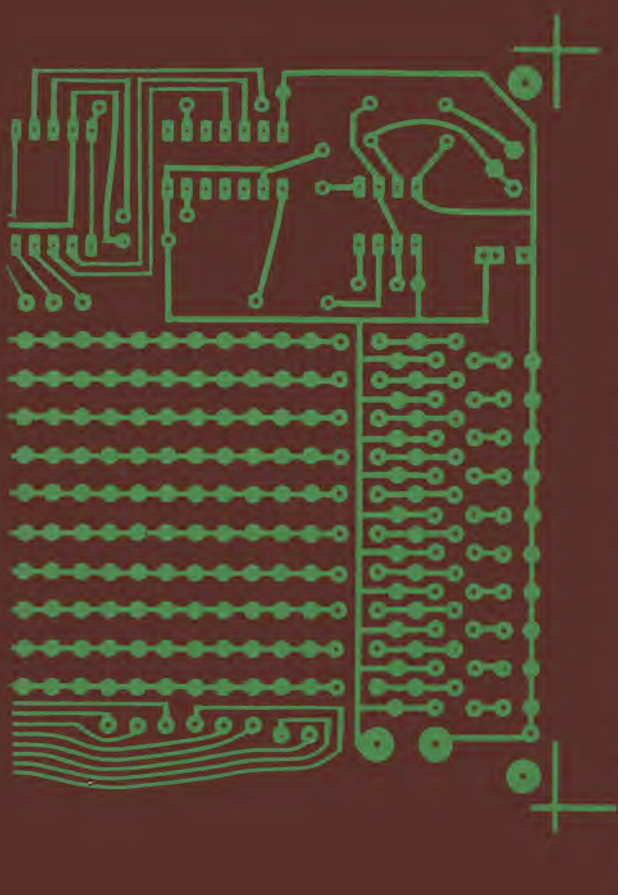
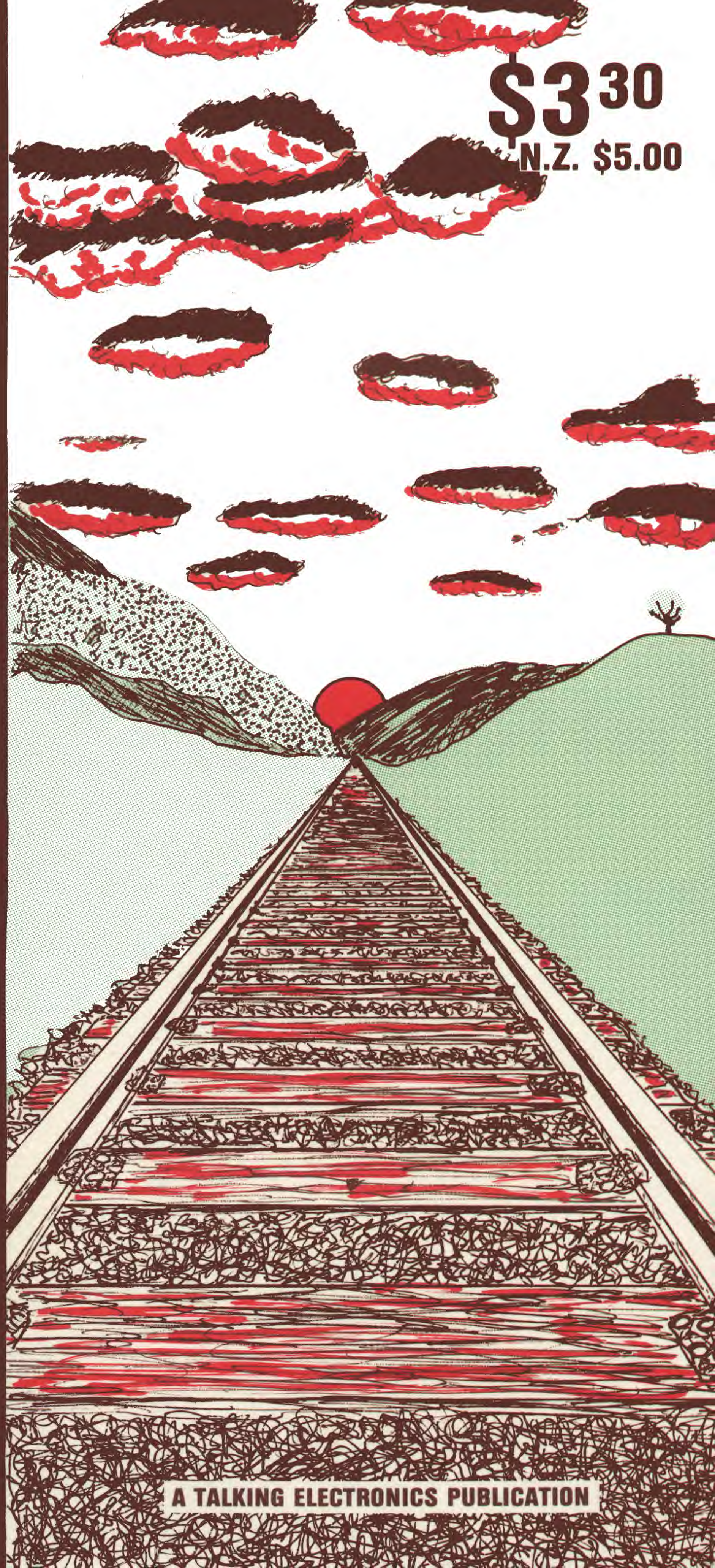
ELECTRONICS FOR MODEL RAILWAYS

By KEN STONE





ELECTRONICS
FOR
MODEL RAILWAYS

by Ken Stone

A TALKING ELECTRONICS PRODUCTION

I would like to thank Colin Mitchell and the Tuesday Night Team at the Victorian branch of the Australian Model Railway Association for their help with this publication.

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Australian Model Railway Association
Victorian branch

Meetings held at the Clubrooms, 92 Wills st., Glen Iris 3146.

General meetings are held on the second Thursday of each month, commencing at 8.00pm

Produced by Ken Stone at 35 Rosewarne Ave, Cheltenham 3192

Introduction

This book has been written to help railway modellers achieve a greater degree of realism on their layouts.

Admittedly all the ideas are not new but most are my own invention. Others are improvements of existing designs.

A classic example is the level crossing. My first level crossing flashing unit consisted of three ex-PMG slow release relays. It was heavy, cumbersome and impossible to hide on my layout which, at the time, was little more than a flat sheet of unpainted chipboard with an oval of track nailed to it. As the layout improved, so did my electronics. The next version was a two transistor multivibrator. It was smaller, but it still had to be manually switched as the train approached the crossing. The circuit presented in this book is a vast improvement. The entire circuit is built on a board 4cm by 8.5cm and is completely automatic.

Most of the circuits are related to 'OO', 'HO' and 'N' scale layouts, as these are the most commonly used and practical scales. Any of the designs can easilly be adapted to other scales and most of them can be used directly.

A balance between realism and complexity has been maintained. The circuits have been designed to be as realistic as possible without being too complex. I don't want to frighten away anyone who is not experienced in electronics.

When you build your own projects, not only do you learn a lot about electronics, but you can save yourself a fortune. I have seen a set of flashing warning lamps selling for $40! You can build an improved version for under half this price.

CMOS IC's have been used for all digital circuits as these chips do not require a precision power supply and can operate on a wide voltage range. This is ideal for layouts where a 12 volt supply is used.

If you are an absolute beginner at electronics, I suggest you read the publications by Colin Mitchell entitled **ELECTRONICS Stage-1**, **ELECTRONICS NOTEBOOK 1** and **ELECTRONICS NOTEBOOK 2**. They cover basic components, how they work and how to use them. Digital electronics is also introduced, and details on project building are covered.

Most modellers should be skilled enough to make an excellent job of the projects (especially if they scratch-build locomotives), but one word of warning . . . Always use resin cored solder. Never use acid cored solder and never use soldering flux. Use an iron with a fine tip and a wattage rating between 15 and 30 watts. Leave the 60 watt monster for the guttering!

All components are readily available from electronic suppliers and/or model shops. If you experience any difficulty in obtaining parts or PC boards, they can be purchased in kit-form from the advertiser on the cover of this book. This will make these circuits the most fully supported electronics projects for the railway modeller ever to be presented.

I hope you will add some of these to your layout and experience the same realism as seen on exhibition displays.

Ken.

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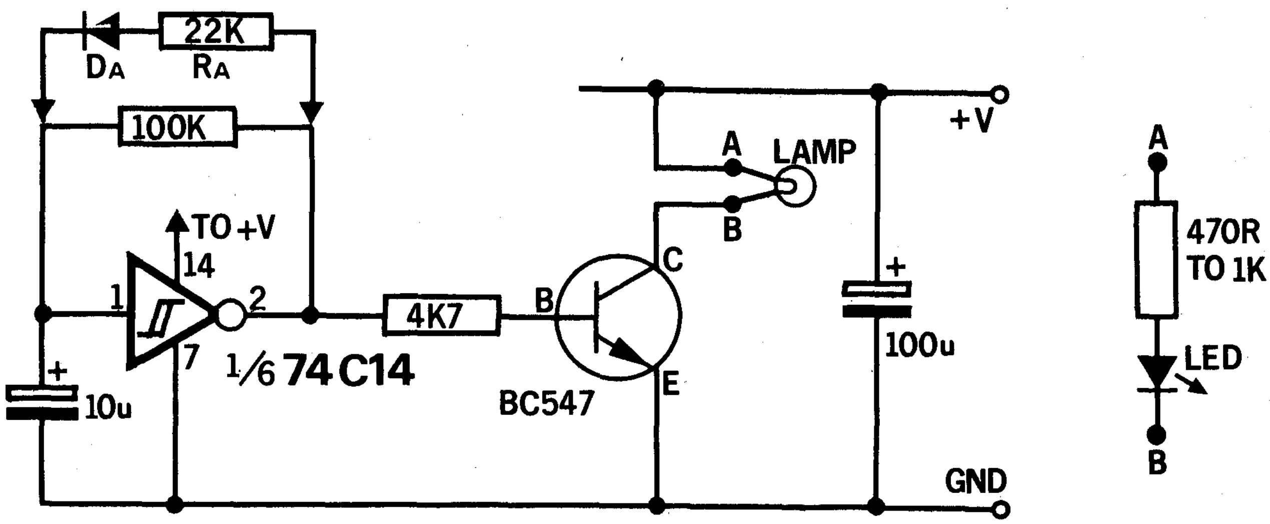
WARNING LAMP FLASHING UNIT

A flashing warning-lamp for scale construction sites, road maintenance areas and 'turn indicators' for cars.



This circuit is repeated 6 times on the PC board.

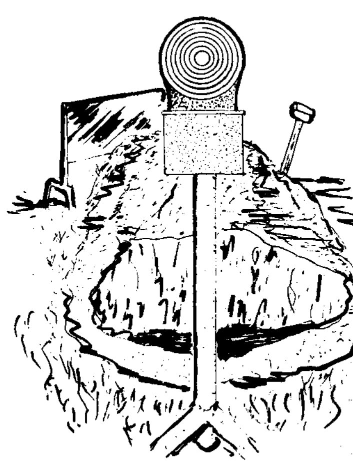
This WARNING LAMP FLASHING UNIT is an ideal first IC project.

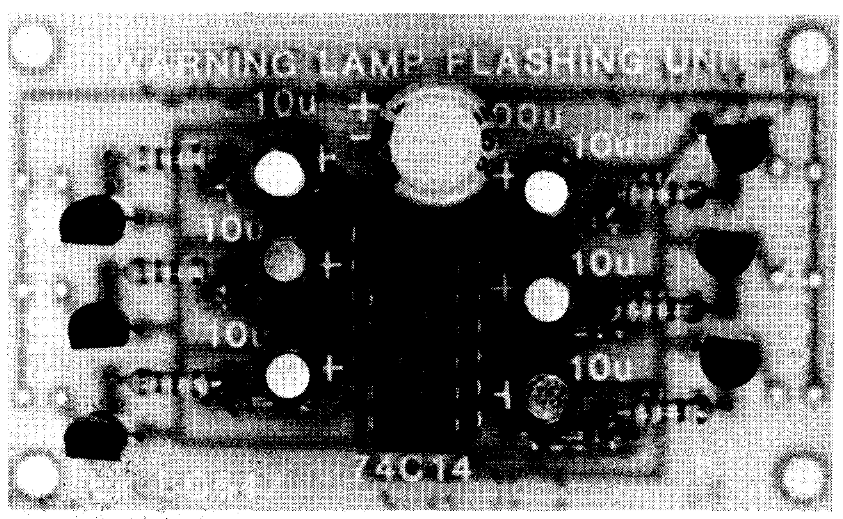
It may look complicated at first, but you will notice on the overlay of the PC board, there are six of each component value (except the IC and 100mfd electrolytic).

This is because the board contains six identical circuits, each capable of flashing one lamp. Each circuit is based around a Schmitt Trigger inverter, of which there are six in the chip. This chip is available under several different code numbers. These are 74C14, 40106 and 40014. You must ask for this chip by its number: don't use the letter codes such as HCF, CD and MC as these only indicate the manufacturer of the chip.

The circuit diagram shows only ONE of these oscillator circuits. The 100mfd capacitor and the power rails are common to the six circuits. In some circuits the power rails are omitted for clarity but they must be connected for the circuit to work!

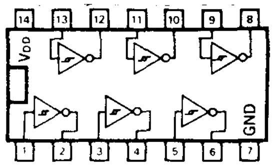
If you look at the pin-out of the chip, you will see it contains six Schmitt Inverters and since the circuit only shows pins 1 and 2, the other circuits will use





the following pairs: Pins 3 and 4. Pins 5 and 6. Pins 13 and 12. Pins 11 and 10 and finally pins 9 and 8.

On the circuit diagram we have shown two components, DA and RA, these are not shown on the PC board overlay and will be discussed later.



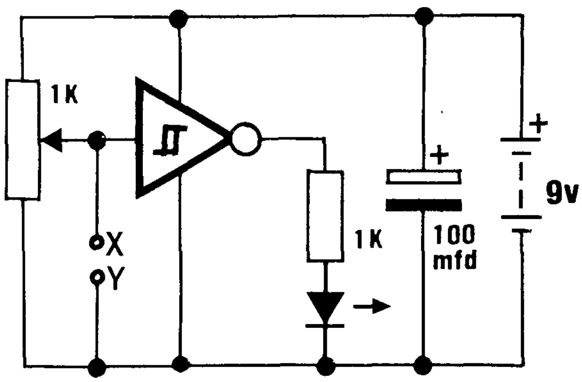
74C14

Pinout of the 74C14

HOW THE CIRCUIT WORKS.

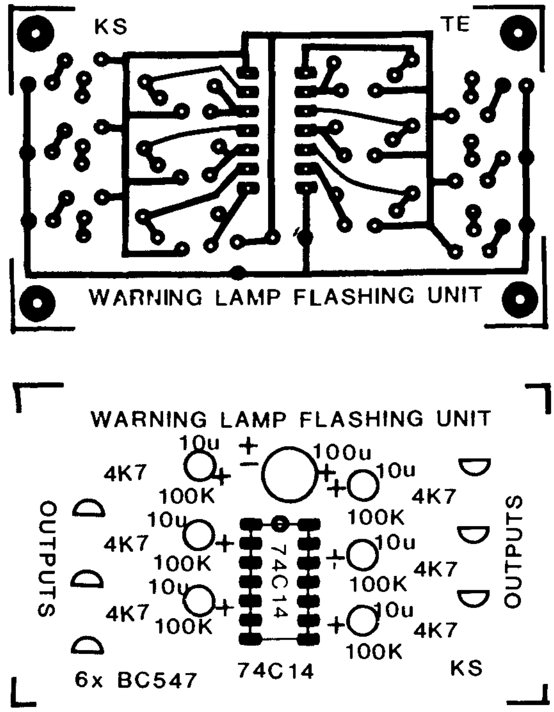
The first component to understand is the 74C14, as it will be used often in this book. This chip contains six Schmitt inverters. Each works as follows:
The Schmitt inverter has two 'threshold' voltages, one at approximately one-third Vcc and the other at approx two-thirds Vcc. (Vcc is the value of the voltage rail).

Consider the Schmitt trigger in the circuit below:



Start with the pot 'set' to the positive end of its travel. This puts a logic 1 or HIGH on the input of the inverter. The output of the chip will be the inverse of the input and in this case it will be 0 or LOW. The LED connected to the output will not light. Connect a multimeter (set to its 10-volt range), across points x and y. Turn the pot slowly toward the negative end of its travel. Nothing happens to the output of the circuit until the voltage becomes about one-third Vcc. (about 3.5v). This is called the LOWER THRESHOLD. At this point the output of the inverter goes HIGH and the LED lights.

Continue turning the pot towards 'zero'. Nothing further happens to the output. Slowly turn the pot back towards the positive end of its travel. As the voltage approaches two-thirds Vcc, the output suddenly goes LOW and the LED extinguishes.



PC board and overlay for the Warning Lamp Flashing Unit.

PARTS LIST

6 - 4k7
6 - 22k
6 - 100k
6 - 220k

6 - 10mfd 16v PC electros
1 - 100mfd 16v PC electro.

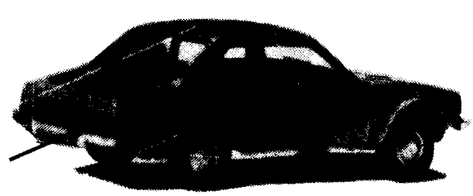
6 - 1N 914 (1N 4148) diodes
6 - BC 547 transistors
1 - 74c14 Hex Schmitt Trigger IC

1 - 14 pin IC socket

*6 - 6v or 12v mini lamps
6 - 3mm yellow LEDs & 470R
WARNING LAMP FLASHING UNIT PC

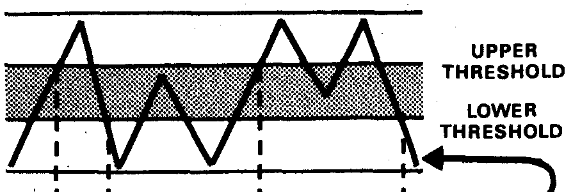
*Lamp voltage is determined by the voltage supplied to the project.

This car has a hole drilled as shown to take a 'shaped' indicator LED.

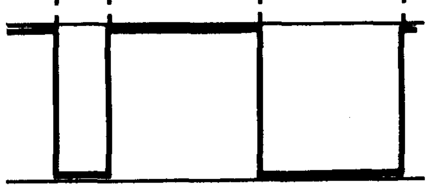


From this it can be seen that when the input voltage is slowly rising from zero to positive, an instant occurs when the output IMMEDIATELY changes from positive to zero. The same occurs when the input is in a 'falling' condition. These 'change-points' are called UPPER and LOWER thresholds.

If we turn the pot very quickly up and down, we will generate a waveform very similar to the following diagram:

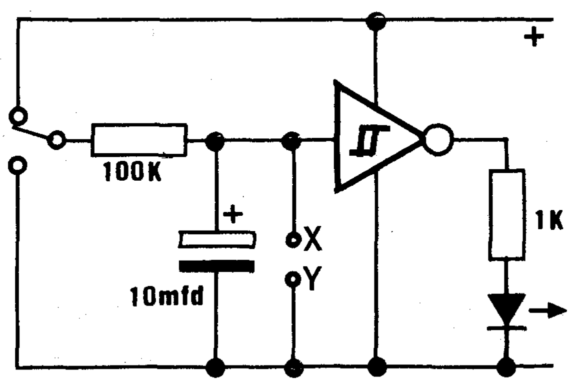


Waveform present at the input of the Schmitt inverter.

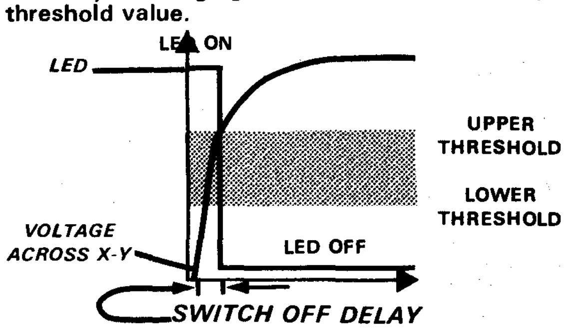


Output of the Schmitt inverter for the above input waveform.

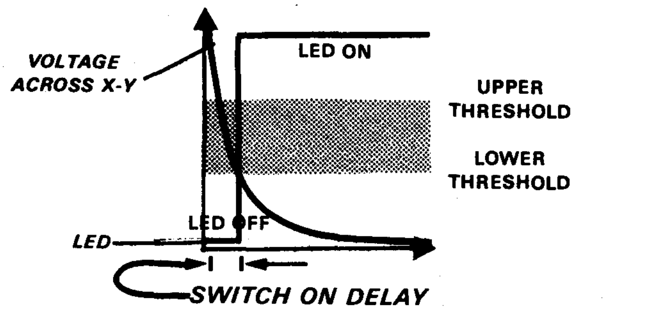
When a random waveform is presented to the input of the chip, the output will rise and fall according to the upper and lower thresholds. The gap between these values is called the HYSTERESIS GAP and is shown shaded on the graph.



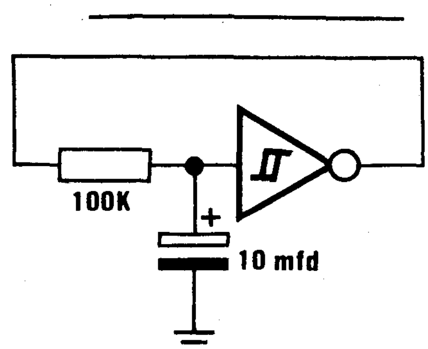
If we add an electrolytic and resistor to the circuit as shown, we produce a DELAY circuit. By taking the switch HIGH a short time-delay will be produced before the LED will go out. This is due to the electrolytic charging via the resistor to the upper threshold value.



Change the switch LOW and once again a delay will occur before the LED responds.

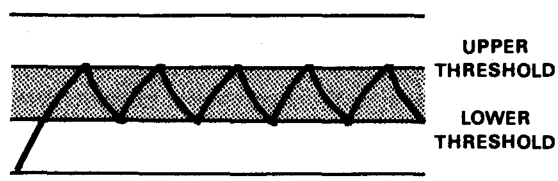


Note that during the delay, the input to the resistor and the output of the inverter are the SAME LOGIC LEVEL.

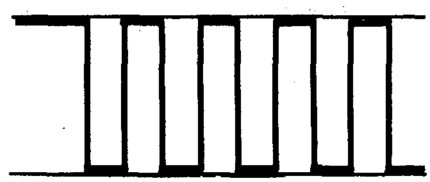


The Schmitt oscillator.

Instead of triggering the delay via a switch, it can be triggered via its own output. Below is a graph of the result of this arrangement.



The voltage across the capacitor during oscillation.



Output of the Schmitt oscillator.

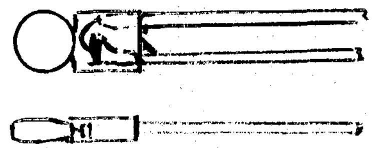
Initially the capacitor is uncharged and the input of the Schmitt inverter is held LOW. The output of the inverter is therefore HIGH. The capacitor charges via the 100K resistor and when the voltage across it reaches two-thirds Vcc, the output of the inverter goes LOW. Since the 100k is connected to the output of the inverter, it discharges the capacitor until the voltage across the input is one-third Vcc. At this point the output of the inverter goes HIGH again.

The circuit will continue to cycle indefinitely.

The test circuit now looks very similar to that of the project.

To provide additional output current, the Schmitt oscillator drives a buffer transistor (via a 4K7 base resistor). This is necessary if grain-of-wheat bulbs or more than one LED per output (via current limiting resistors) are to be driven by the unit.

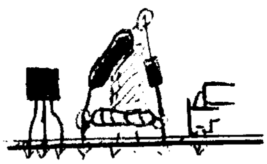
You will notice that each of the oscillators flash with a mark-space ratio very near to 50%. In other words the lamp is lit for the same duration as it is extinguished. With this circuit two LEDs (and their current-limiting resistors) can be connected in parallel to simulate the turn indicators in a scale car. A LED or lamp can also be connected to the circuit to simulate the portable warning lamps around road-side holes. 'Rivet Counters' will immediately say that these roadside lamps run at 10% - 90% mark-space ratio to save battery power. You can get the same effect by adding a modification.



