in the black box to the right and the sensor is the silver box suspended from the roof of the building. The beam of IR light is diagonal across the track to ensure the beam is broken when a train passes, even between train cars. The circuit for the beam breaking IR track trip is shown in Figure 31.

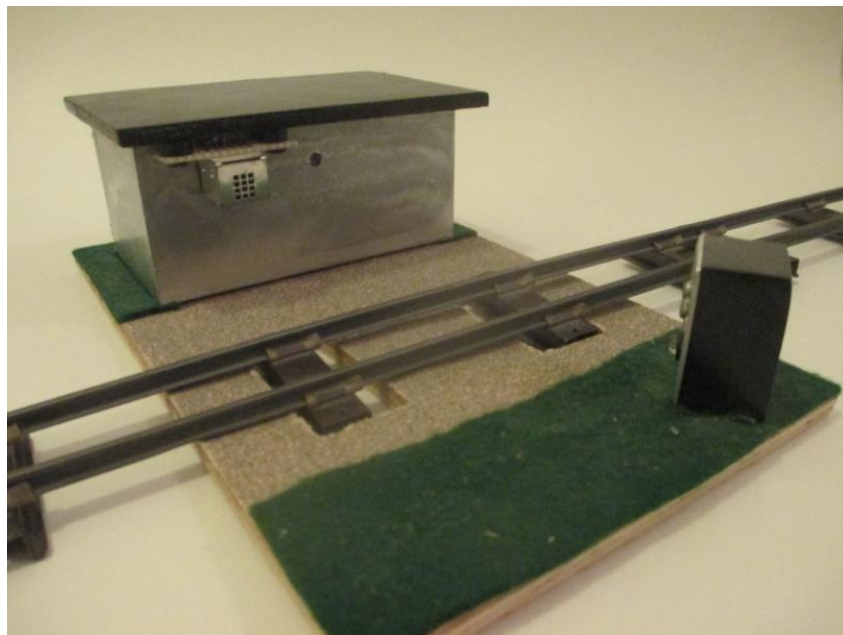


Figure 30: Beam Breaking IR Track Trip



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## Appendix B: Track Switch Direction Sensor

Automating operation of the reverse loop requires a reliable signal for the direction of the reverse loop track switch. Sensing the direction of the switch can either be done directly or indirectly. With the indirect method, the position of the switch is determined by sensing which of the two track switch coils was last energized. This method does not require any modification to the remote control switches, but can provide an erroneous signal on power-up or if the track switch is manually changed. Indirect sensing can also be done at the location of the switch controller, and thus do not require running extra sensor wires to the actual track switch.

The direct sensors determine the actual position of the track switch, and thus provide a more reliable signal. The direct sensors do require a reversible modification to the track switch. I prefer using the direct sensors.

In sensing the direction of a switch with a single electrical signal, a convention must be established for relating the sensor output to a switch direction. For me personally, I am adopting the convention that the sensor output will be a "short" to ground when the switch is in the curved position, and a "open circuit" to ground when the switch is in the straight position.

### B.1 Indirect Sensing using Atlas Snap Relay

The Atlas Snap Relay can be used to indirectly sense the position of the track switch. One set of contacts can be used for the signal and the other set of contacts can be used for LEDs to indicate the direction sensed.

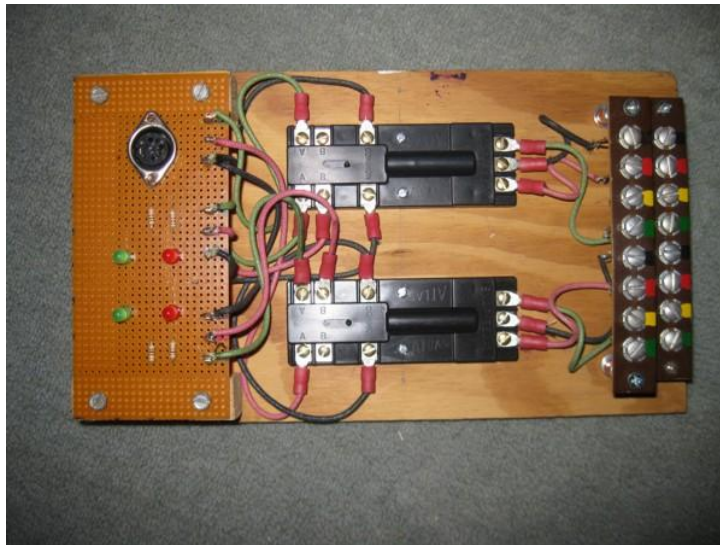


Figure 32: Example of Atlas Snap Relays used for Switch Direction Sensing

## B.2 Indirect Sensing using Opto-Isolators

Another method of indirectly sensing a track switch direction is to detect when one of the two lamps of the switch remote controller is on. Figure 33 is an example of such an indirect sensor. Figure 34 is the schematic diagram. The circuit connects to the light socket of the red light bulb of the controller. When the red light is on, the LED in the opto-isolator is also energized, thereby turning the output transistor on.