An enlarged view of how to file a 3mm yellow LED to resemble a warning lamp.

First you must replace the 100K resistor in each oscillator to be modified with a 220K. RA and DA are then soldered across the top of the 220K resistor so that the cathode of DA is facing towards the chip (for all oscillators), as shown in the diagram below. RA is 22K resistor and DA is a 1N914 diode.

This is what the LED will look like after filing. It has been given an undercoat of black paint to prevent light shining through the body of the lamp.

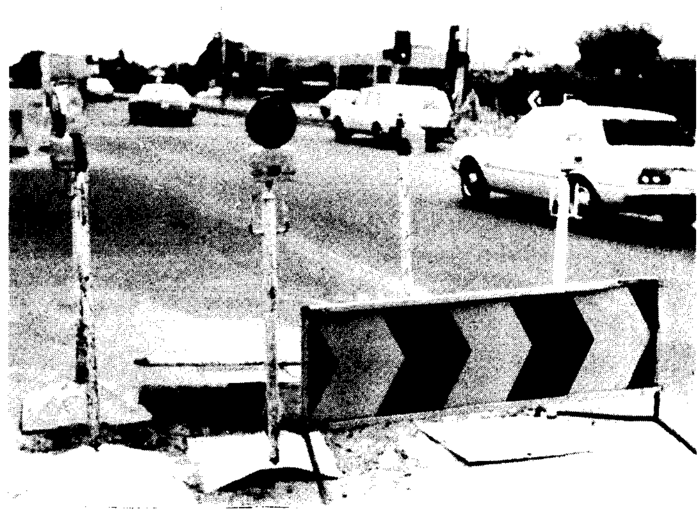


There are six independent flashing circuits on the board. These will flash at slightly different rates due to the slightly different value of each component. The effect produced adds greatly to the realism of your layout, especially when the lamps are placed near each other.

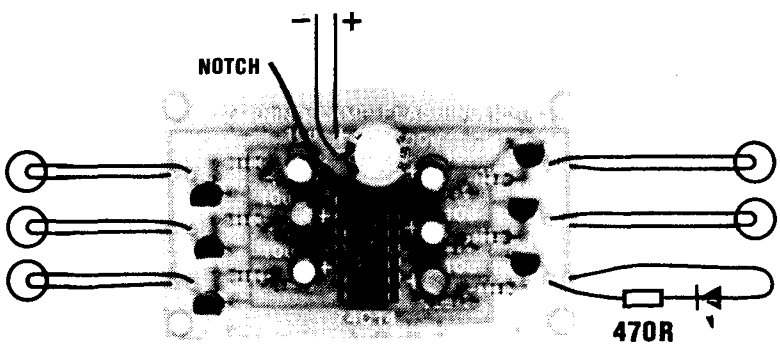
CONSTRUCTION

Solder the resistors onto the printed circuit board first, followed by the IC socket. Next solder the transistors and capacitors, making sure their polarity is correct. Finally insert the chip into the socket with the notch near the 100mfd electrolytic.

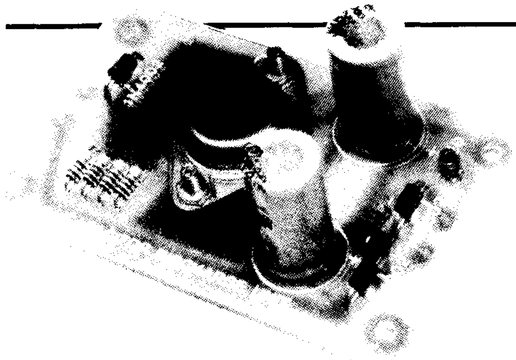
The unit can be mounted under the base-board of the layout or even on part of the frame. Use fine hookup wire between the board and the lamps. Use a supply voltage to suit the voltage of the lamps. Do not supply the circuit with a voltage above 12v as this can very easily damage the IC.



This photo should help you to model realistic warning lamps and stands. There several other types of stands used with these warning lamps. Some warming lamps are also built with red lenses, as was one of these.



This diagram shows how to wire the lamps and LEDs to the PC board. It is important not to forget the 470R to 1K resistor in series with the LED.



Switch your points with this . . .

CAPACITOR DISCHARGE UNIT

Every model railway has points. I don't consider a layout to be co' plete without at least one. Without them, the layout is a train set!

Many of these points are switched remotely due to their distance from the operator or inaccessibility in tunnels etc.

Their method of control is usually electrical and up to now a number of problems have been associated with these circuits. They had the tendency to overheat the solenoids and even burn them out. If this happened, the points, and even the track, could be damaged.

The electrical control of a set of points is simple. Electrical energy is converted to mechancial movement via a solenoid actuator. This device is called a 'POINT MOTOR'. They are mounted under or near the point in such a way that the movement sets the blades of the points for one direction or the other.

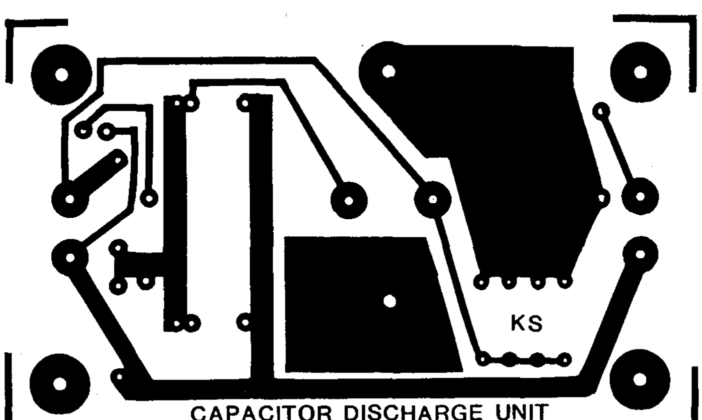
This involves a linear movement of about 5mm. To create this movement, the simplest device is the solenoid. It is simply a coil of wire wound on a former. Inside the former is an iron actuator or slug which can be pulled into the coil when the power is applied. By placing two of these coils end-to-end, a forward and reverse motion can be created. These arrangements are called 'Switch Machines' or 'Point Motors'.

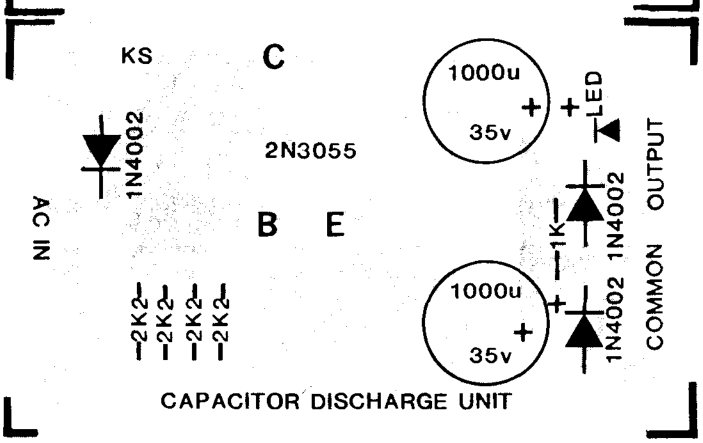
These two-solenoid point-motors are usually switched by short pulses of electricity. The pulse length is often determined by the operator or by a simple spring-loaded switch.

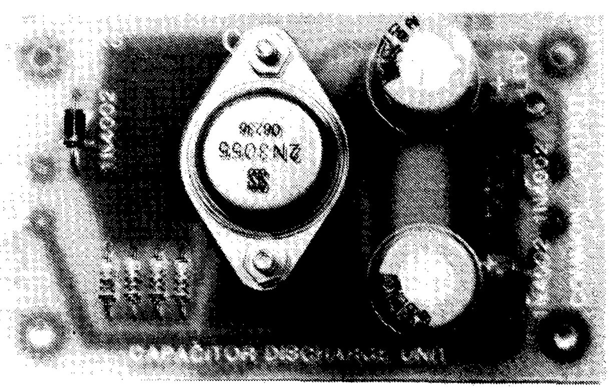
But there are several problems with this arrangement. Point motors require a considerable amount of current for their operation. This means the full capacity of the transformer will be needed. Any other items using the same supply will suffer.

There are other problems too. The high currents will play havoc with switches. The back emf (reverse voltage) generated by the solenoid is sometimes sufficient to weld the switch closed. This will keep the current flowing through the solenoid and it will over-heat very quickly.

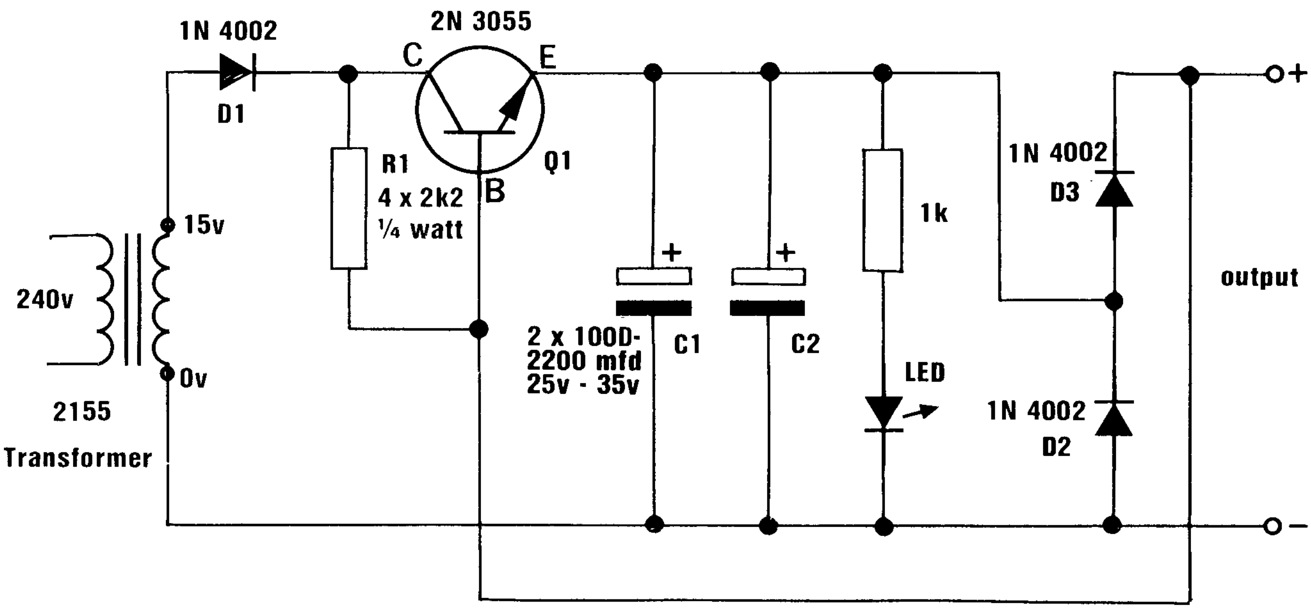
Our CAPACITOR DISCHARGE UNIT overcomes all these problems. Capacitor Discharge Units (CDU) supply a high current 'burst' to the solenoid. This current burst is over by the time the switch contacts open, thus eliminating back emf across the switch contacts. Should a solenoid be left in circuit, the current flowing through it (after the initial surge) will be less than 50mA. This won't even be enough to warm the coil!







All components fit neatly on the PCB.



Very few components are needed to make this unit, as can be seen from the simplicity of the circuit diagram. R1 can be a 470R 1 watt resistor or four 2K2 ¼ watt resistors in parallel.

HOW DOES IT WORK?

The AC voltage (16v) at the input of the CDU is rectified by D1. This diode passes every positive half-cycle of the AC and blocks the negative half-cycle.

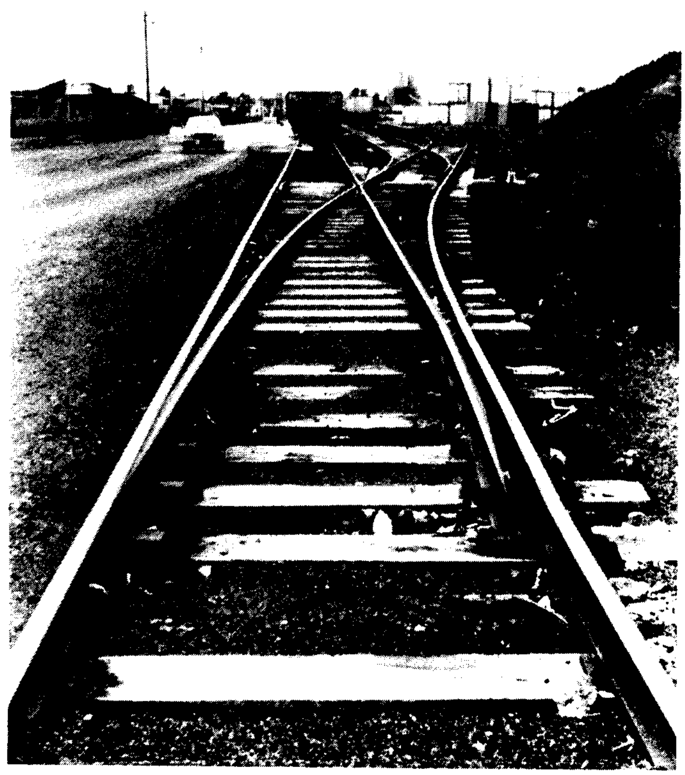
Assuming no solenoid is connected to the CDU, R1 pulls the base of Q1 high, switching ON the transistor and allowing current to flow through it (from C to E), to charge the capacitors C1 and C2. These are the reservoir capacitors that will supply the surge of current to the solenoid.

D2 and D3 are protection diodes which prevent any back emf from damaging the transistor or capacitors.

This is what happens when a solenoid is connected across the output of the CDU:
The reservoir capacitors will discharge through D3 into the solenoid. The low impedance of the solenoid (typically 3 ohms) is now holding the base of the transistor LOW, switching it OFF. The only current now flowing is going through R1 and the solenoid. This current is less than 50mA. The transistor remains OFF preventing the charge-current reaching the solenoid.

Removing the solenoid from the output of the CDU will allow the base of the transistor to be pulled HIGH by R1. The transistor will turn on and charge the reservoir capacitors again, ready for the next operation. Recharge time is less than half a second.

Assembly of the PC board is straight-forward. Four 2k2 ¼watt resistors are wired in parallel to form R1. A 470R 1 watt resistor could be used but ¼watt resistors will look much neater. The transistor is



bolted to the PC board with its base and emitter leads soldered and trimmed. It requires no insulation or heatsink.

The capacitors can be rated at 25v if the unit is to be operated on 15 -16v AC. If connected to 18 -20v, the capacitors must be rated at 35vw.

Note: Train transformers often have an output of 15 to 16v when labelled 12v, so this must be taken into account. (They drop to 12v on full load).

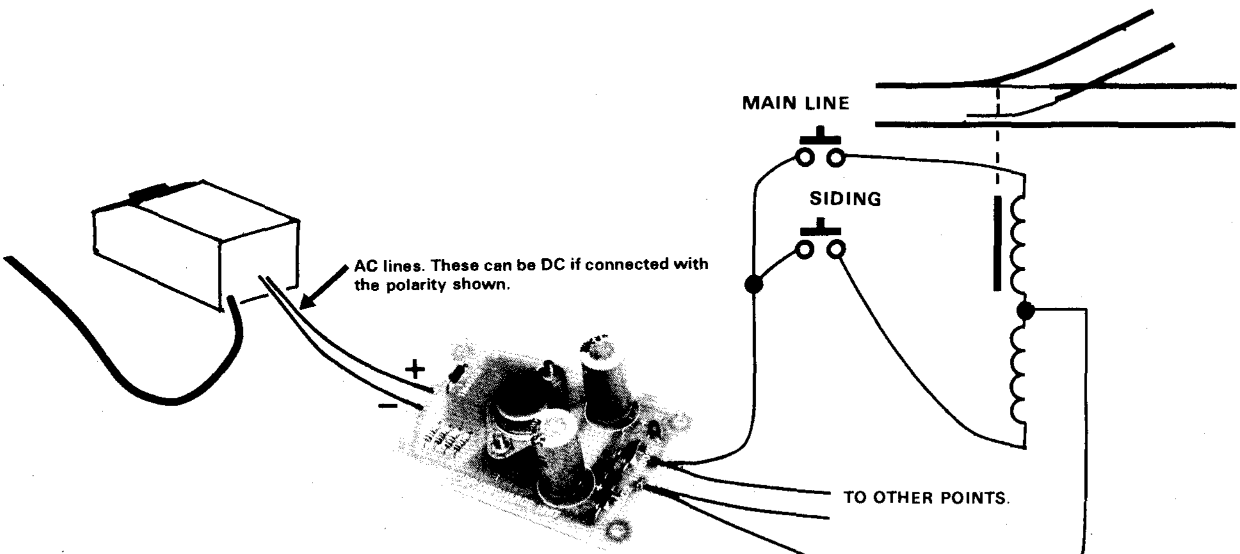
A single 2200mfd capacitor can be substituted for the two 1000 mfd capacitors. If a more powerful unit is required, an extra 2200mfd capacitor can be added.

Care must be taken with orientation of all components other than the resistors. Any error will result in damage to some or all the components.

CONNECTING THE UNIT

Disconnect the wires of your existing system from the transformer and connect them to the output of the CDU. Connect the input of the CDU to the transformer. The system is now ready for operation. See the completed wiring diagram for the connections to the capacitor discharge unit.

The LED can be placed on the main control panel of the layout to indicate the condition of the unit. The LED will light to indicate when the unit is ready. When a point is operated, the LED will extinguish, then come back on as the capacitor charges. If it remains extinguished, it indicates a fault is present and the solenoid may still be in circuit. No other points can be operated until this is fixed, but at least the solenoids will not be damaged!



How to wire the capacitor discharge unit into your point switching system.

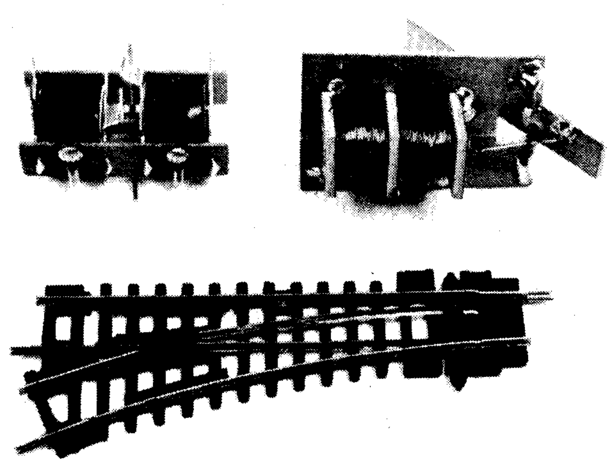
Capacitor Discharge Unit Parts List

1 - 1K
4 - 2K2

2 - 1000 mfd 25v-35v. See text.

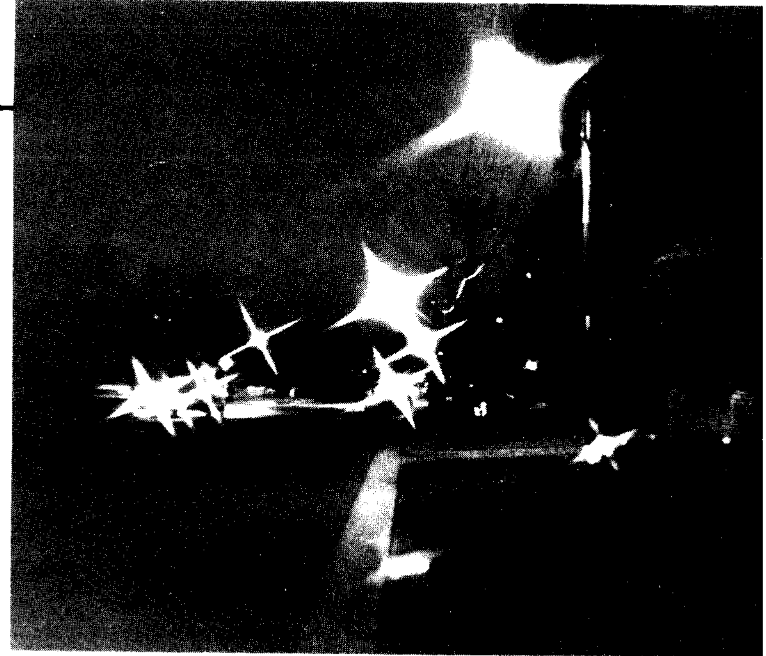
3 - 1N4002 diodes
1 - 3mm red LED
1 - 2N3055

2 - Nuts & bolts
1 - Capacitor Discharge Unit PCB



A commercial point motor and a home made point motor alongside an N gauge point.

SCALE
FLUORESCENT
LAMPS



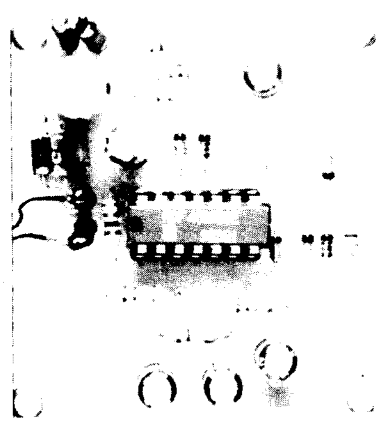
Simulates the effect of a fluorescent lamp starting or the flickering of one with a fault.

REALITY is the keynote with this project.

It is a simple yet clever circuit to provide the flickering effect of a fluorescent tube, when it is first switched on. The clever part of the circuit is the type of lamp it drives. We are producing the flicker from a normal incandescent lamp!

Imagine the reaction when you ask your friend to turn on the street lights on your layout. He will not realize you have installed 3 Fluoro Simulator units and connected them to a row of model fluorescent street lights.

The lamps flicker, flicker, flicker then come on. . . exactly like real fluoro's! If he isn't surprised. . . he must have read this article.



HOW IT WORKS

The Fluorescent Simulator is built around a 74c14 Schmitt Trigger. See the explanation of the operation of the chip in the Warning Lamp Flashing Unit.
The circuit can be divided into several sections to make explaining how it works easier.

Four of the six Schmitt Trigger inverters are wired as oscillators, each having a different frequency as determined by the resistor and capacitor in the R-C network.

The second section is an OR gate followed by an inverter. It consists of four diodes, a 100k pull-down resistor and one inverter. The outputs of the four oscillators are fed into this OR gate.

The percentage of time when four independent oscillators are LOW, is very small. And to make it more interesting, these pulses are of random duration. We invert these pulses to produce short ON times for the lamps.

The sixth Schmitt inverter is wired as a delay. When power is first applied to the circuit, the 4.7mfd electrolytic is uncharged, holding the input (pin 13) of the inverter HIGH.

The output (pin 12) will be LOW. The 4.7mfd electrolytic charges slowly through the 1M resistor and as the voltage on the input passes the lower threshold of the Schmitt inverter, the output will go HIGH.

The output of this delay, and the 'flicker' circuit, are gated together via D5 and D6 into the driver transistor.

This gate passes the signal from the flicker circuit while the output of the delay is LOW, but when the output of the delay goes HIGH, the flicker circuit has no more effect. The result is the output of the gate remains HIGH.

Any lamp connected to this circuit will flicker for a length of time at switch-on and then remain lit.

If you wish to simulate a 'dead' fluorescent, leave out D5 (which is marked by two circles on the component overlay on the PC). This will disconnect the output of the delay from the gate and means that the flicker signal will be present at the output for the full length of time.

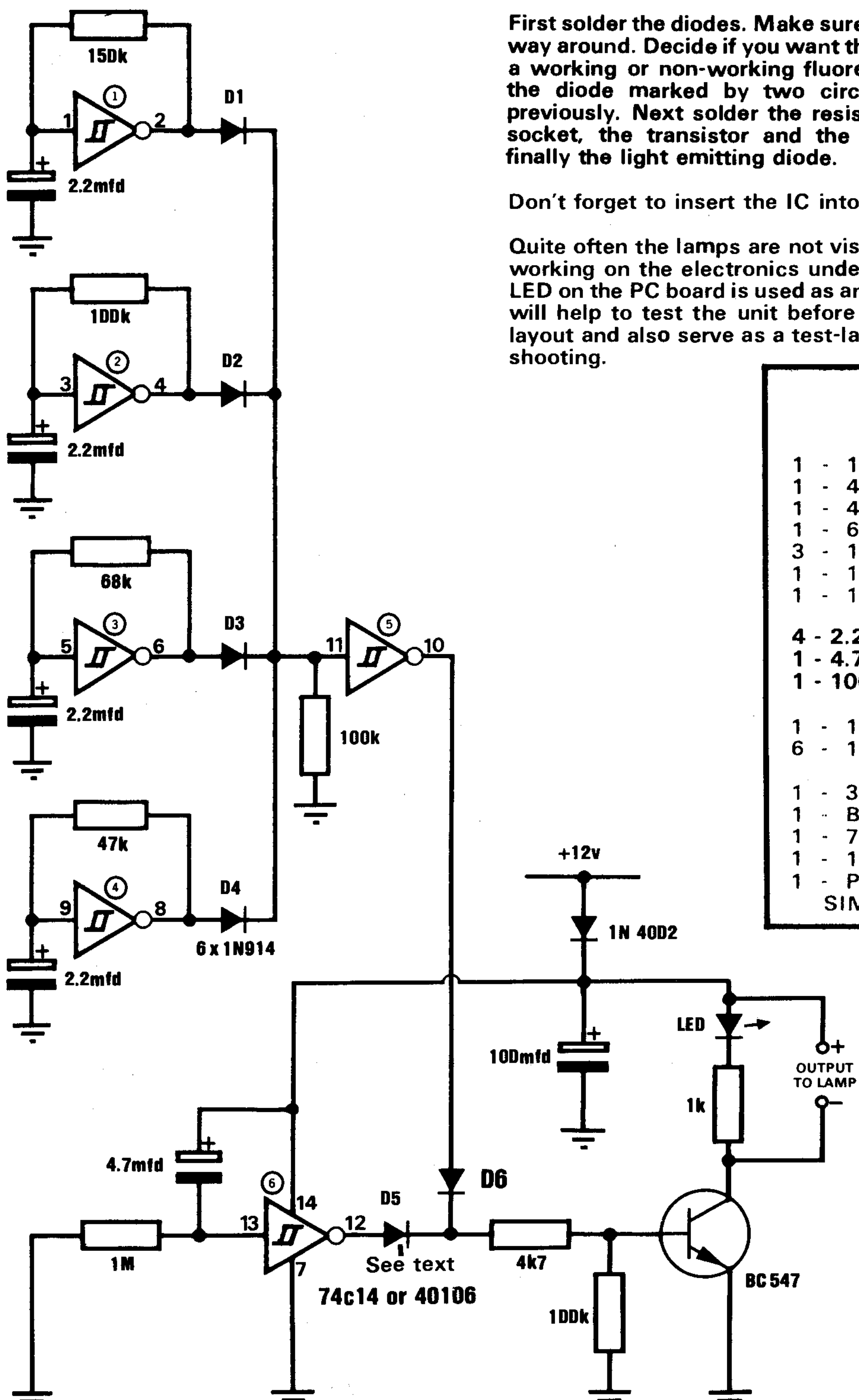
CONSTRUCTION

The fluorescent Simulator is built on a PC board 5cm x 5.5cm. This can be made smaller but our size makes construction easy.

First solder the diodes. Make sure they are the right way around. Decide if you want the unit to simulate a working or non-working fluorescent. Leave out the diode marked by two circles as explained previously. Next solder the resistors, then the IC socket, the transistor and the electrolytics and finally the light emitting diode.

Don't forget to insert the IC into the socket.

Quite often the lamps are not visible when you are working on the electronics under the layout. The LED on the PC board is used as an indicator lamp. It will help to test the unit before wiring it into the layout and also serve as a test-lamp when trouble-shooting.



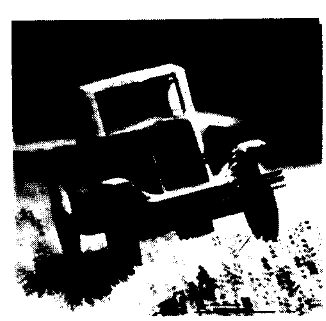
Parts List

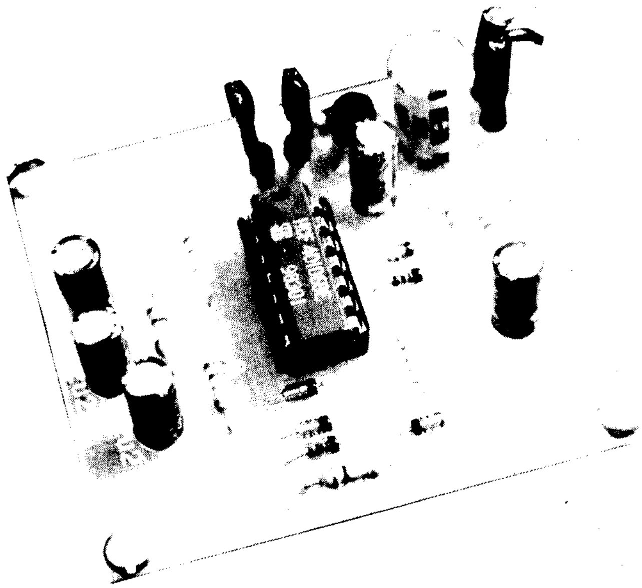
1 - 1k
1 - 4k7
1 - 47k
1 - 68k
3 - 100k
1 - 150k
1 - 1M

4 - 2.2mfd electro's
1 - 4.7 mfd electro
1 - 100 mfd electro

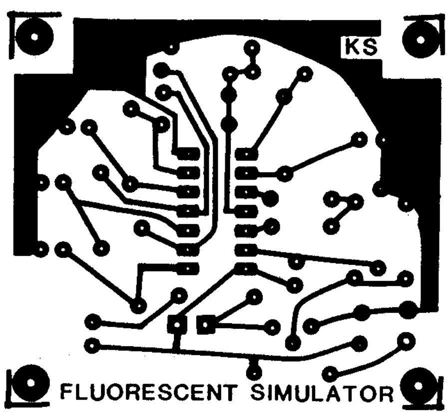
1 - 1N4002 diode
6 - 1N914 diode

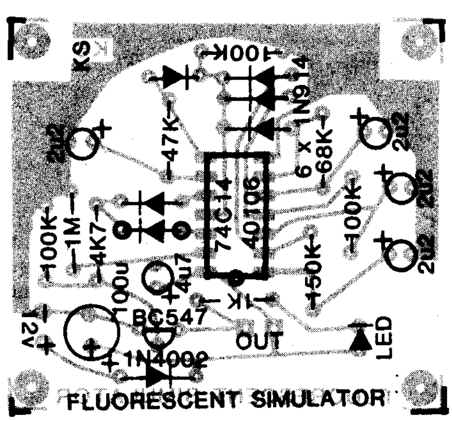
1 - 3mm LED
1 - BC 547 transistor
1 - 74c14 or CD 40106 IC
1 - 14 pin IC socket
1 - PC board "FLUORESCENT SIMULATOR"





Quick connect terminals make it easier to work on the unit after it has been wired into the layout.





By leaving out the diode marked with the two circles, the unit can be made to simulate a faulty fluorecsent lamp.

MODIFICATIONS

The delay-length before turn-on can be lengthened or shortened very easily.

To shorten the delay, decrease the value of either the 1M or the 4.7mfd electrolytic.

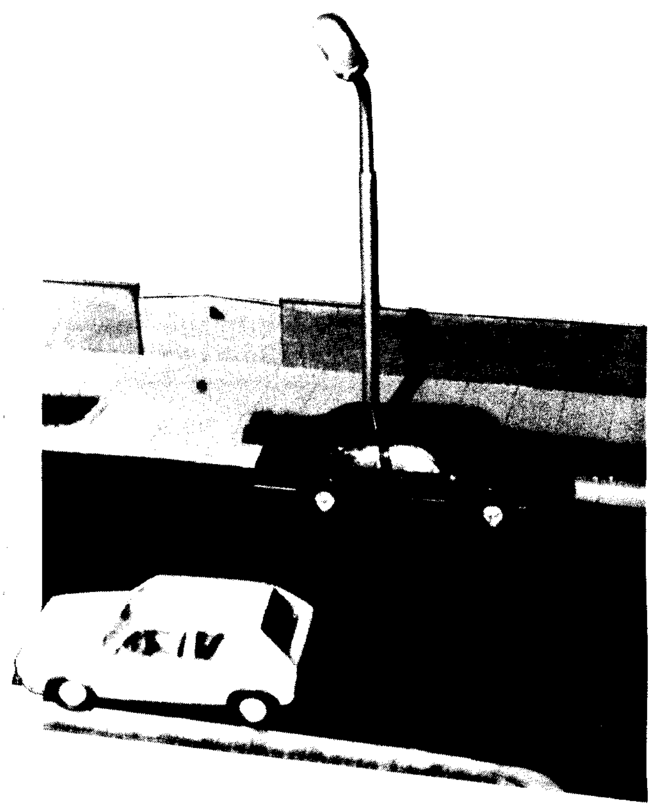
To increase the delay, increase the value of one of the above.

By replacing the BC 547 with a BD 139, several lamps can be run off the same unit, however I advise that the lamps be placed as far as possible from each other as the effect would be ruined by having several lamps flashing near each other in unison.

I have heard people ask if the scale 'fluorescent' lamps are real. Unfortunately, they are not. They are incandescent globes shaped to look like a fluorescent tube. When lit, the light source is a bright spot near the centre of the globe, not an even all-over glow like real fluorescent tubes.

This circuit will add untold realism and pleasure to your layout.

Visitors seeing your lights start-up will invariably ask to see it again!



AIR HORN

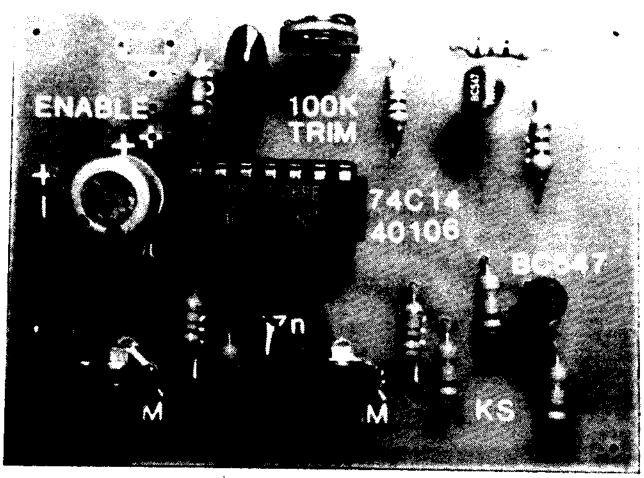
Add a little extra life to the shunting yard with this dual or triple Air Horn.

One effect rarely included in a model railway is SOUND. Many modellers keep electronics to a minimum so, due to the complexity of the circuits needed to produce sound effects, they are quite often out of the question.

Undoubtedly there are many ways of producing sound effects, ranging from playing recordings of real trains, to complicated circuits which are synchronised to the motion of the trains on the layout.

There are some sound effect chips on the market, but they are not readily available and will not be considered in this book.

The circuit presented here simulates a dual or triple AIR-HORN as used on diesel and electric locomotives. It is based on the versatile CMOS Schmitt Inverter, the 74c14 or CD 40106.



The push button is connected between the holes marked 'ENABLE' and '−'.

HOW IT WORKS

Only 4 of the six Schmitt Inverters are used in this project, three as oscillators, and the fourth in the gating or control circuit.

Each oscillator consists of a Schmitt Inverter, a 47n capacitor, a 1k resistor and a 100k mini trim pot. It functions as described in the article on the WARNING LAMP FLASHING UNIT. The only notable differences are that the oscillators in the AIR-HORN project operate at audio frequency and can be adjusted via the trim pot.

The output of each oscillator is mixed, via a 10k resistor, into the base of a BC 547 transistor which is part of the gating circuit that enables or disables the sound output.

The collector of this transistor is connected to the output of the fourth Schmitt inverter, which is normally LOW, held there by a 100k pull-up resistor on its input.

The emitter of the transistor is held LOW by a 10k pull-down resistor and from the junction of these two components the signal is taken to the output transistor via a 4k7 separating resistor.

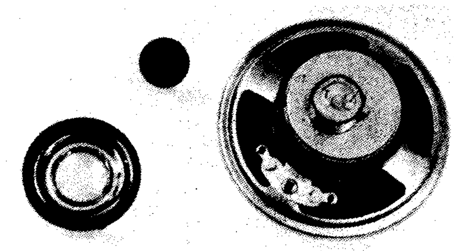
When the push button at the enable input is closed, the output of the Schmitt Inverter will go HIGH, taking the collector of the transistor HIGH. The transistor will now function as an emitter-follower. Any signal at its base will appear at its emitter. The signal will be amplified by the second transistor to produce the sound.

When the switch is released, the output of the inverter falls LOW, taking the collector of the transistor LOW.

With the collector LOW, the emitter follower is disabled and no signal can pass to the amplifying transistor and the horn is silent.
Why such a complex method of switching?

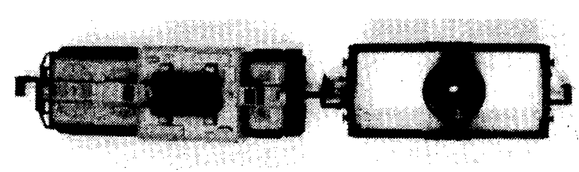
Wouldn't it be easier to have the push switch wired directly between the oscillators and the amplifier? Or wired so that it switches power to the whole unit?

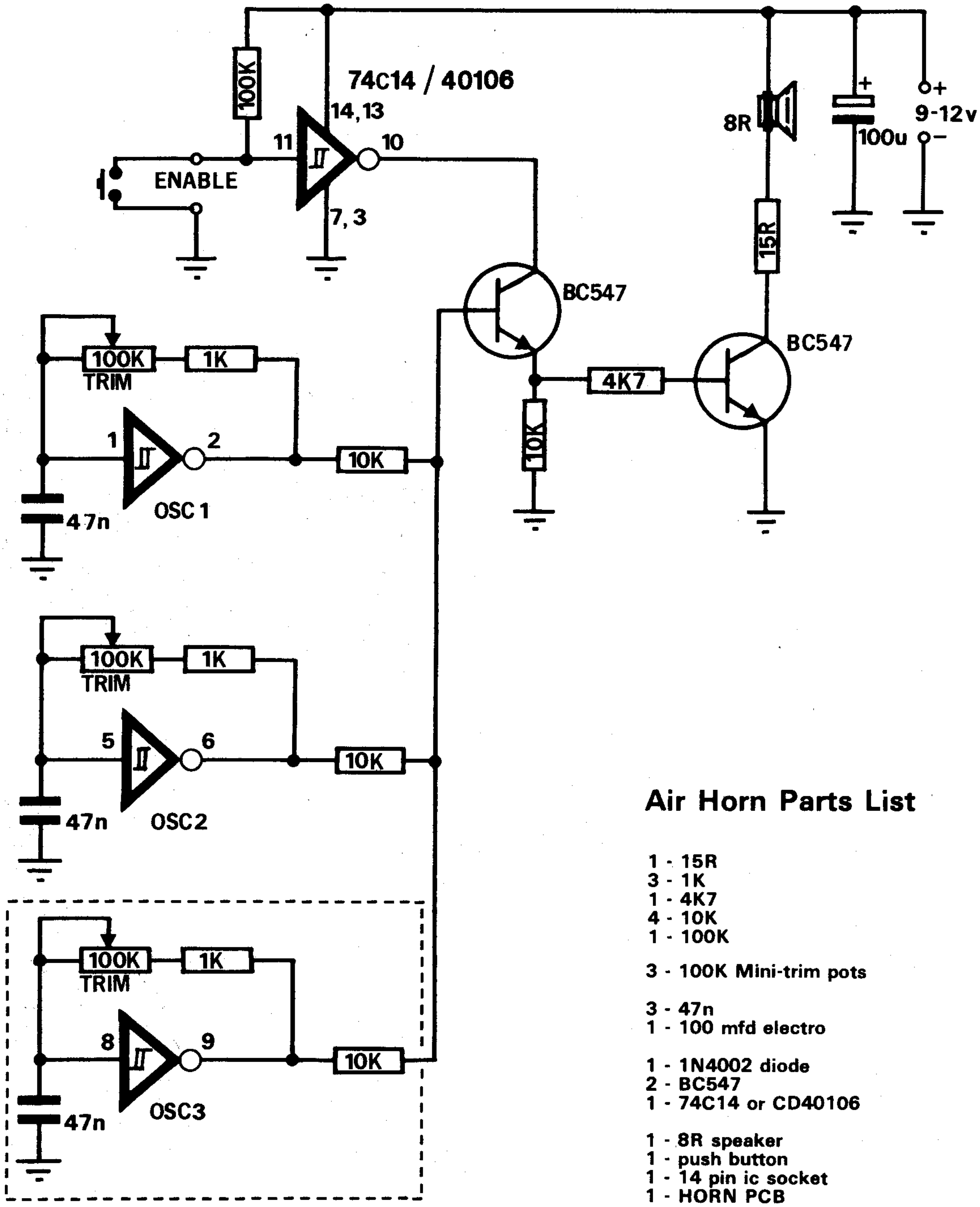
This method of switching was chosen because it can be controlled by a digital circuit. An active LOW signal at the enable will sound the horn, which opens great possibilities for automatic control of the horn.



For those who wish to experiment with sound through rails systems, there are several small speakers available. The picture above shows two 12mm Mini - speakers and a 27mm speaker with a standard 58mm or 2¼" speaker.

The photograph below shows the 12mm speaker inside an 'N' gauge wagon.





Air Horn Parts List

1 - 15R
3 - 1K
1 - 4K7
4 - 10K
1 - 100K

3 - 100K Mini-trim pots

3 - 47n
1 - 100 mfd electro

1 - 1N4002 diode
2 - BC547
1 - 74C14 or CD40106

1 - 8R speaker
1 - push button
1 - 14 pin ic socket
1 - HORN PCB

The various sections of the air horn circuit can easilly be seen from this diagram. Oscillator 3, which is drawn inside the dotted box, is omitted for the dual version of the air horn.

CONSTRUCTION AND SETTING UP

Firstly decide whether you want a dual or triple horn. If you want a dual horn, omit all parts shown in the dotted box on the circuit diagram and solder a link onto the PC board in place of the 47n capacitor.

Before commencing construction, check that the trim pots fit into the holes on the board. If not, open them up with a slightly larger drill.

Install all resistors except the 10K resistor connected to oscillator 3 (pin 9 of the IC). Next fit the IC socket, followed by the trim pots, capacitors and transistors. Finally insert the IC.

Power is connected to the board via the terminals near the edge. Be careful not to swap these wires or the electrolytic will explode! The chip may also be damaged. If you like, a 1N 4002 diode could be placed in line with the positive lead to protect the circuit. Wire an 8 ohm speaker to the circuit and the project is ready for testing.

The push button will be connected between the holes marked 'ENABLE' and '-', but for the moment, connect a length of hook-up flex between these holes.

Switch on the power. You should hear two oscillators 'beating' against each other. Turn the trim pot on oscillator ONE to the lower end of its travel. Turn the trim pot on oscillator TWO so that the two oscillators are running at the same pitch. Slowly advance oscillator TWO until all beating stops again. For those who are musically minded, tune it to a 'fifth'.

Solder the remaining 10k resistor into the circuit.

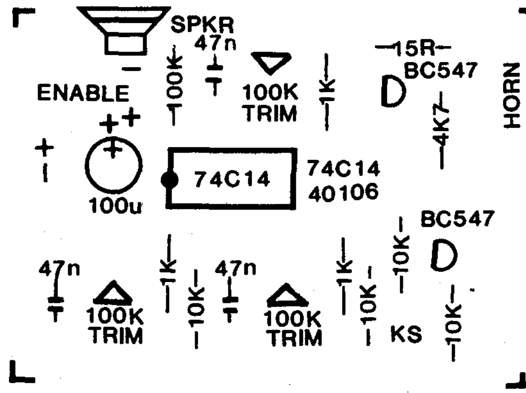
When you power the unit this time, you should be able to hear the third oscillator. Adjust it to the same frequency as oscillator TWO. Then slowly advance it until the beating stops again. In other words, tune it to a 'seventh'. Cut the length of hook-up wire and solder in the push button.

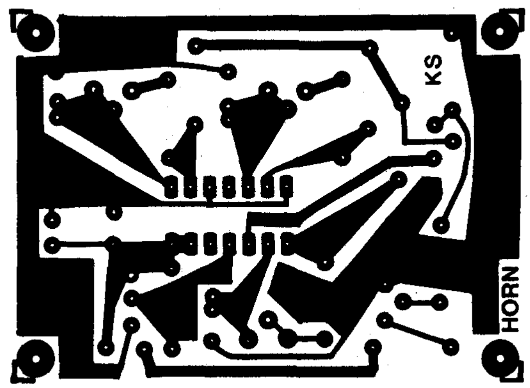
The unit is now complete.

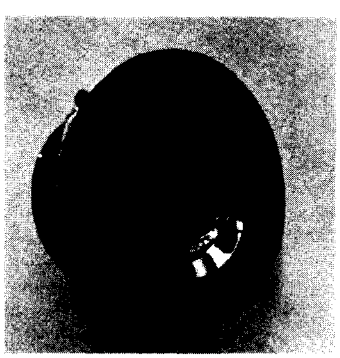
GOING FURTHER

Several speakers could be mounted at locations around the layout. These could be stations, level crossings and tunnels. Each of the speakers could then be selected via a rotary switch or by spare contacts on relays that are being operated by track detection circuits. The AIR-HORN could also be triggered by detectors placed around the layout.

Experiment with it. The possibilities are endless.



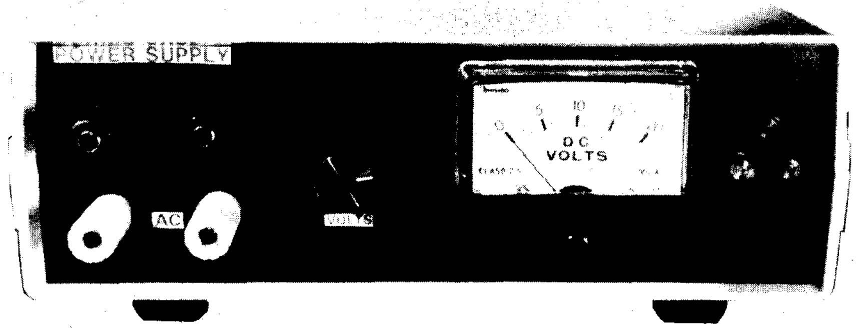




ABOVE: This 100 mfd cepecitor which wes across the power rails of one circuit, exploded when accidently connected in reverse to 12 volts. It covered the desk in electrolyte and the flying cep left e smell dint in the ceiling. It exploded within 5 seconds of being connected to the power.

LEFT: Pictured here, larger then life, is the 27mm speaker. It has e clear plestic cone. These speakers are not readily eveileble and are often over priced.

POWER SUPPLY



OUR 5 - 15v 2 AMP PROTOTYPE.

Now that you have constructed several of the projects in this book, you will find it necessary to build a power supply.

Train controllers often have an output labelled "Uncontrolled DC". This means the output is not controlled by a rheostat. It is un-smoothed and is quite useless for powering electronic circuits.

The power supply described in this project is ideal for powering the circuits in this book. It has a very low output ripple and maintains a constant voltage over a wide range of current.

It is capable of delivering up to two amps depending on the type of transformer you use. It is variable between 5 and 15 volts and uses readily available components.

The overload protection device is a simple fuse. This has been chosen as it is the only really successful way of protecting a supply. Automatic trips usually operate too fast and give a false indication of a malfunction.

The project can be used as a bench supply as shown in the photograph, or mounted along with other circuitry on your layout.