Figure 33: Example of opto-isolators used for Switch Direction Sensing

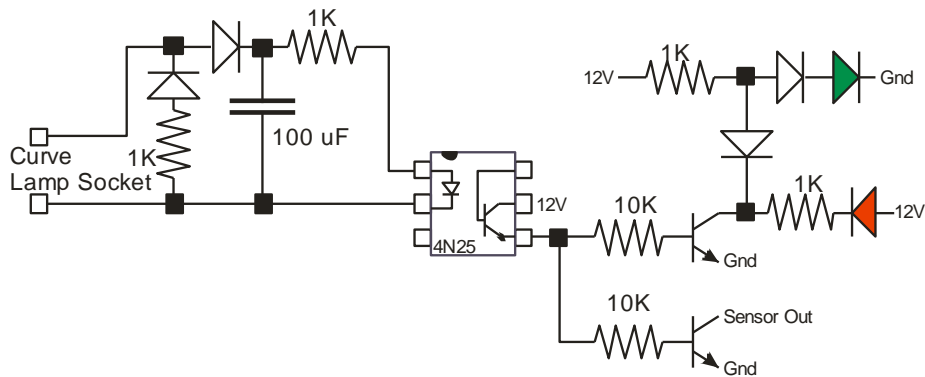


Figure 34: Schematic for opto-isolator indirect Switch Direction Sensing

This sensor may be inaccurate if the operator only pushes the switch lever far enough to activate the curved switch coil, and not far enough to energize the red light.



### **B.3 Direct Sensing using reed switch**

A reed switch (Figure 35) is a very simple electromechanical device consisting of two metal reeds inside a glass tube. For a normally open reed switch, the two reeds are not in contact normally. When a magnet is placed next to the reed switch, the magnet attracts both reeds, causing both to bend and make contact. Hence the reed switch can detect the presence of a magnet.

As shown in Figure 36, it is possible to glue (I use hot melt glue) a reed switch inside the housing of an American Flyer Switch and attach a small, but strong magnet on the shutter mechanism for the light. When the shutter is in the "curved" direction, the magnet is close enough to the reed switch for it to complete the circuit. The wires for the reed switch can be routed through the bottom of the switch.

Radio Shack sells small (3/16 inch) "Rare Earth Super Magnets" which work well in this application.

Getting a reliable orientation and position for both the reed switch and the magnet may take some experimentation. I have found that once reliable operation is achieved, this method works well and I have not had to readjust the reed switch or magnet when placed in operation.



**Figure 35: Magnetic Reed Switch**



**Figure 36: Example of magnetic reed switch used for Switch Direction Sensing**

#### B.4 Direct Sensing using hall effect sensor

A hall effect sensor is essentially a solid-state replacement for a reed switch. It does require three wires: Two for power and one for the signal. I have found that it is much easier to get reliable operation with these sensors as compared to reed switches. I use a Cherry Corporation MP101301 (Figure 37), available from Jameco Electronics. The 3/16 inch "Rare Earth Super Magnets" from Radio Shack work well. An example of direct sensing using a hall effect sensor is shown in Figure 38.

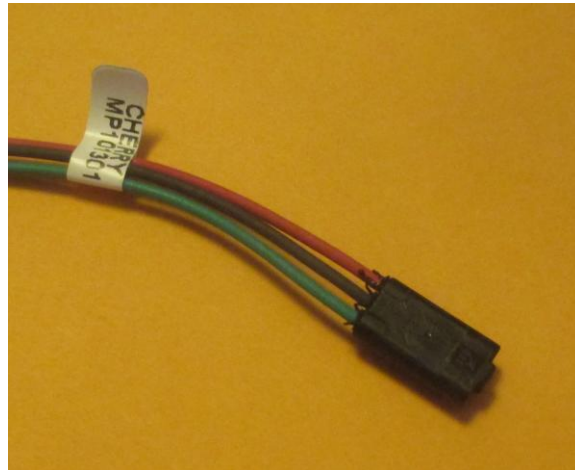


Figure 37: Hall Effect Sensor (MP101301)



Figure 38: Example of hall effect sensor used for Switch Direction Sensing

# Appendix C: GNU Free Documentation License

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