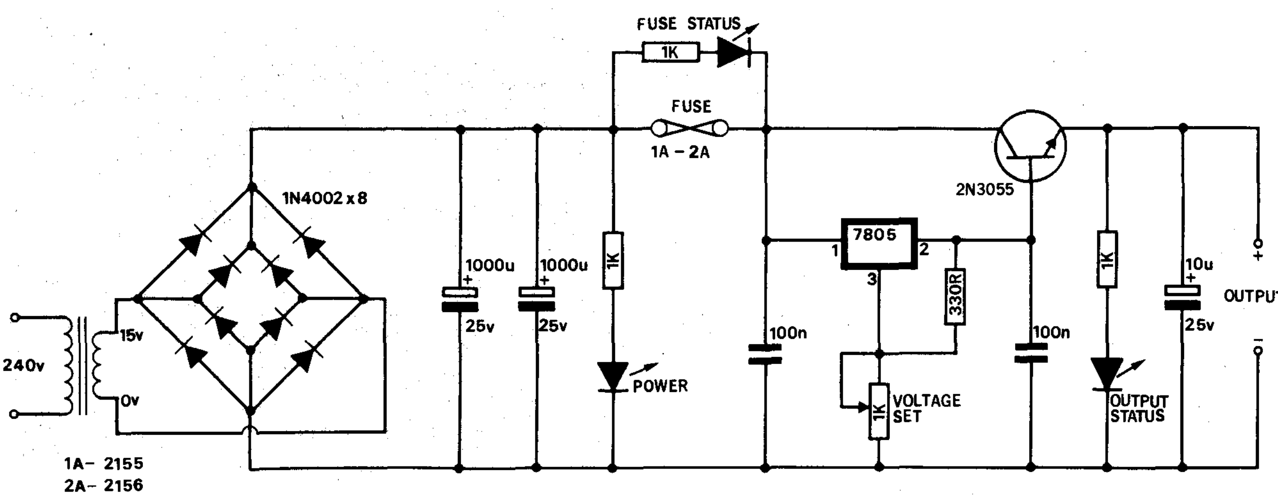
It would be advantageous to power all 'grain of wheat' lamps from an adjustable supply to give them a brightness comparable with those on a street. Invariably they are too bright when supplied with 12 to 15v. Dimming them adds to the realism of the layout as well as allowing them to last a lot longer.

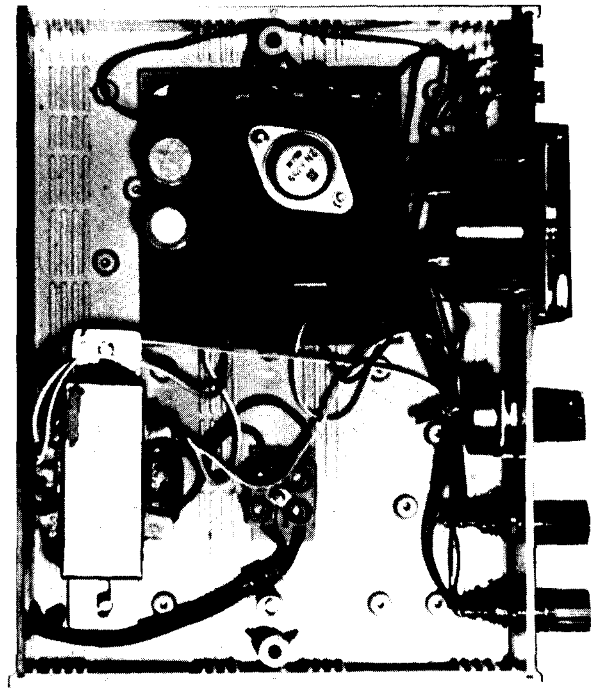
HOW THE POWER SUPPLY WORKS

The AC is rectified by a full-wave rectifier consisting of 8-1N4002 diodes. These are 1 amp diodes and have been paralleled to form a 2-amp bridge. These could be replaced by a set of diodes with a higher current rating if desired.

The rectified AC is then smoothed by the electrolytic. Provision has been made on the board for mounting two 1,000mfd electrolytics or one 2,200mfd electrolytic.

The smoothed DC then passes through a fuse to the regulation circuit. This consists of a 7805 voltage regulator which is a positive 5 volt type. These regulators can have their output voltage increased by a simple voltage divider network which 'jacks up' the common line and consequently increases the output voltage.
A 2N3055 transistor is wired as an emitter follower to supply the current to the output.





There are three LEDs in the circuit. The first is connected across the unregulated DC voltage. This indicates the power is ON. The second LED is connected across the fuse. It will light when the fuse blows. This is a handy indication to show that the supply has been overloaded. Before replacing the fuse, you should look for the cause of the overload and prevent if from occurring again.

The third LED is across the output and functions as a very simple voltage indicator. Its brightness will give an indication of the output voltage and you will need to have some comparison with another LED to determine the voltage value. This can be done with the power LED.

A 0-20v meter can be connected across the output to give a more accurate indication. This will be worthwhile in a bench-top model but for a model with a pre-set output voltage, it will be wasted.

If your system uses several pre-set supplies, one meter could be connected to a rotary switch and the switch turned to monitor each of the supplies. This will keep costs to a minimum while providing accurate monitoring.

The upper voltage limit of the power supply will be set by the output voltage of the transformer and should not be above 15v for any of our circuits.

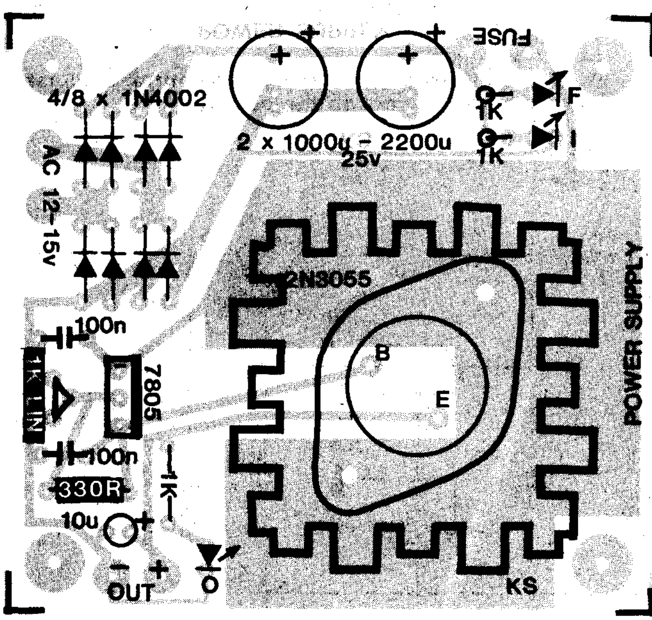
The regulator does not have to be heat-sinked because it is only supplying the base current for the emitter-follower transistor. All the output current flows through the emitter follower transistor and it will need to be heat-sinked adequately via a fin. Space is provided on the PC board for mounting a small TO-3 minifin heatsink and this will be suitable for currents up to 1 amp. If you intend to draw currents above 1 amp, it will be necessary to mount the 2N 3055 on an larger heatsink which is external to the board.

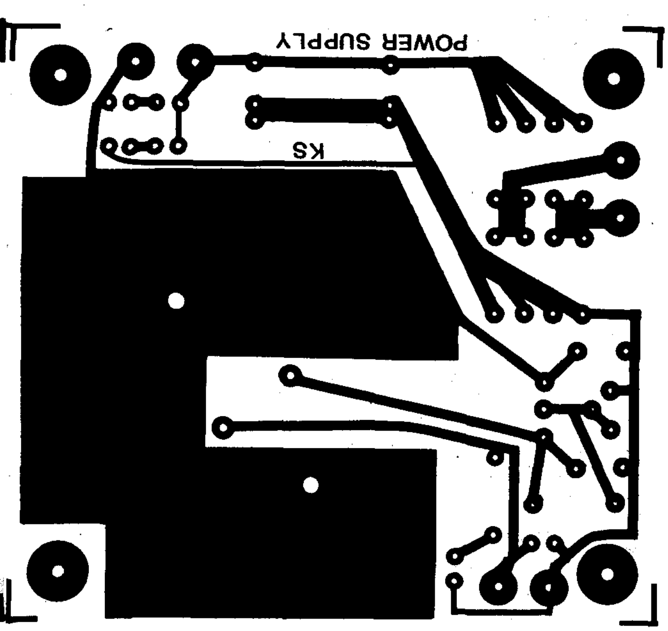
CONSTRUCTION

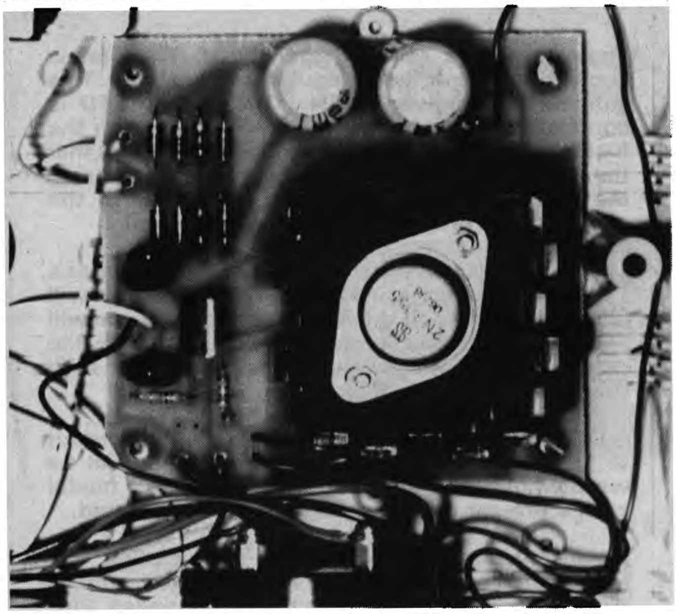
Firstly mount all resistors and diodes on the PC board. If you are making a pre-set unit, the LEDs and trim pots should also be mounted at this stage.

Cut two pieces of insulating sleeving, each 2mm long, and slip them onto the base and emitter leads of the 2N 3055 power transistor. These pieces of sleeving are to prevent the transistor from shorting against the heat-sink.

Bolt the transistor and heatsink onto the PC board. No insulating kit is needed but care should be taken when mounting the completed unit so that the heatsink does not come into contact with anything metal because it is at full unregulated DC voltage.







Next solder the 7805 regulator. The input pin (pin 1) is marked on the PC board and it is important to connected the regulator the correct way around. It must not touch the 2N 3055 or its heatsink as these are at different voltage potentials.

Next solder in the two 100n greencaps and the electrolytics.

The final mounting of the PC board and front panel controls is up to you. Our prototype was mounted in a plastic instrument case. It is important to choose a case which has vents, to allow proper cooling of the power transistor.

The fuse is mounted in a panel-mount fuse holder and the fuse should be a 1 amp or 2 amp type.

Power Supply Parts List

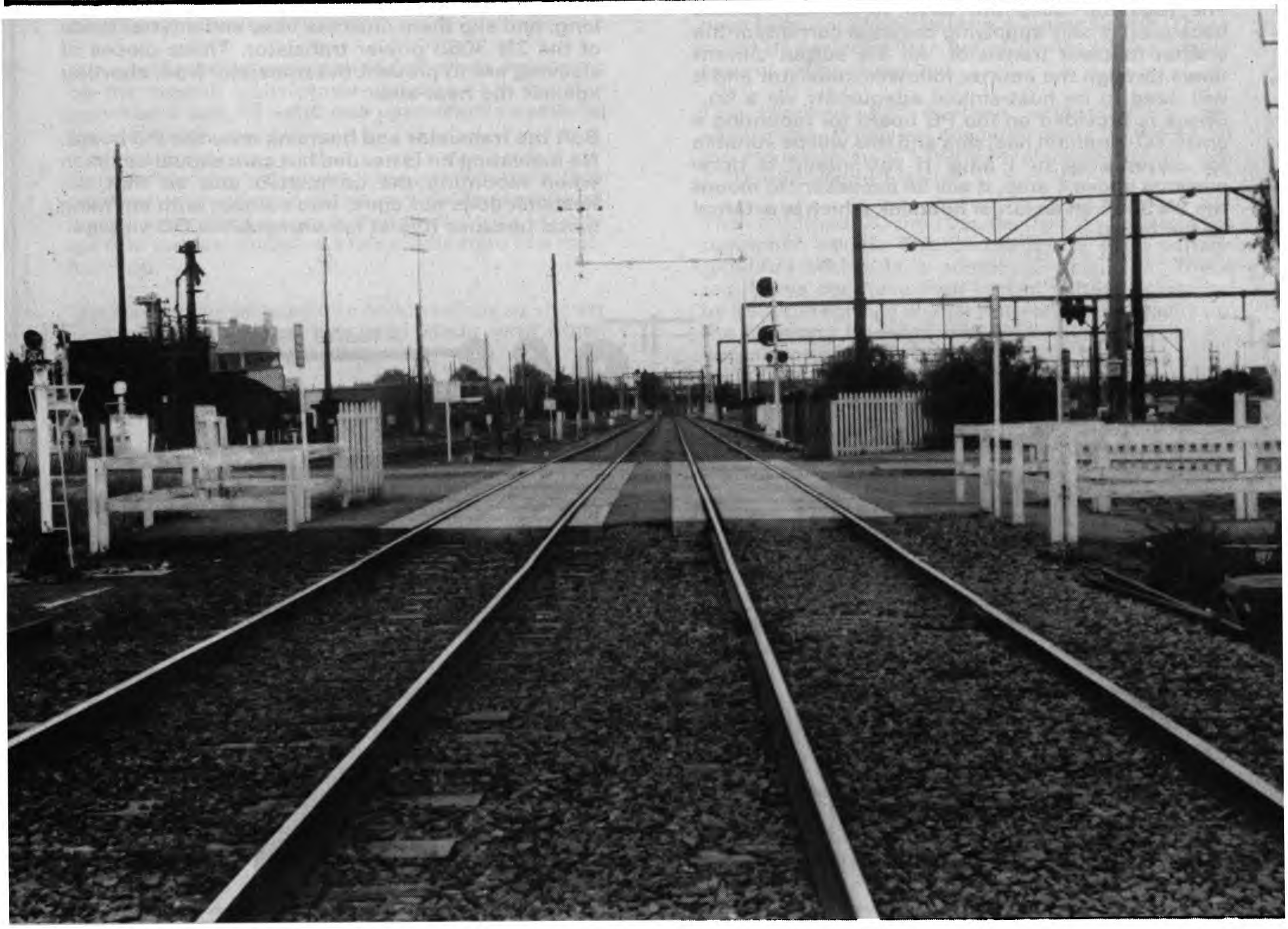
1 - 330R
3 - 1K
1 - 1K Mini-trim pot

2 - 100n greencap
1 - 10 mfd 25v pc electro
2 - 1000 mfd 25v pc electro

8 - 1N4002
3 - 5mm LEDs
1 - 7805 regulator
1 - 2N3055

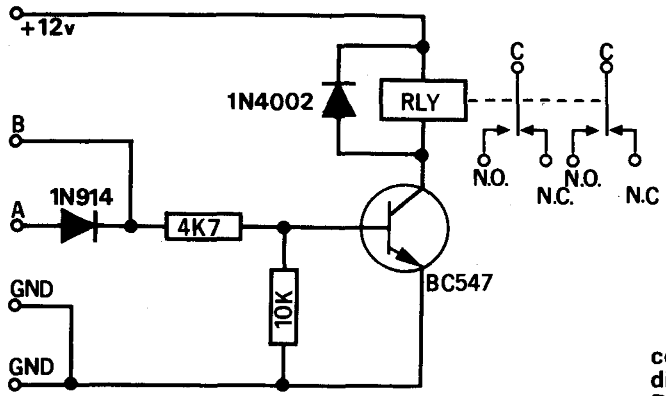
2 - Nuts & bolts
1 - TO3 Heatsink
1 - Power Supply PCB

Extras
Fuse & fuse holder
transformer. 15v@2A
1K lin pot

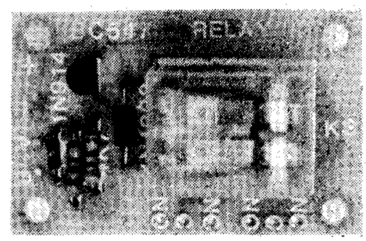


REMOTE RELAY UNIT

A buffered relay driver that can be used in many places around a model railway.



The Remote Relay Unit is little more than a buffer transistor driving a relay.



This actual - size photograph shows how compact the Remote Relay Unit is.

Although this circuit is very simple it can have many uses around the layout. It can be considered to be a very sensitive relay; one that can be driven by the low current supplied at the output of CMOS logic or from any other low current or low voltage source.

A voltage placed at input 'B' will switch on the transistor that drives the relay. The 4K7 resistor is to limit the base current to the transistor. The 10K resistor makes sure the transistor switches off when there is no signal at the input or when input 'A' is being used.

Construction could not be simpler. Mount the six components on the PC board. The relay should be the last component to be installed. Take care not to bend any of the pins on the relay, as they may break off or cause internal damage.

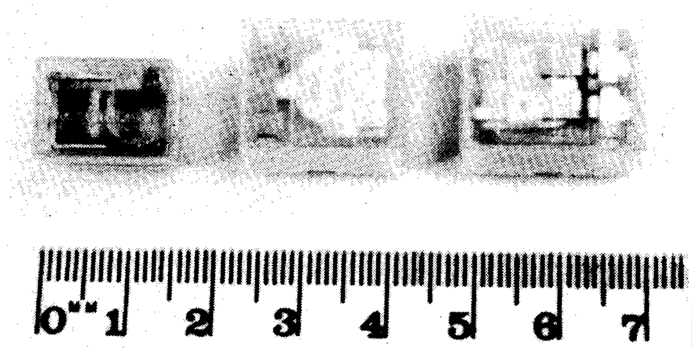
Uses of the Remote Relay Unit.

If wired to a digital circuit, the Remote Relay Unit can be used to switch street lamps or motor driven accessories. It can also be used to deaden blocks of track in an automatic signalling system.

If one ground (GND) terminal is connected to the common rail on your trackwork and input 'A' is connected to the other rail, the unit can be used as a direction indicator. In this application the Remote Relay Unit must be powered from an isolated supply, in most cases, to prevent short circuits.

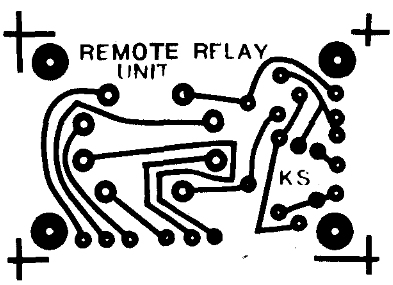
In the direction indication mode, the Remote Relay Unit can be used to switch bidirectional signalling systems from one direction to the other.

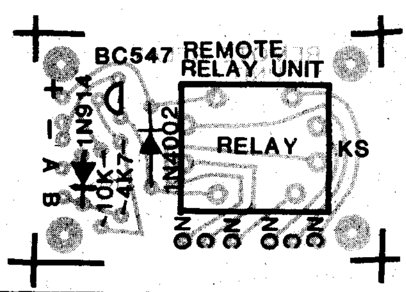
These are only some of the applications of this versatile device.



Various small relays are available for 12 volt operation. The relay chosen for this project is a Double Pole Double Throw (DPDT) device and is the third relay in this picture.

All components of the Remote Relay Unit fit neatly onto the 3cm by 4.5cm printed circuit board.



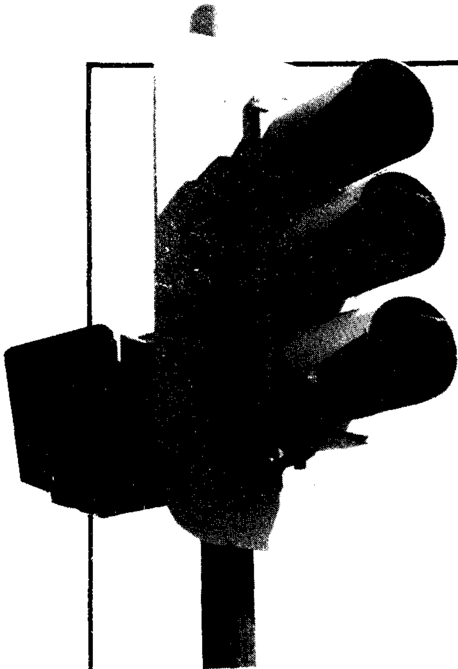


Remote Relay Unit Parts List

1 - 4K7
1 - 10K

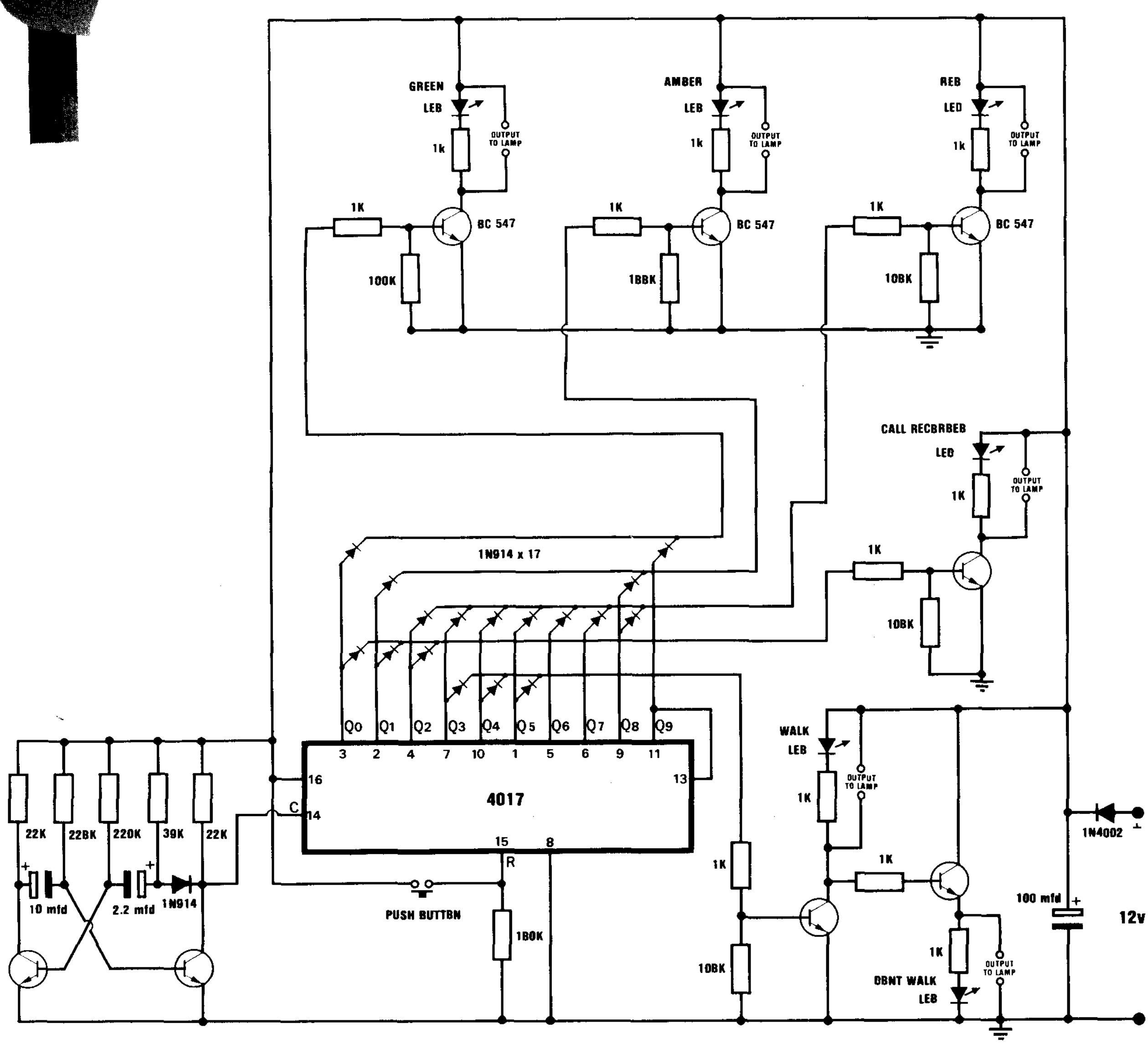
1 - 1N914 diode
1 - 1N4002 diode
1 - BC547 transistor

1 - 12v Mini DPDT relay
1 - Remote Relay Unit PCB



PEDESTRIAN CROSSING

A clever device that will amuse any person visiting your model railway.



The circuit of the pedestrian crossing is made of several distinct blocks, all of them easily seen on this diagram.

This circuit has been designed to fascinate spectators at exhibitions, but it can be used just as successfully to impress those viewing your layout.

It is an OPERATING PEDESTRIAN CROSSING complete with WALK and DON'T WALK signs. The unit is normally displaying a green light to the traffic and a DON'T WALK to the pedestrians, but when a person presses the button (mounted at the edge of the layout), the CALL RECORDED or WAIT lamp illuminates.

Then after a few seconds, the traffic lights change to yellow, then red. And the WALK sign comes on. After the scale pedestrians have been given time to cross, the DON'T WALK sign illuminates. This lets the slow walkers or those who insist on walking against the DON'T WALK sign, to cross! The traffic lights then change to green.

This unit controls only the lights on the model crossing but I am sure someone will create scale pedestrians to cross the road when the WALK sign comes on.

HOW IT WORKS

The Pedestrian Crossing circuit can be separated into a number of sections for easy explanation.

The first section is the MASTER OSCILLATOR, from which all timing is taken. It is a 2 - transistor astable multivibrator operating at a low frequency. The second section is the 4017 and the push button.

The reset pin of the 4017 is held LOW via a 100k pull-down resistor. The signal from the oscillator is fed to the CLOCK input of the 4017, and the chip will count until it reaches Q9, and then halt. It halts because the CLOCK INHIBIT is tied to this output (Q9). When Q9 goes HIGH, the clock signal is internally prevented from reaching the counter in the 4017. This means the chip will freeze every time it comes to Q9.

The only way to start the chip counting is to RESET it. This is what the push button does. The chip will then count up to Q9 and halt again.

The third section of the circuit is the DIODE MATRIX consisting of 17 1N 4148 diodes. The outputs of the 4017 are gated through these diodes to produce the light sequence i.e. the TRAFFIC LIGHT sequence and the WALK/DON'T WALK signs.

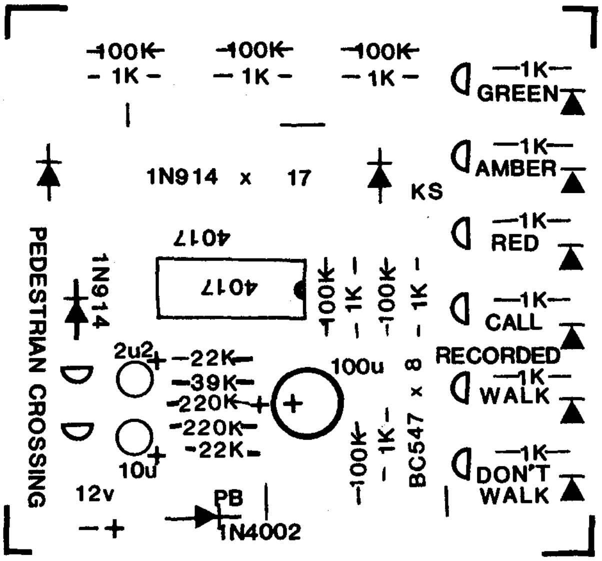
The outputs of the matrix are all buffered and they are capable of driving one or two miniature 12v lamps. The outputs to the traffic lights and the CALL RECORDED light are all driven via these one-transistor buffers.

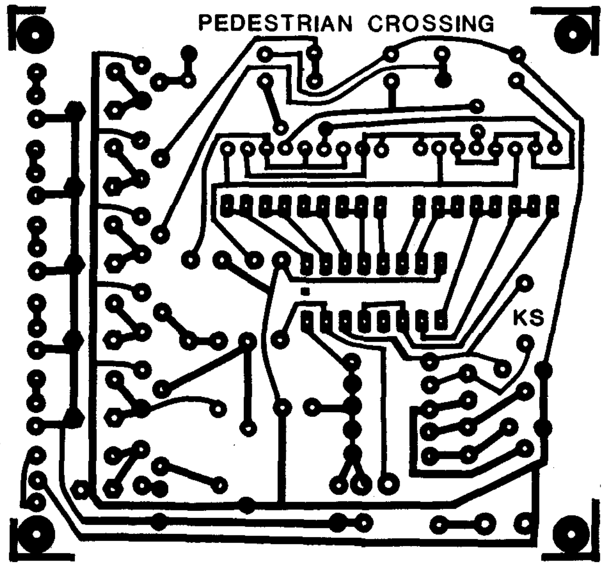
But the buffer for the WALK/DON'T WALK sign is a little different.

You will notice that there are only five lines out of the diode matrix. The line for DON'T WALK is missing. As the DON'T WALK sign will be ON every time the WALK sign is OFF, and vise versa, it is simpler to invert the signal of one, to produce the other. As the number of diodes required to produce the WALK signal is only three, rather than the seven for the DON'T WALK, it was decided to invert the WALK signal to produce the DON'T WALK signal.

The buffer for the WALK signal is similar to the buffer for the other signals, except for the line taken from its collector. This line is connected to an emitter-follower transistor which drives the DON'T WALK sign.

The positive voltage needed to turn on the emitter-follower is supplied through the lamp connected to the output of the WALK buffer. Or if a lamp is not present, through the LED and resistor.





CONSTRUCTION

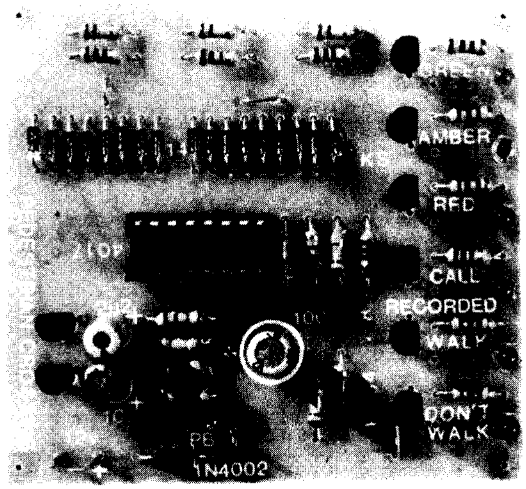
The Pedestrian Crossing unit is constructed on a 7 cm x 7.5 cm printed circuit board.

Firstly solder the 17 1N 4148 (1N 914) diodes. These are all in a row above the 4017. Only the two outside diodes are marked on the PC overlay but all 17 are soldered onto the board the same way around. That is, with their cathode facing away from the 4017.

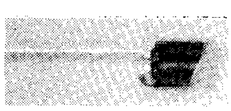
Next solder the links, resistors and the 1N 4002 power diode, followed by the IC socket. You will notice that the socket has a notch at one end. This should be lined up with the dot marked on the overlay. This notch is used as a reference when inserting the IC, so to make it easier when trouble-shooting later, the socket must be positioned correctly.

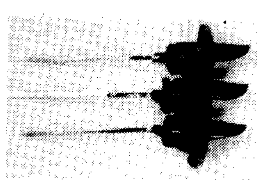
Next insert the LEDs, transistors, electrolytics and the 4017 integrated circuit. Be careful with the orientation of the 4017, as it is upside down with respect to the rest of the components. Finally connect the push button via short lengths of hook-up flex.

Connect the unit to a power supply of 9v to 12v and watch the LEDs come on. Push the button to initiate the sequence. Do not hold the button ON because it takes the RESET line HIGH, preventing the 4017 from counting. Watch the unit cycle through the sequence to check its operation.



The circuit board of the pedestrian crossing: the cycle can easily be followed by watching the on-board LEDs. Note that the 4017 is upside down.





LEFT: Shown here are a partially completed WALK sign and a signal head. Both use LEDs instead of grain of wheat bulbs.

THE MODEL

The model of the Pedestrian Crossing can be built around a commercial 3 - aspect signal. The lamps will need to be removed and replaced in the propper order with red at the top. If you wish to have more than two signal-heads on the crossing, replace the lamps with LEDs. Make sure each LED is in series with a 470R to 1K resistor to prevent it burning out.

The WALK/DON'T WALK signs can be constructed from rectangular LEDs or from dual LEDs. See the article later in this book called: Three Coloured LEDs.

If your layout is of a recent period, the WALK and DON'T WALK signs can be the newer design, displaying a man walking (in green) or not walking (in red).

The CALL RECORDED lamp is mounted near the push button, at the edge of the layout. Some constructors may even model the button to look like the real thing! It would also be possible to shape a 3mm LED to resemble the CALL RECORDED sign on the post itself.

Don't place a model car at the lights as it is sure to bring some smart comment about it never moving when the light is green . . . however, if it had its bonnet open . . .

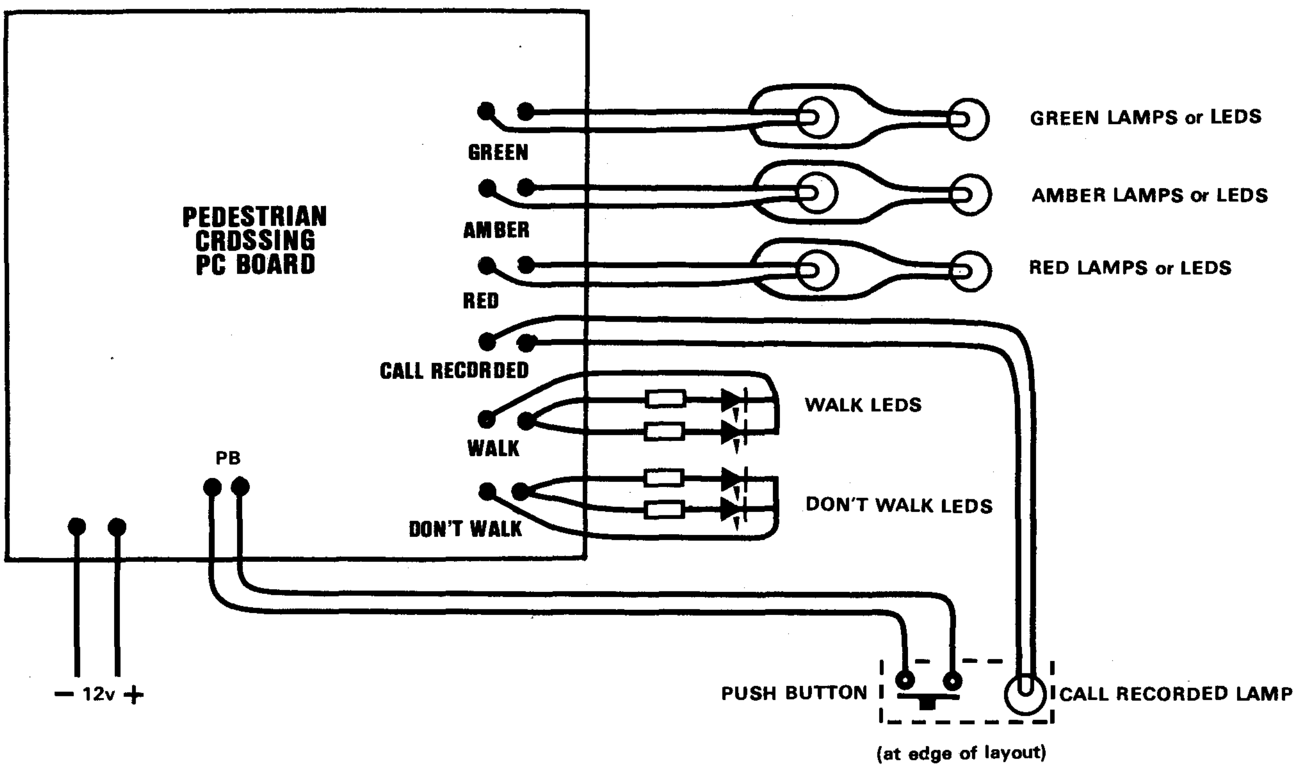
Pedestrian Crossing Parts List

12 - 1K
2 - 22K
1 - 39K
6 - 100K
2 - 220K

1 - 2.2 mfd
1 - 10 mfd
1 - 100 mfd

2 - 3mm Red LEDs
2 - 3mm Green LEDs
2 - 3mm Yellow LEDs
1 - 1N4002 diode
18 - 1N914 diodes
8 - BC547 transistors
1 - CD4017 IC

1 - 16 pin IC socket
1 - Push button
1 - Pedestrian crossing PCB



This diagram shows how to wire both lamps or LEDs to the pedestrian crossing PC board though LEDs are recomended if more than two signal heads are to be used. Each LED must be in series with a 470R to 1K resistor.

LIGHT CHASERS AND SHOP DISPLAYS

The potential of flashing lights was seen by shop owners, and soon flashing lights were being employed as 'attention grabbers' in many shops and advertising signs.

Early signs used different coloured neon tubes twisted into the shape of letters or pictures.

Later, fluorescent tubes were used to back - light signs of coloured perspex. These signs did not flash, due to the nature of the fluorescent tube.

Then someone thought of the chaser.

By sequentially illuminating chains of bulbs, an illusion of movement could be generated. Chasers were soon being used around neon advertising signs, and shop windows.

The circuit described here is sure to attract attention from the people viewing your layout. Quite a number of variations are possible using the Shop Display PC board. These are a set of arrows, a window display and five straight lengths, which can be used individually or together.

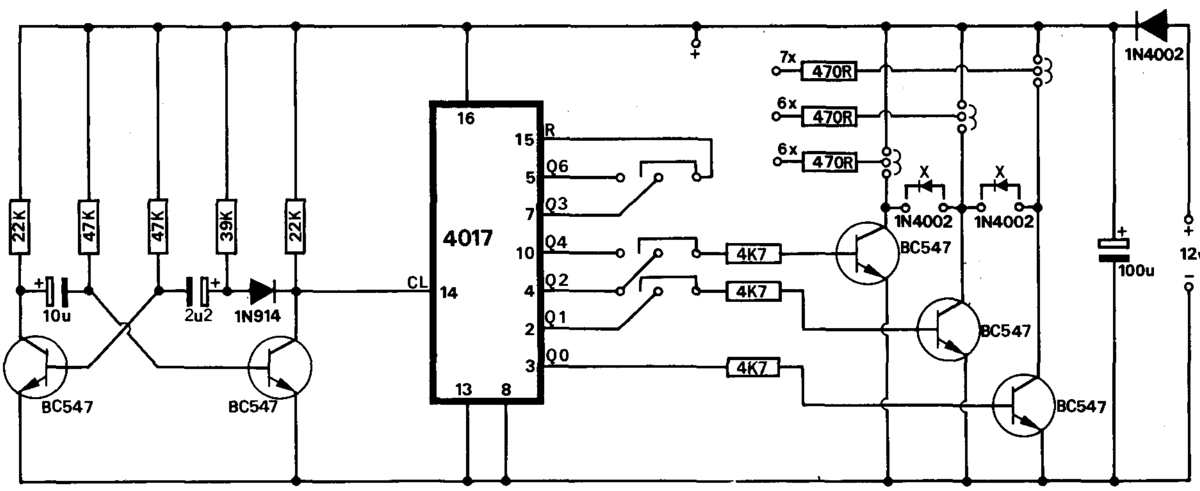
The driver circuit is made on a separate printed circuit board and is connected to the display board via a set of wires. The project was designed this way so that the main bulk of the circuitry will not need to be mounted in the model shop, but can be placed under the layout with other circuitry.

How it works

Because the shop display driver PC board is designed to be used in several different arrangements, the circuit diagram is a little confusing, so we will look at it in several parts.

The first stage is a two transistor multivibrator operating at 6HZ. The signal from this is fed into the 4017 counter decoder.

This is where the first decision has to be made. The reset line of the counter can be connected by a link to either output 'Q3' or output 'Q6'. When connected to output 'Q3' the counter will reset after every third pulse, and when connected to output 'Q6' it will reset after every sixth pulse.



The first two sections of this diagram are self explanatory; the third section has been designed to cater for several different types of display, and is covered in the text. If you wish to change the speed of the oscillator, replace the 10 mfd with an electrolytic of different value.

The first output, 'Q0' drives the first buffer transistor. The second buffer transistor can be driven by either output 'Q1' or 'Q2' and the third buffer transistor can be driven by either output 'Q2' or 'Q4'.

When making an ordinary sequencer, the reset pin is connected to 'Q3' and the buffer transistors are driven by outputs 'Q0', 'Q1' and 'Q2'. Wired like this, only one of the three driven outputs will be on at a time, but immediately one output switches off, the next will switch on.

This diagram shows what will be displayed on three LEDs, one connected to each output of the shop display PCB. Q0 to Q3 are the steps. The unit will reset instantaneously from Q3 to Q0 making the sequence 3 steps long. (Q0, Q1, Q2)

	LEDS
Q0	●○○
Q1	○●○
Q2	○○●
Q3	RESET

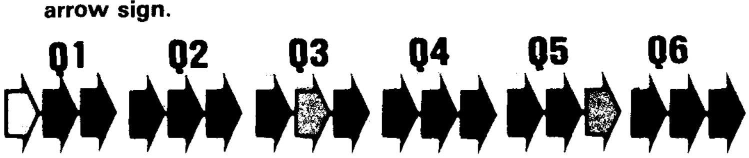
When the reset line is connected to 'Q6' and the buffer transistors are driven by outputs 'Q0', 'Q2' and 'Q4', there will be a blank step between each driven output.

If a LED is connected to each of the driven outputs, this is what you would see.

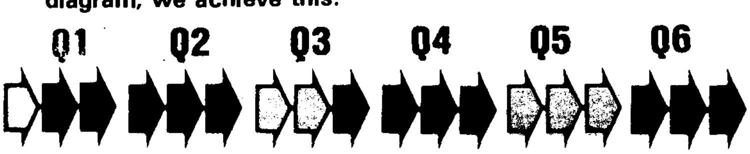
This sequence is much the same as the one above except that there are twice as many steps, every second one being blank.

	LEDS
Q0	●○○
Q1	○○○
Q2	○●○
Q3	○○○
Q4	○○●
Q5	○○○
Q6	RESET

This second type of display would be good with the arrow sign.

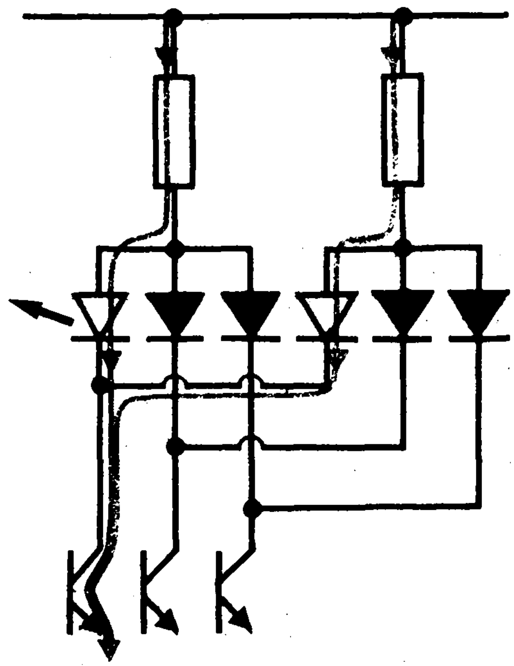


By adding the two diodes marked 'X' on the circuit diagram, we achieve this:

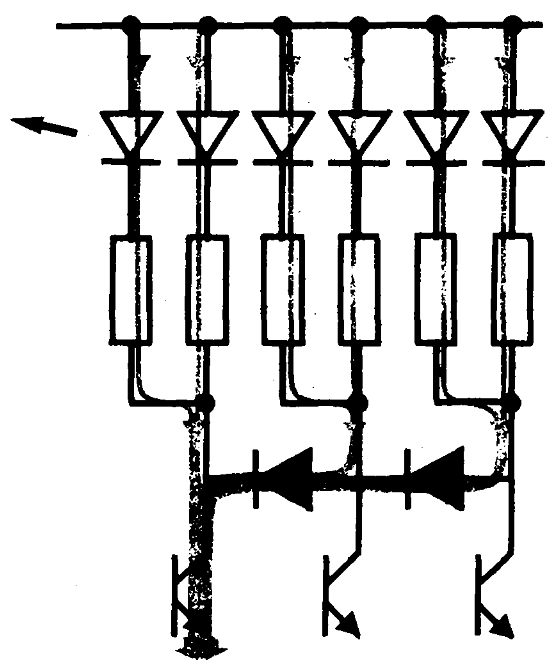


Of course it looks much better than these diagrams can possibly show.

Depending on whether you build the arrow sign or the chaser, a different arrangement is needed for the current limiting resistors.



With the chaser, only one LED in three is on at a time, so three LEDs can share each resistor as shown in the diagram above. This reduces not only the number of resistors needed, but also the number of wires between the display and the driver board.



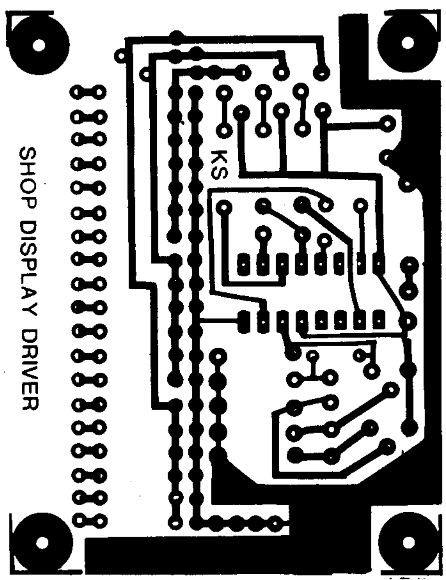
On the arrow sign, there is a cycle when all LEDs are lit, so every LED will need its own resistor.

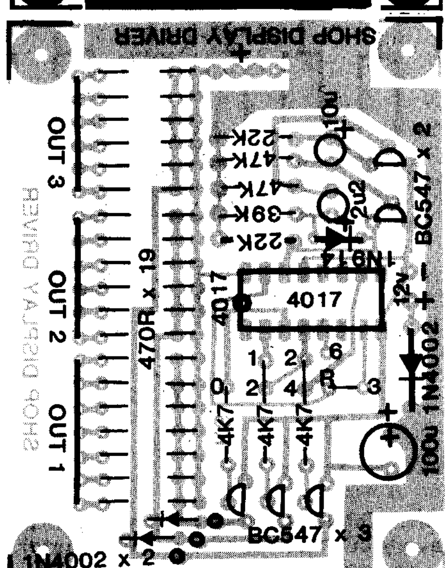
Construction

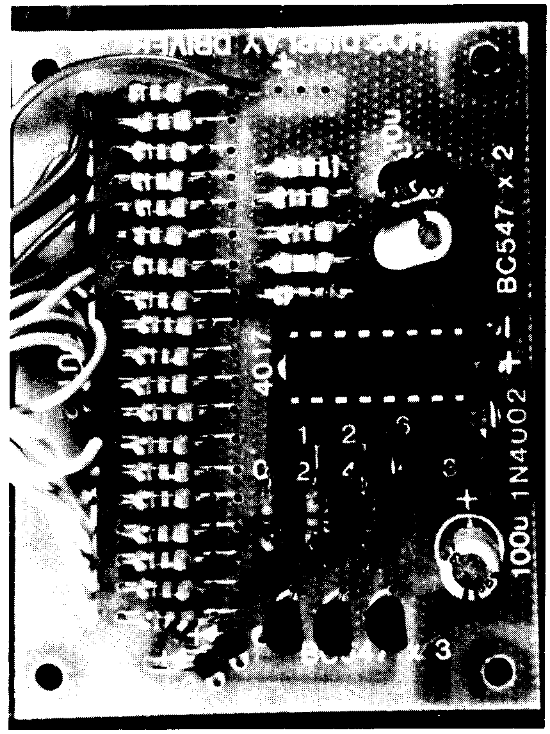
Decide which display you are making. This will determine which way you assemble the Shop Display Driver PC board. Look at the two photographs of the assembled Driver board. You will notice some resistors can be mounted in two locations. This is because the PC board is designed to cater for both the arrow sign and the chaser.

If you are making the arrow sign, solder all resistors into the closer holes, and solder a link between the holes marked 'R' and '6'. Mounting the rest of the components is straight forward. Use the diagrams and photographs for part locations. Be careful with the orientation of the 4017 chip. The two 1N4002 diodes in the lower corner are stood on end so they will fit. If you feel like experimenting, try reversing one or both of these two diodes. They are the diodes marked 'X' on the circuit diagram.

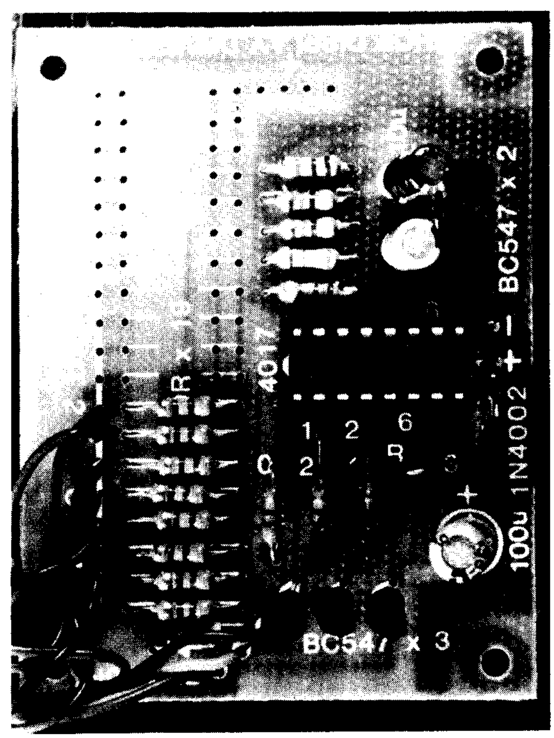
For the shop display and chaser bars, the resistors should be mounted between the outer holes. A link should be soldered between the holes marked 'R' and '3'. The two 1N4002 diodes in the lower corner are omitted.







This photograph shows component layout for the Arrow sign. Note the spacing of the resistor leads and the position of the link. The two 1N4002 diodes are in the lower left-hand corner.



This is the layout used for the shop display and chaser bars. The number of 470R resistors used is determined by the number of leds used, in this case (the shop display) 8 resistors are used for 24 LEDs. To increase the speed of the chaser, the 2.2mfd electrolytic has been replaced with a 1 mfd.

The display board

To minimise the wiring needed, the displays are constructed on a double sided PC board. This board measures 9cm x 5,5cm and can be cut into seven smaller boards as needed.

Select the display you want, and cut it from the PC board. Smooth the edges with a file. Insert the LEDs as shown in the diagram. Solder them in, making sure that they are in straight lines and all at the same height. A good way of doing this is to place the board on a piece of expanded polystyrene foam and push the wires of the LED through the PC board and into the styrene.

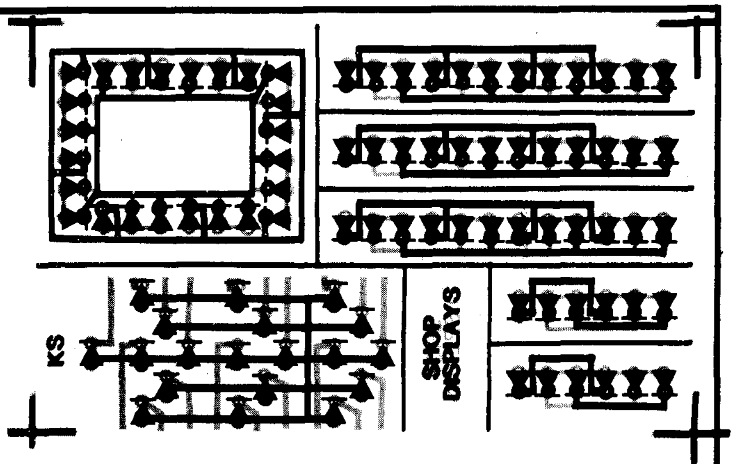
One wire of each LED can then be soldered on the top side of the PC board, to hold each LED in place. Remove the board from the styrene. Solder all the connections on the bottom of the PC board and trim the leads.

Follow the wiring diagrams and photographs to connect the Display board to the Driver board.

How the display is to be mounted can be determined by you as each model it is to be mounted in will differ. It is possible to cut the centre out of the Shop Display board to give the model more depth.

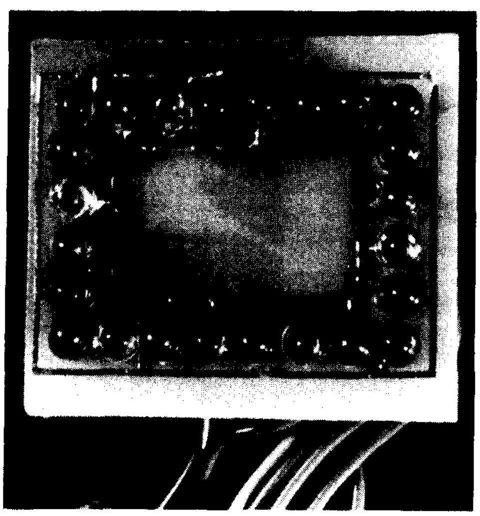
The arrow sign could be used to indicate the entrance of a multi - storey car park or could be built using orange LEDs and fixed to a trailer to represent a scale road works sign.

Experiment with this project; many variations are possible.

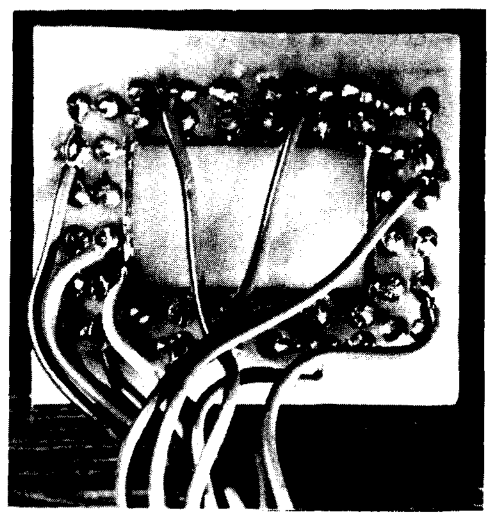


The polarity of each LED on the Shop Display PC board is shown in this diagram.

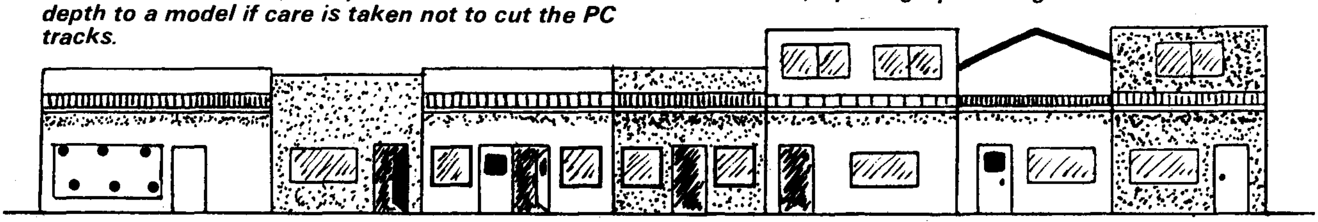
These are the two types of chaser bar provided on the Shop Display PC board. They use the same driver PC board layout as the shop display.

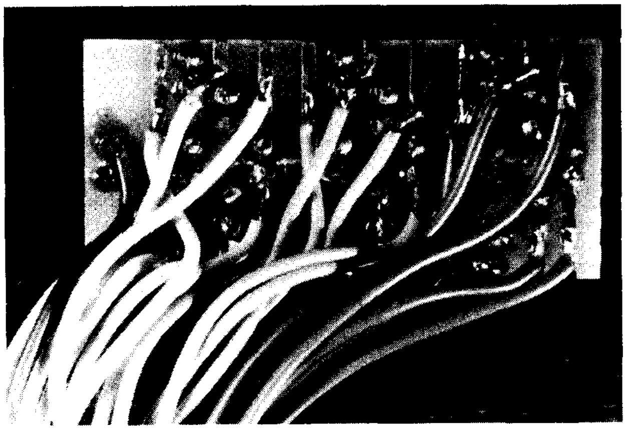


This is the shop display. Make sure all LEDs are mounted in straight rows and are at an even height. See the text above for an easy way of doing this. The centre of the board may be cut out to add more depth to a model if care is taken not to cut the PC tracks.

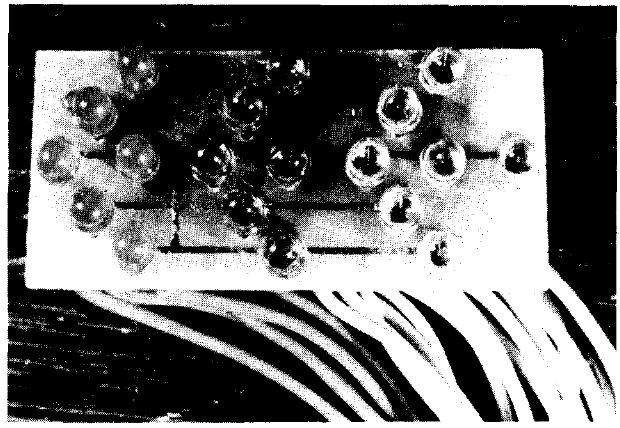


Wiring the shop display. The wiring between the shop display and the driver PC board is shown on the next page. Use this photograph as a guide.

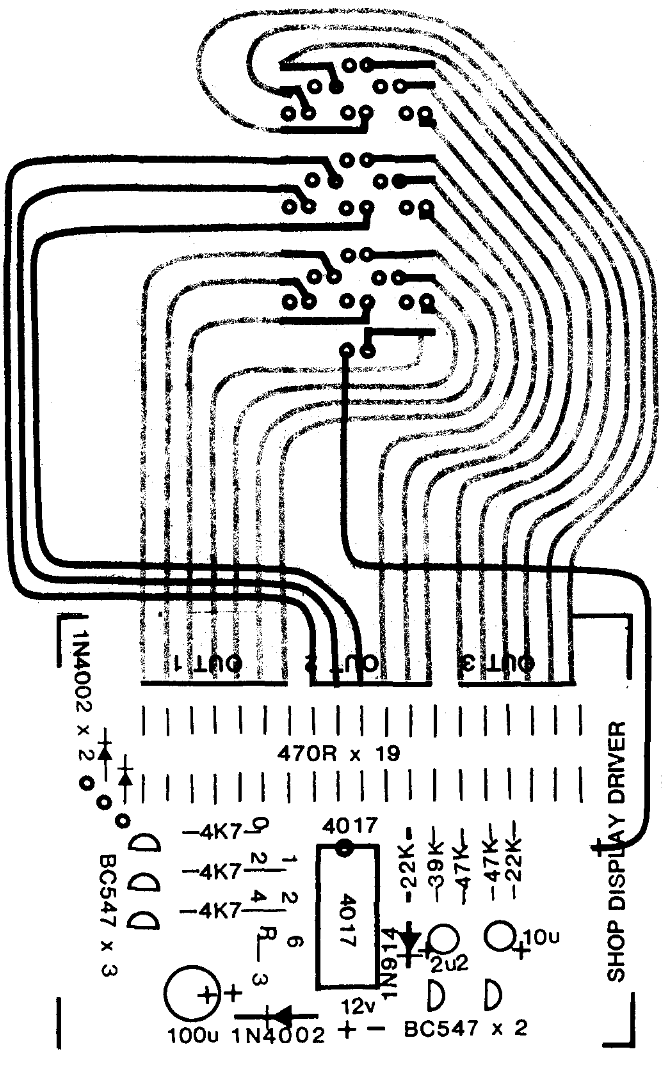




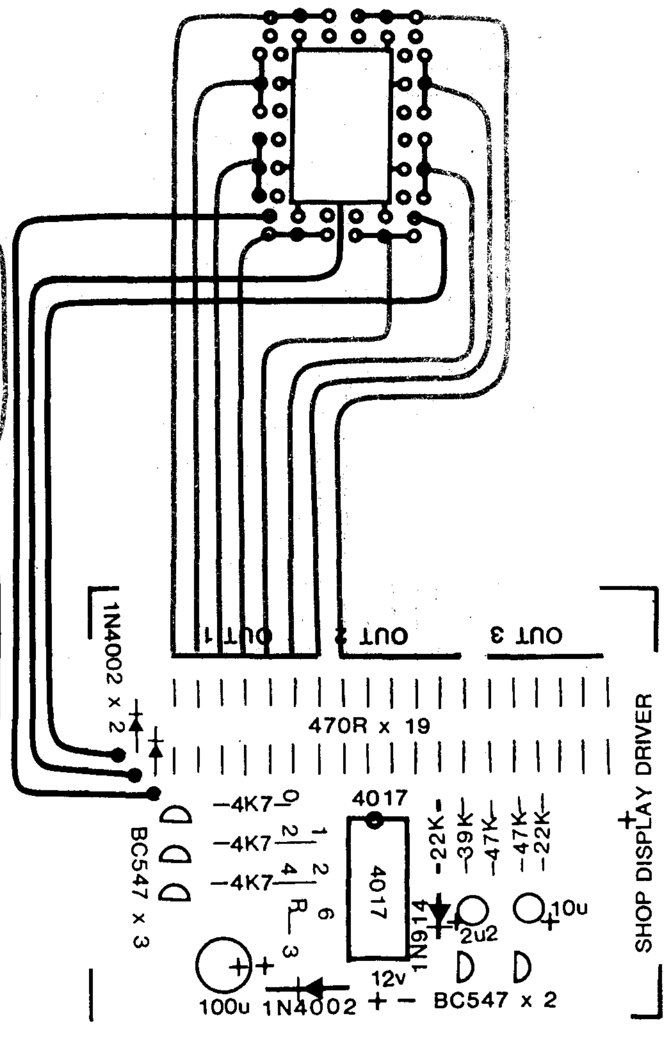
There are twenty wires between the arrow sign and the Shop Display Driver PC board. To avoid wiring errors it is a good idea to use colour coded wires. On this board wire colours corresponded to the colours of the LEDs to which they were connected.



Each arrow head can be made with a different coloured LED. The one shown here uses red, orange and yellow LEDs. If all the LEDs are orange, a model roadworks sign can be made.



To wire the arrow sign, follow this diagram. The Shop Display Driver PC board must be made as shown in the photograph at the top of page 30.



This is the wiring diagram of the shop display. The Shop Display Driver PC board is made as shown in the photograph at the bottom of page 30.

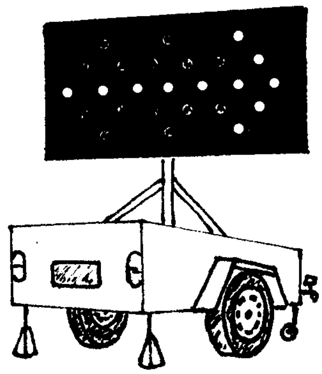
Shop Display Driver Parts List

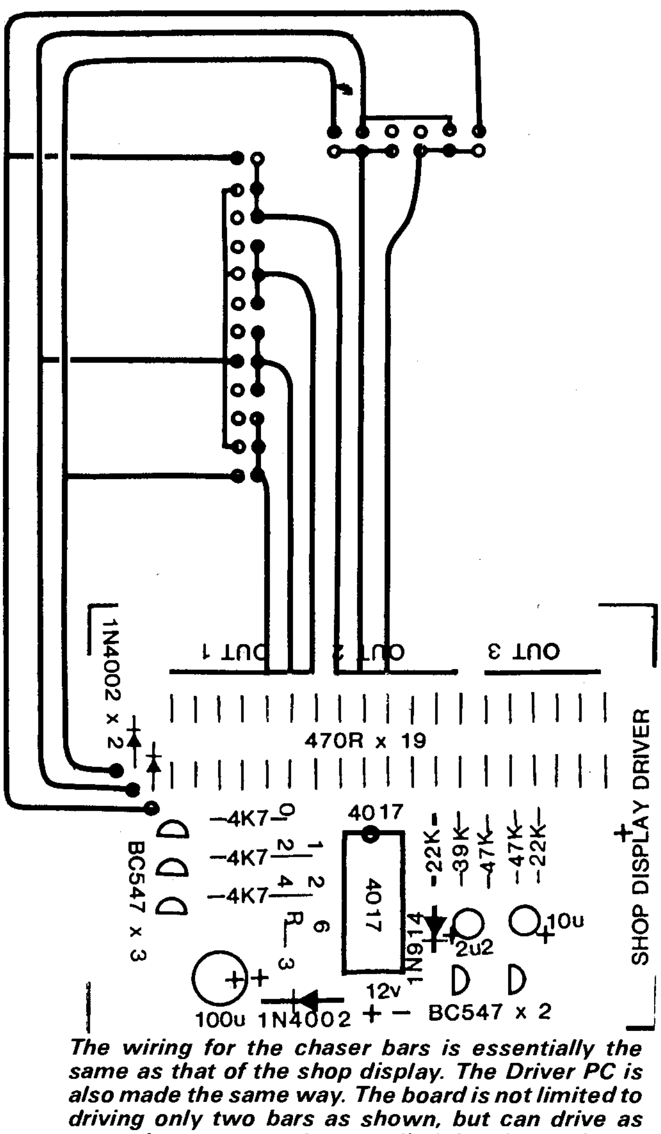
19 - 470R
3 - 4K7
2 - 22K
1 - 39K
2 - 47K

1 - 2.2mfd electro
1 - 10 mfd electro
1 - 100 mfd electro

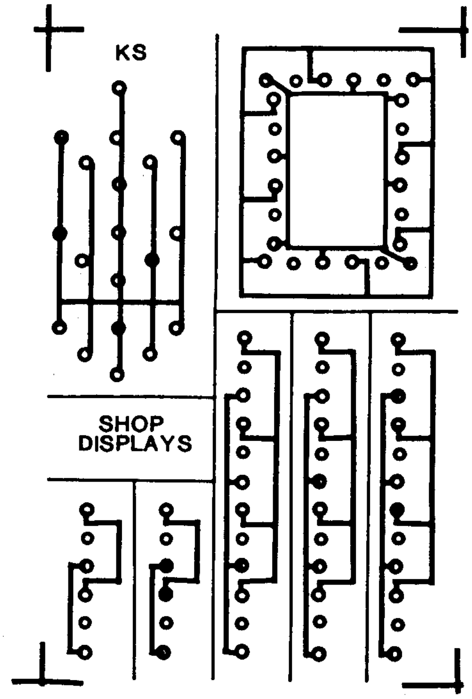
1 - 1N914 diode
3 - 1N4002 diodes
5 - BC547 transistors
1 - CD4017

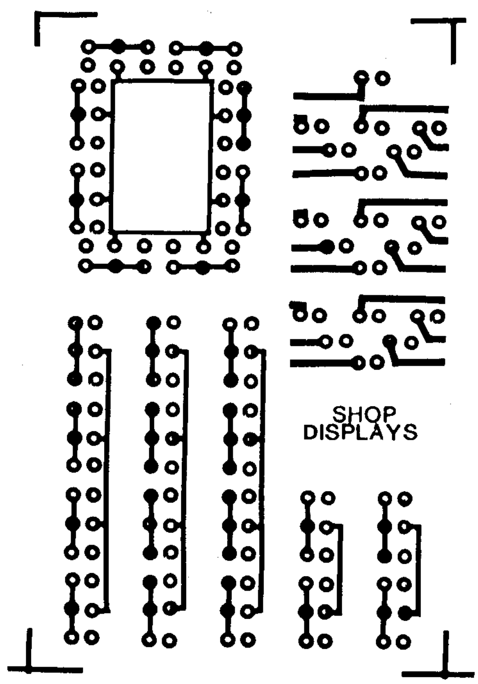
1 - 16 pin IC socket
1 - Shop Display Driver PCB

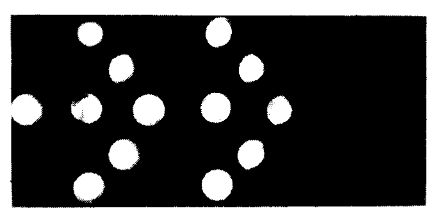




The wiring for the chaser bars is essentially the same as that of the shop display. The Driver PC is also made the same way. The board is not limited to driving only two bars as shown, but can drive as many bars as can be supplied by the resistors provided.







LEVEL CROSSINGS

On almost every model railway there is at least one place where road and rail cross. If prototype practice is to be followed, some way of making the crossing safe is needed.

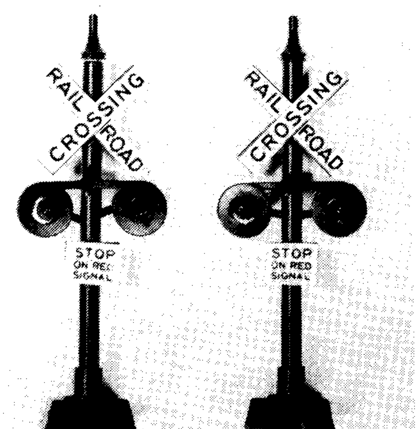
There several ways of doing this, including gates, booms and crossing lights.

Modelling gates is fairly simple, as they are available as plastic kits, but making them operate is quite difficult, as complex gearing is needed.

Operating booms have been approached in several different ways. The simplest uses the weight of the train pressing on a small bar under the track to mechanically hold down the booms. The main problems with this system are that the booms only close when the train is actually on the crossing, and often only the engine is heavy enough to hold them closed.

Booms can also be actuated by solenoids or motors. For the automatic operation of these, sensors will be required to detect the presence of the train.

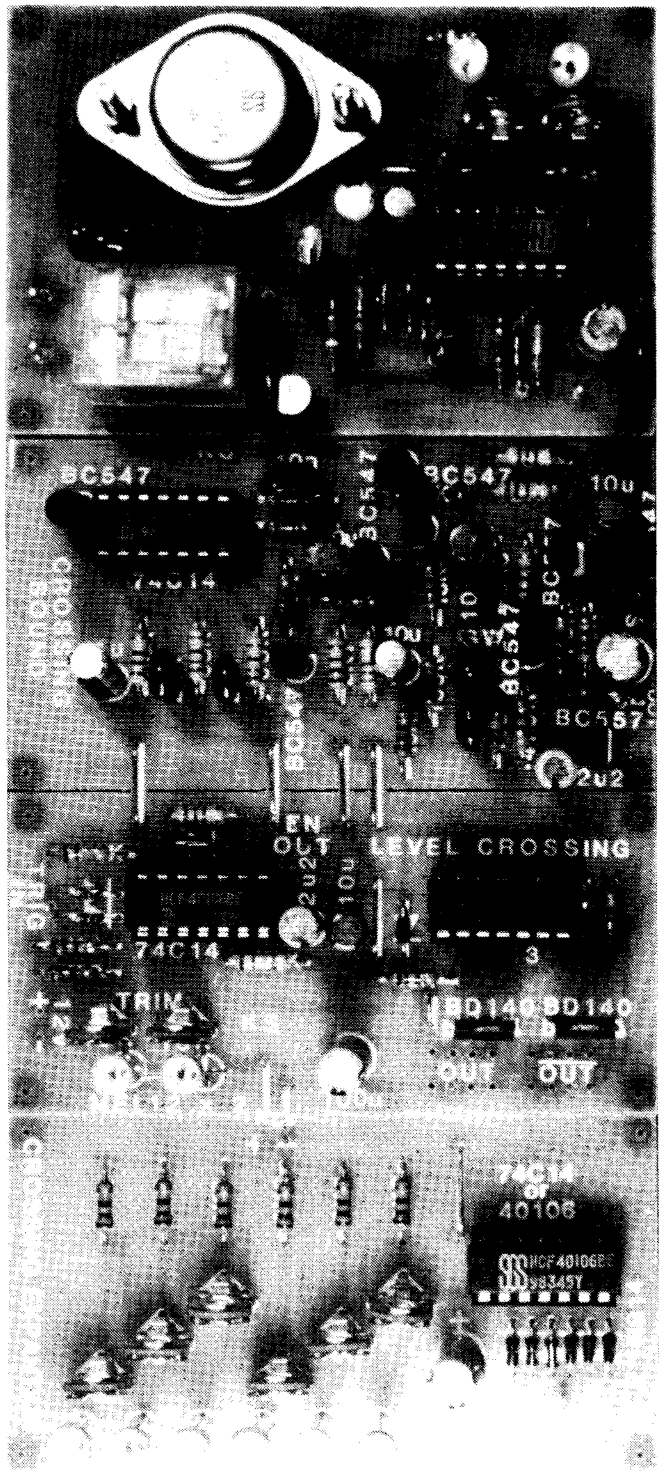
Flashing crossing lights are another option and these require no mechanics, however they are often used in conjunction with booms.



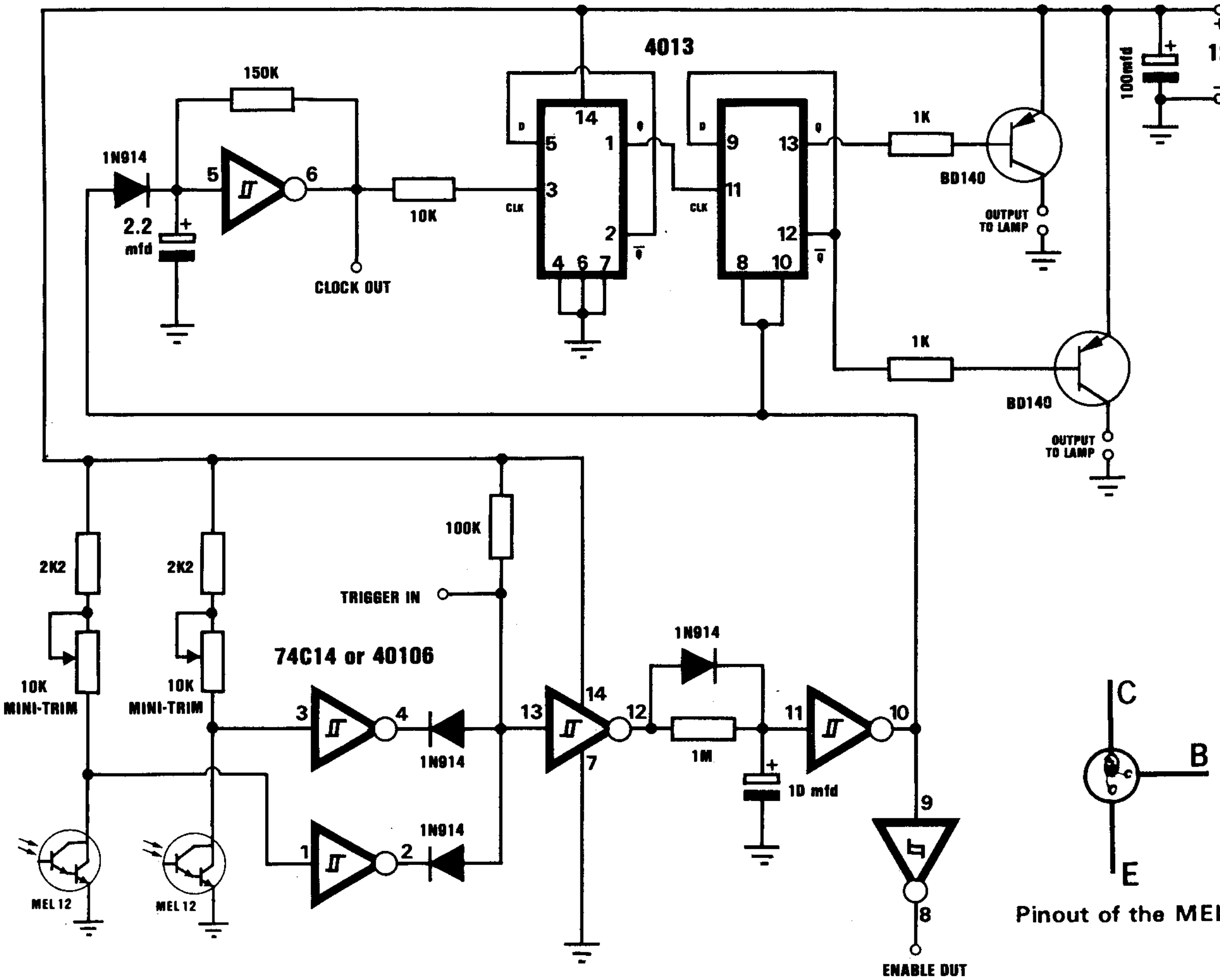
This photograph shows a pair of commercial railway crossing signals. These signals are available at most model railway stores.

The electronics required to alternately flash two lamps is simple. Two-transistor multivibrators are available for around ten dollars. They come in small plastic or epoxy cases and can drive one or two crossing lights but the only way of switching them on and off automatically is to connect them to a spare set of contacts on a relay used in an automatic block signalling circuit.

Presented here is a fully automatic light flashing unit that can detect trains coming from both



Actual size photograph of the four modules of the Level Crossing system.



Pinout of the MEL-12

This is the circuit diagram of the Level Crossing. You may not see the necessity of all the parts. They are used when the unit is expanded.

directions on one track or one direction on each of two tracks. It can be expanded to cover four tracks in both directions.

A crossing bell sound option can be added, as can an operating boom device. The bell sound and boom control do not work well together, as the motor driving the booms creates a lot of electrical noise, especially when driven by a pulse speed controller.

Some people may find a quieter mechanism for driving the booms than the one mentioned in this article. Isolated power supplies and shielding could be used to reduce the noise level.

The circuit will be described in several different stages, as each option is made on a separate PC board. The first stage will be the flashing light unit and automatic control.

How it works.

This unit is based on the 74C14 schmitt inverter and a 4013 dual D flip-flop. The operation is quite complex so it will be described in sections.

The first section is the train detection circuit. The track sensor is placed on the approach to the crossing so that the train will activate it before it arrives at the crossing.

Each sensor is an MEL-12 darlington photo-transistor. The sensitivity can be adjusted using the trimpots that feed the photo-transistors. The output from the junction of these is taken to the input of a schmitt inverter which is part of an OR gate.

When light falls on the MEL-12 it conducts, pulling the input of the schmitt inverter low. If a train covers the MEL-12 making it dark, it turns off and the input of the schmitt inverter is pulled high by the trimpot.

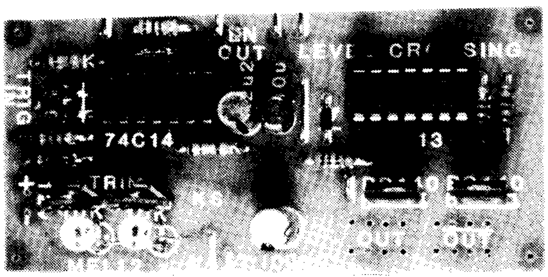
The outputs of the MEL-12 photo-transistors are OR gated together by three schmitt inverters two diodes and a 100K pull-up resistor. This complex type of OR gate was chosen because it had to be easily expandable and have schmitt inputs.

The output of the OR gate is fed into a delay circuit consisting of a diode, a 1M resistor, a 10 mfd electrolytic and a schmitt inverter.

When the output of the OR gate goes high, indicating the presence of a train, the 10 mfd capacitor is charged quickly by the diode. As long as there is a train over either photo-transistor, this capacitor will be held charged through the diode. This will hold the output of the schmitt inverter in the delay circuit low, thus enabling the oscillator and the second D flip-flop of the 4013.

The output frequency of the oscillator is divided by two in each of the flip-flop stages of the 4013 and the complementary outputs of the second stage are fed to the two buffer transistors that drive the lamps.

When the train is no longer over the MEL-12, it switches on and pulls the input of the OR gate low. When both inputs of the OR gate are low the output will also be low, and the 10 mfd electrolytic will discharge through the 1M resistor. After about 15 seconds the output of the schmitt inverter in the delay (pin 10) will rise, disable the oscillator and jam the outputs of the second stage of the 4013 HIGH. This will switch off both output transistors.



Construction

All components of the level crossing project except for the MEL-12 photo-transistors are mounted on a 4cm x 8.5cm PC board. Check that the trimpot leads will fit down the holes on the PC board. If not, enlarge them. Solder in the links first, then the diodes and resistors. Next solder in the IC sockets. The usual care should be taken with the orientation of the electrolytics.

The BD140 transistors are mounted with their metal faces toward the edge of the PC board. Solder in the trimpots and insert the ICs.

You can now test and adjust the unit. Solder in the MEL-12 phototransistors as shown in the photograph. The base leads may be cut short as they are not used. Wire a lamp to each output and connect the unit to 12 volts. This unit has no diode protection so care must be taken with polarity.

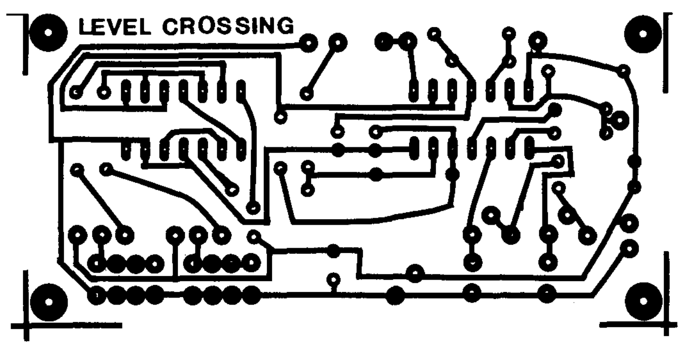
Place the unit in an area that is lit similarly to your model railway. Set both trim-pots to the centre of their travel. Cover one of the photo-transistors. The lights should start flashing. If they don't, adjust the corresponding trimpot until they do. Uncover the photo-transistor. After about fifteen seconds the lights should stop flashing. If they don't, try the adjustment again. The adjustment for the second photo-transistor is the same. To make adjustment easier, the 10 mfd electrolytic can be temporarily removed from the delay circuit. The unit will require a final adjustment when mounted on the layout.

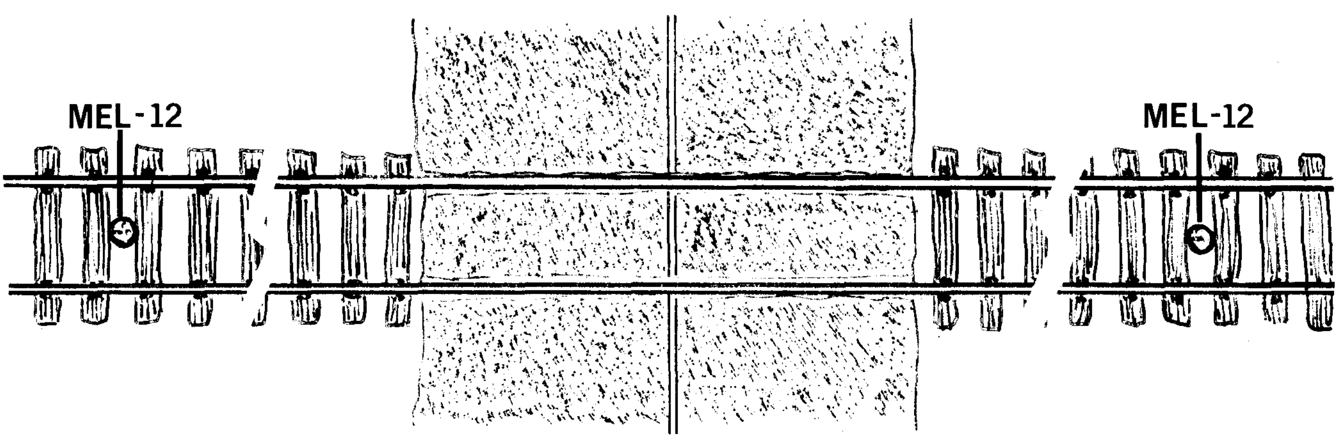
Four lamps can be driven off each output because medium power transistors have been used. They will not be in continuous use so heatsinks are not necessary.

The MEL-12 photo transistors are set between the sleepers of the track. If there is not enough ambient light, mount a street light near the photo-transistor.

A photo-transistor is needed only in the approach to the crossing, as the delay will allow enough time for the train to pass before the lamps stop flashing. If the trains travel along the track in both directions, a photo-transistor will be needed on both sides of the crossing. There should be 15 to 30cm gap between the crossing and the photo-transistor, depending both on scale and the speed at which the trains travel.

The unit is not limited to spanning one bidirectional track or two single direction tracks. The next circuit allows it to span four bidirectional tracks.





The MEL-12 sensors are placed on either side of the level crossing if bidirectional traffic travels along the track. The distance between the sensor and the level crossing should be between 15 and 30cm.

If trains travel along the track in one direction only one sensor is needed because the delay in the circuit will allow enough time for the train to pass.

Level Crossing Parts List

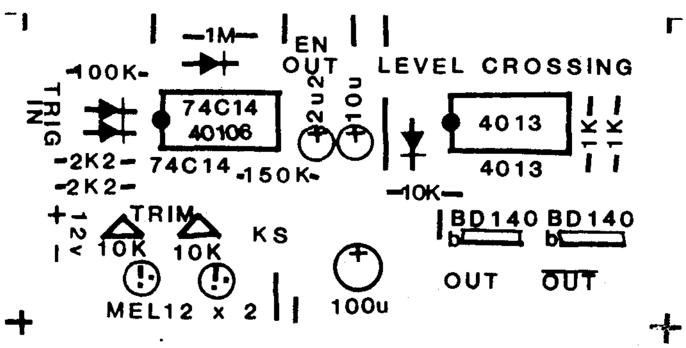
2 - 1K
2 - 2K2
1 - 10K
1 - 100K
1 - 150K
1 - 1M

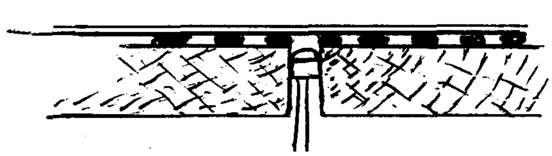
2 - 10K Mini-trim pots

1 - 2.2 mfd electro
1 - 10 mfd electro
1 - 100 mfd electro

4 - 1N914 diodes
2 - BD140 transistors
2 - MEL12 Darlington phototransistors
1 - CD40106 or 74C14
1 - CD4013

2 - 14 pin IC sockets
1 - Level Crossing PCB

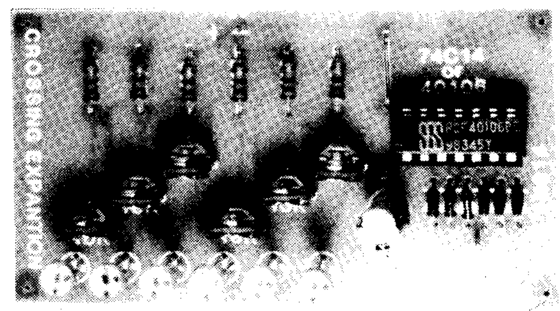




To mount the MEL-12 phototransistors, drill a hole between the sleepers. Push the MEL-12 up the hole from below and secure it with some tape. With it connected to the circuit, adjust its position in the hole so that only light from directly above will fall on the cell. If light falls on the cell from too low an angle, the train will not have enough shaddow to trigger the unit.

It is important to remember that it is not light but shaddow that triggers the unit. When adjusting the unit, make sure all cells you are not adjusting are well lit. If they are not lit they will trigger the unit, making adjustment impossible.

CROSSING EXPANSION



If the level crossing on your layout spans four tracks you will need this expansion unit. It has six sensors that when used in conjunction with the two sensors on the Level Crossing project will enable the unit to span four bidirectional tracks or more single direction tracks. Adding another expansion unit to this allows seven bidirectional tracks to be spanned.

How it works

The circuit is made of six blocks, each exactly identical to the sensors described in the Level Crossing article.

The outputs of all of these blocks are fed into the 'trigger in' terminal on the Level Crossing board, becoming part of an eight input OR gate.

Covering one of the photo-transistors on the expansion board will have exactly the same effect as covering one of the photo-transistors on the Level Crossing board.

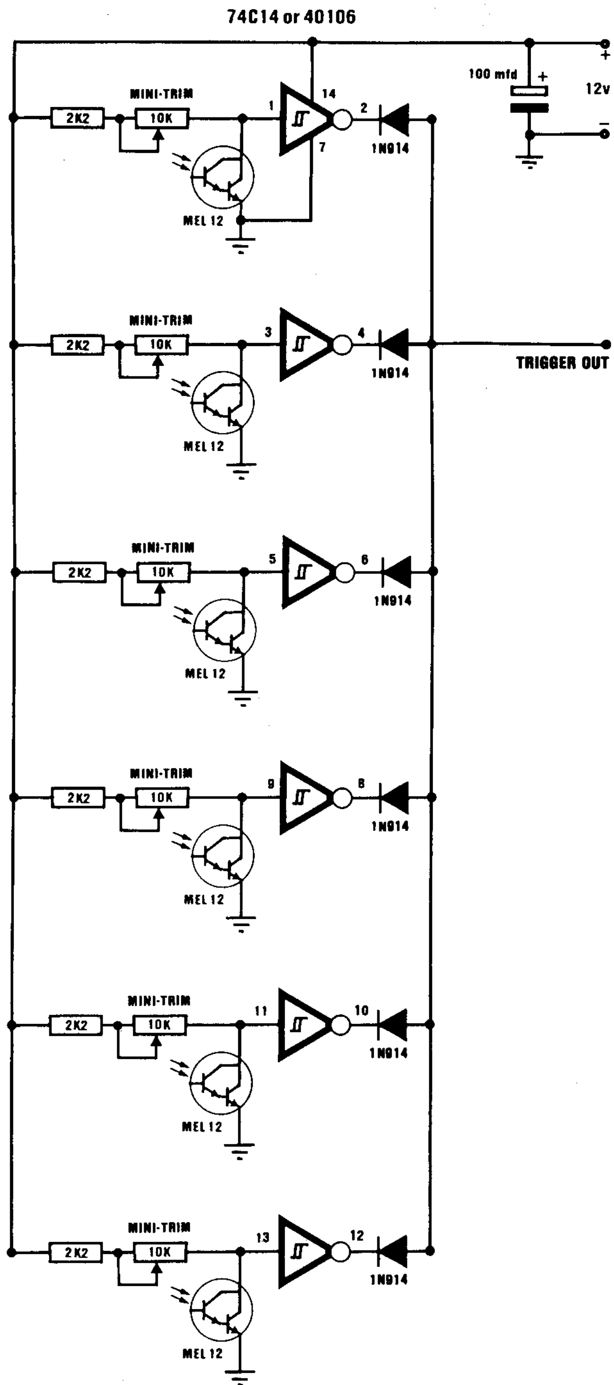
If you do not need all of the sensors on the board, leave out the resistor and trim pot on each one you do not require, and put a link in place of the photo-transistor. The diode can also be omitted.

Construction

First check to see if the holes are large enough for the trim pots. If not, enlarge them. The usual order of construction can be followed, starting with the link and ending with inserting the chip.

Power is connected to the unit through the two holes at the top of the PC board. If this board is placed against the lower edge of the Level Crossing board, power can be connected by two links from one board to the other. Use a short length of hook-up flex to connect the 'trigger out' line on the Crossing Expansion board to the 'trigger in' on the Level Crossing board.

Alignment is as described in the Level Crossing article.



This is the circuit diagram of the Crossing Expansion unit. The circuit is made of six blocks, each the same as the sensors in the Level Crossing unit.

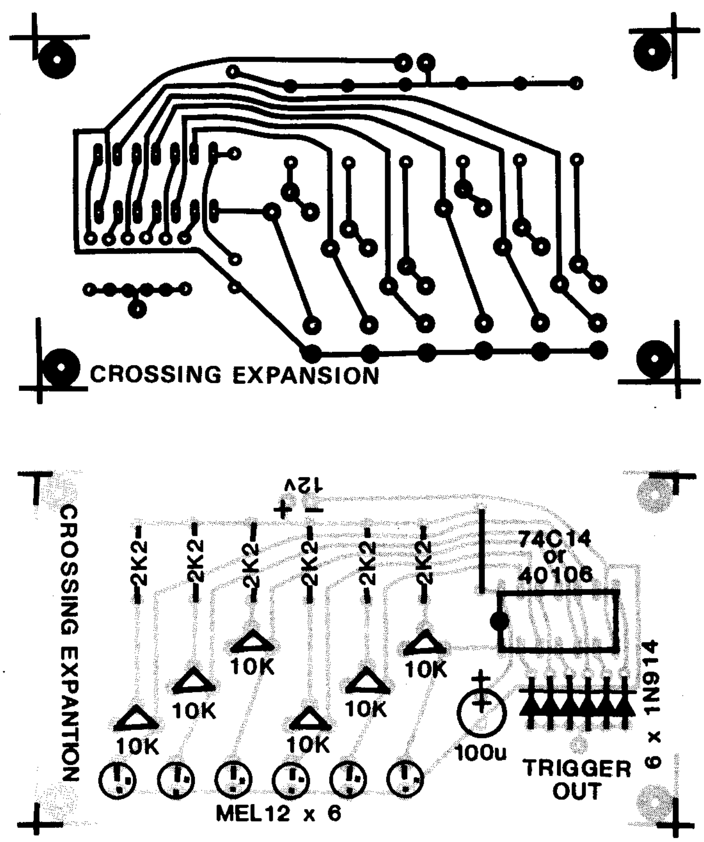
Crossing Expansion Parts List

6 - 2K2
6 - 10K Mini trim pots

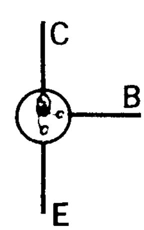
1 - 100 mfd electro

6 - 1N914 diodes
6 - MEL-12 photo-transistors.
1 - 74C14 or 40106

1 - 14 pin IC socket
1 - Crossing Expansion PCB



Shown here is the PC diagram and overlay for the Crossing Expansion board.



Pinout of the MEL-12

CROSSING SOUND

The bell sound is the third module of the level crossing. Sound is a detail rarely included in model railway crossings because of the difficulty in producing realistic bell tones.

There are two methods that can be used to produce the bell sound: obviously the first is by using a bell.

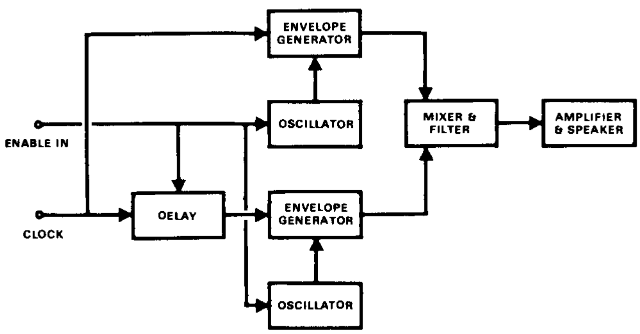
Unfortunately, the small bells used are incapable of producing a good tone.

The second method is to generate the sound electronically. The quality of an electronic bell tone depends entirely on the design of the circuit.

The circuit described here generates two bell tones, both at approximately the same frequency. One is slightly delayed to be as near to the sound of prototype crossings as possible.

How it works

Look at the block diagram of the Crossing Sound module. The unit can be divided into seven simple blocks.



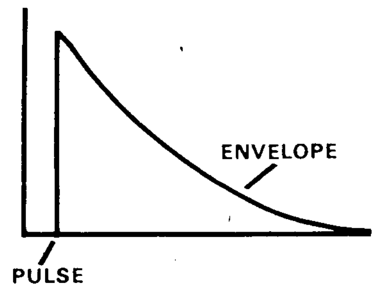
Both oscillators are schmitt inverter oscillators based on the 74C14. Each uses components of the same value. The slight variations in individual components cause the oscillators to work at slightly different frequencies, making each bell tone distinguishable.

The delay is an R - C network followed by two schmitt inverters. This provides a short noninverted delay.

The clock output from the Level Crossing board is fed into one envelope generator directly and into the other via the delay.

If you have been wondering why the clock frequency was divided by four on the Level Crossing board, it is because the lamps on a railway crossing flash slower than the bells ring. As the clock determines the bell speed, the lamps had to be driven via a frequency divider.

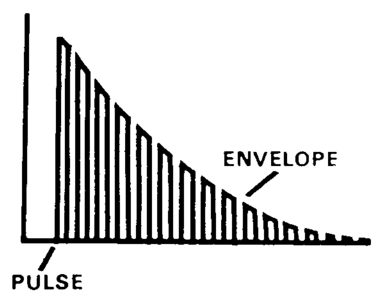
Each envelope generator works like this: a pulse from the clock (or delay) is passed through a 10K resistor and a 10n capacitor. This take the base of the BC547 HIGH. It is normally held low by a 100K resistor. The BC547 is wired as an emitter follower. Every time a pulse is passed to its base, it switches on briefly, charging the 10 mfd capacitor. The capacitor discharges through the 15K resistor, producing a voltage envelope.



This envelope gives the bell its ringing sound.

The voltage envelope is fed through a 2K7 resistor to a second transistor and an electrolytic. The output of the envelope generator is taken from the other side of this electrolytic.

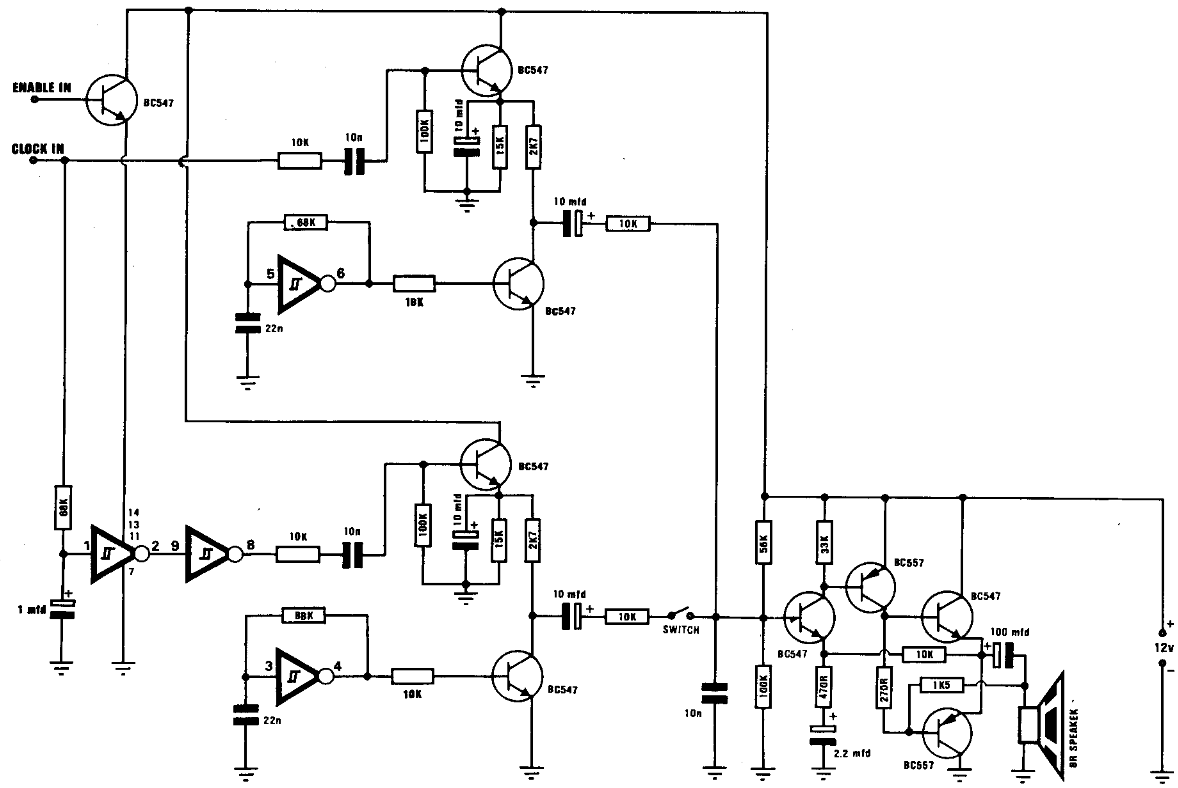
The second transistor is wired as a 'chopper' transistor. It is driven by the oscillator. It imposes the waveshape of the oscillator onto the voltage envelope.



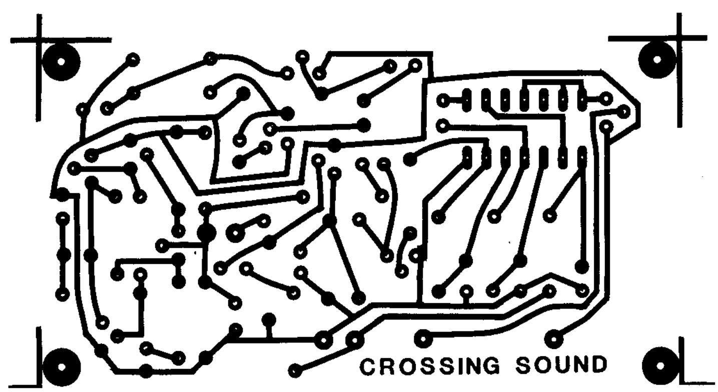
This first bell sound is then mixed with the bell sound produced by the second oscillator and the signal is fed to the output amplifier, which is a simple four transistor push-pull amplifier.

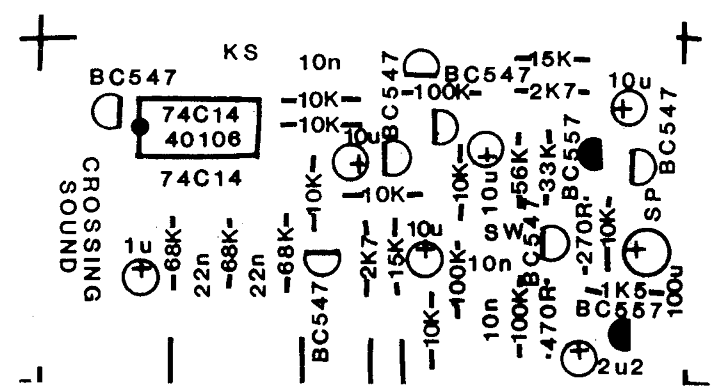
At the point where the signal is fed into the amplifier, it is filtered by a 10n capacitor connected between the input and earth. This capacitor removes the high frequency component of the square wave, mellowing the tone being fed into the amplifier.

A switch can be placed in line with one bell tone to switch it on or off. This will be discussed in the boom control article.



The Crossing Sound module. Compare the circuit diagram with the block diagram. You should be able to see the various blocks on the circuit diagram.





The ENABLE line from the Level Crossing unit switches ON the sound via an emitter follower that feeds the 74C14 power. The amplifier remains on all the time.

Construction

The crossing sound unit is constructed on a PC board measuring 4.5cm x 8.5cm. The board is designed to line up with the top of the Level Crossing PC board, making the wiring between the two units as simple as four links.

Solder in the twenty two resistors first, followed by the IC socket. The transistors are next. Two of them are BC557's and the rest are BC547's, so make sure you get them in the right place. Solder in the electrolytics and capacitors, taking care with the polarity of electrolytics. Insert the 74C14.

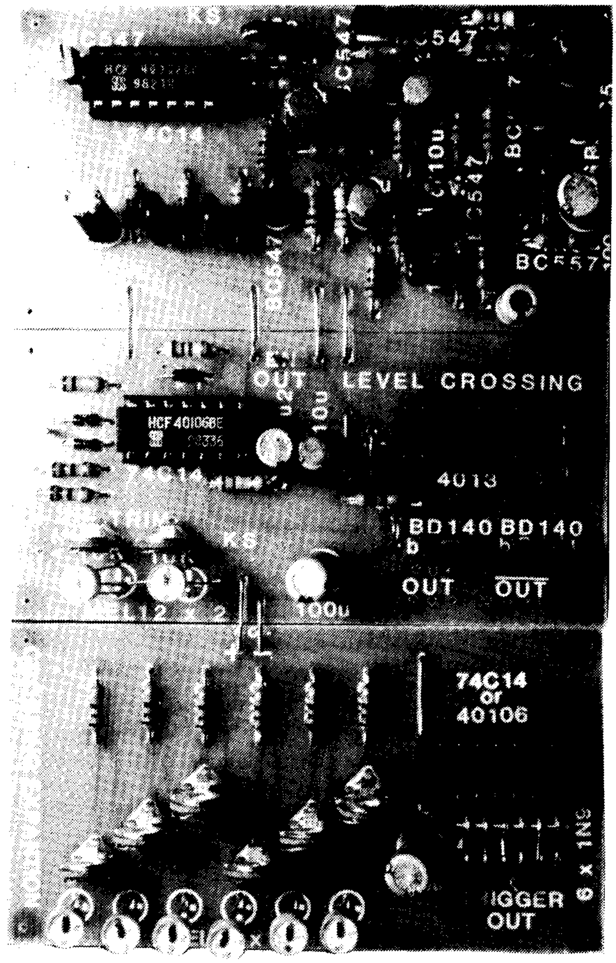
You may find it convenient to use PC pins for connection to the speaker, switch and Level Crossing board. Alternately the two PC boards can be placed side by side and joined as shown in the photograph.

Going further

The speaker can be mounted underneath the model of the level crossing, and the sound let out through some well disguised holes under hedges or something similar.

If it is too loud, a 15 ohm resistor can be placed in line with the speaker. As mentioned previously, the amplifier remains on all the time. In the event that it picks up noise from your trains, it can be modified to switch off. A track on the PC board is cut, to separate the unit from the power supply. It is then wired to the other side of the emitter follower that switches the 74C14. The transistor is replaced with a BC338.

See page 44.



Crossing Sound Parts List

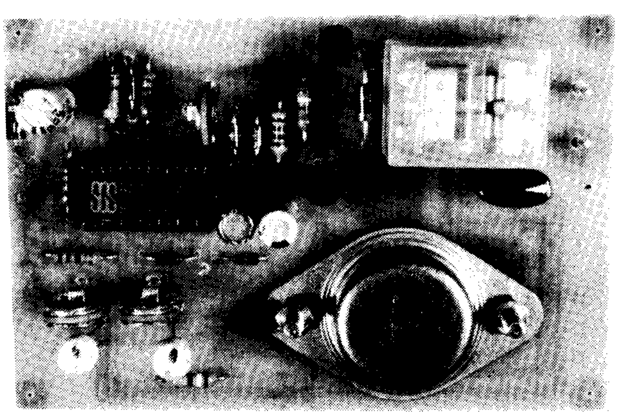
1 - 270R
1 - 470R
1 - 1K5
2 - 2K7
7 - 10K
2 - 15K
1 - 33K
1 - 56K
3 - 68K
3 - 100K

3 - 10n
2 - 22n
1 - 1 mfd electro
1 - 2.2 mfd electro
4 - 10 mfd electro
1 - 100 mfd electro

7 - BC547 transistors
2 - BC557 transistors
1 - 74C14 hex schmitt inverter

1 - 14 pin IC socket
1 - 8R speaker
1 - Crossing Sound PC Board

CROSSING BOOM CONTROL



The power transistor on the Crossing Boom Control board should not need a heatsink unless a motor with a high current consumption is being used to drive the booms.

The module described here will make working boom gates a practical possibitity for model railways. It is designed for use in conjunction with the level crossing modules previously described.

The mechanical details will not be covered as these will vary with individual modelling methods. The prototype unit controlled a Mann Made 'point drive' which is a point motor that is actuated by a small electric motor driving a long threaded shaft. A plate containing limit switches is pushed back and forth by this shaft. Two tags on this plate are connected to the item that is being controlled, in this case the boom gates. Any similar motor drive with limits would work as well.

How it works

The Boom Control module can be looked at in three main blocks. They are track sensors, delay, and motor drive.

The track sensors are the same as described in both the Level Crossing and the Crossing Expansion units. They were included to use up spare schmitt inverters that were not required by the rest of the circuit. They would be particularly useful if the booms were being used on a double track crossing.

The delay circuit provides a delay on the positive going enable signal from the Level Crossing board. This delay is the warning period where the bells ring for a short time before the booms lower, to allow traffic to move out of the way.

The delay drives a relay via a buffer transistor. It is this relay that switches power to the 'point drive' so that it will raise and lower the booms.

When the enable signal goes low, it immediately discharges the capacitor in the delay circuit via the diode so that the booms will be raised as soon as the bells stop ringing.

The remaining block is the pulse throttle. It is a low frequency variable mark-space ratio oscillator followed by two buffer transistors. Adjusting the mark-space ratio of the oscillator controls the amount of power reaching the motor operating the booms making it possible for them to move very slowly. The pulse throttle is a lot more reliable in this situation because with a normal voltage controlled throttle, the motor often fails to start at this low speed.

Construction

It may be necessary to enlarge several of the holes on the Crossing Boom Control PC board. These are the holes for the trim pots, the holes for the relay and the holes for the 2N3055 transistor.

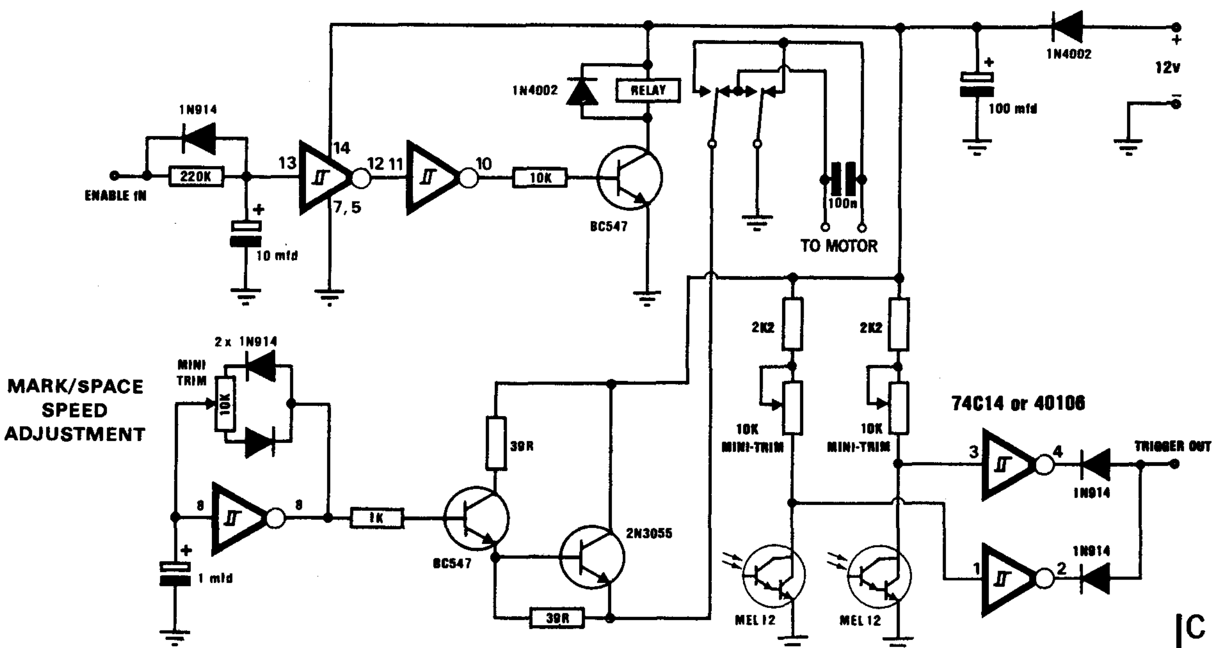
Mounting of the rest of the components is as usual. When mounting the relay, take care not to bend any of the leads as they may break off or cause internal damage to the relay. Insert the 2N3055 and bolt it to the board. Solder the pins and trim them. The connection to the collector is through the bolts. The unit will not be running enough to warrant heat-sinking the transistor.

It may be necessary to power the Crossing Boom Control module from an isolated supply if the Crossing Sound module is being used. A common earth should be used between the modules.

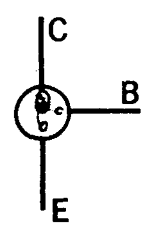
Connect the module to the Level Crossing unit to test it. The relay should switch a short while after the level crossing lamps start flashing. Connect the 'point drive' to the output from the relay and adjust the speed with the 10K trim pot. If it is too slow the 'point drive' may stick.

If the sensors are needed, connect the trigger out on the Crossing Boom Control board to the trigger in on the Level Crossing board. If they are not required, put links in place of the MEL-12 phototransistors and omit the trim pots.

A spare switch on the point drive can be used to switch off the second bell sound on the Crossing Sound unit when the boom gates close, as is often done in real life. Two shielded wires can be run from the point drive auxillary switch to the two terminals marked 'SW' on the Crossing Sound board. The shields should be earthed to the Crossing Sound board. See the diagram on page 44 for the wiring.



The Crossing Boom Control circuit is made of several smaller blocks. They are the delay, the relay driver, the pulse throttle and the track sensors.



Pinout of the MEL-12

Crossing Boom Control Parts List

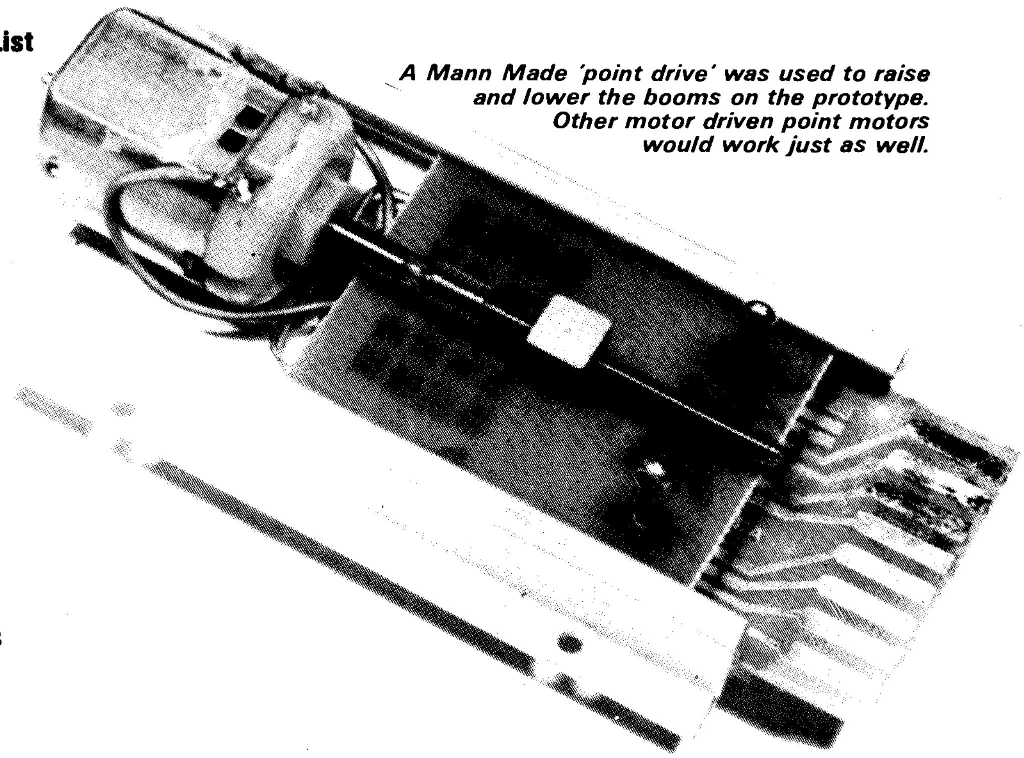
2 - 39R
1 - 1K
2 - 2K2
1 - 10K
1 - 220K

3 - 10K trim pot

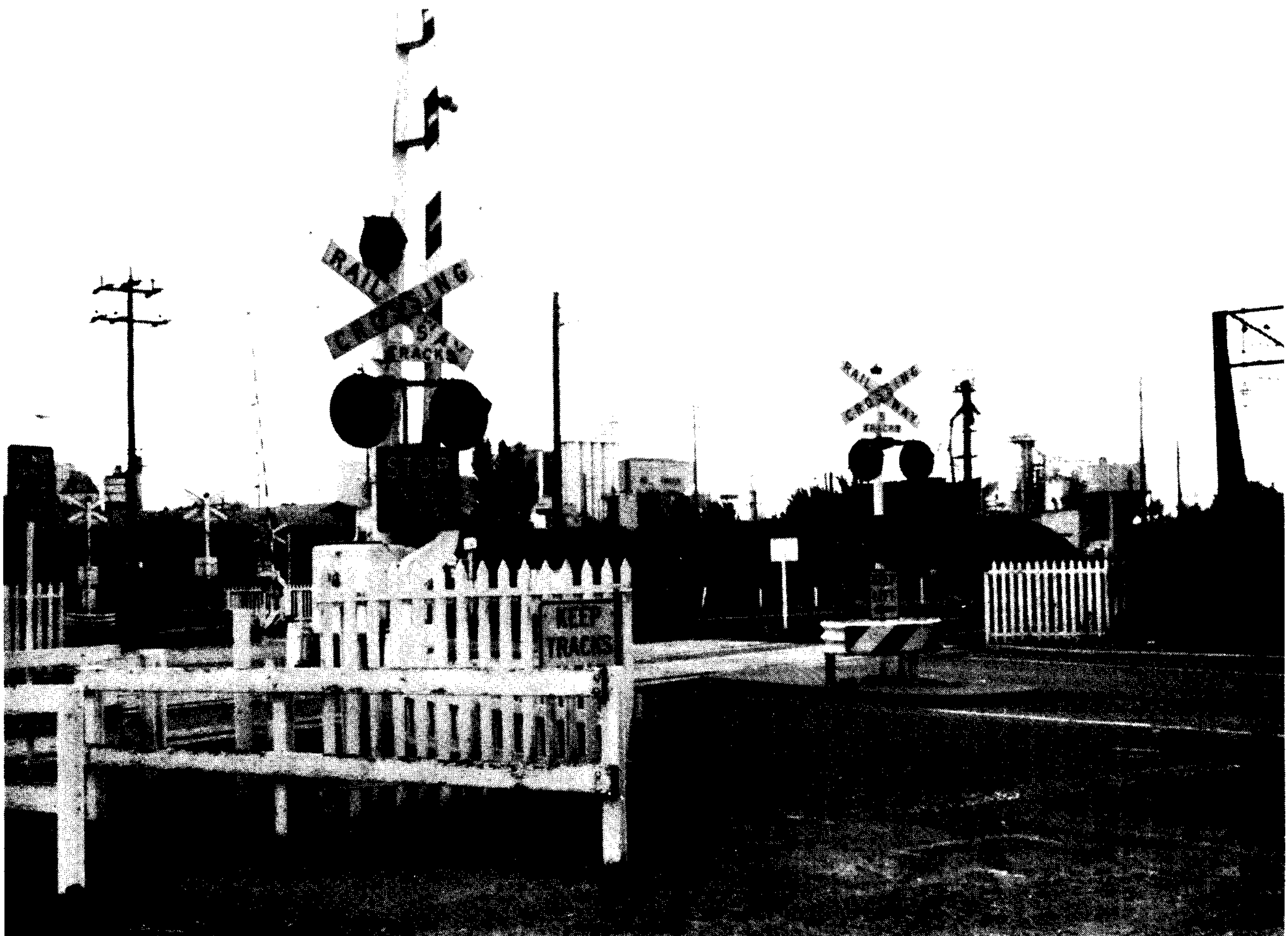
1 - 100n
1 - 1 mfd electro
1 - 10 mfd electro
1 - 100 mfd electro

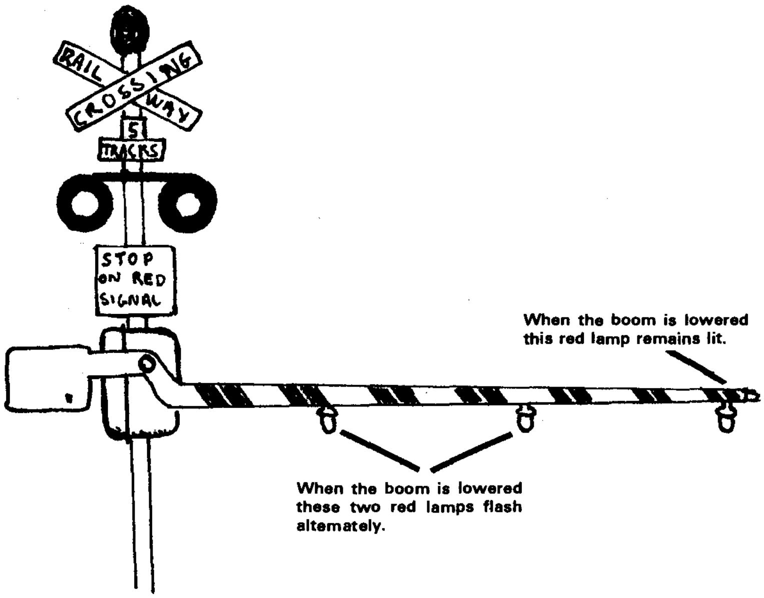
5 - 1N914 diodes
2 - 1N4002 diodes
2 - BC547 transistors
1 - 2N3055 power transistor
2 - MEL-12 phototransistors
1 - 74C14 chip

1 - 14 pin IC socket
2 - nuts & bolts
1 - DPDT 12v Mini relay
1 - Crossing Boom Control PCB

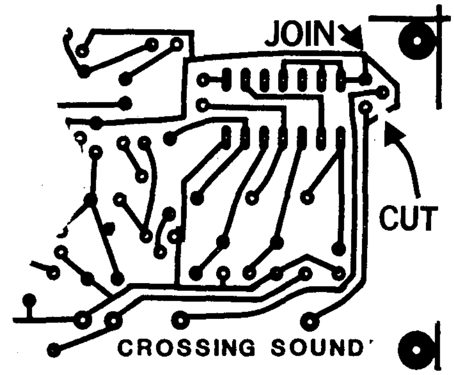


A Mann Made 'point drive' was used to raise and lower the booms on the prototype. Other motor driven point motors would work just as well.

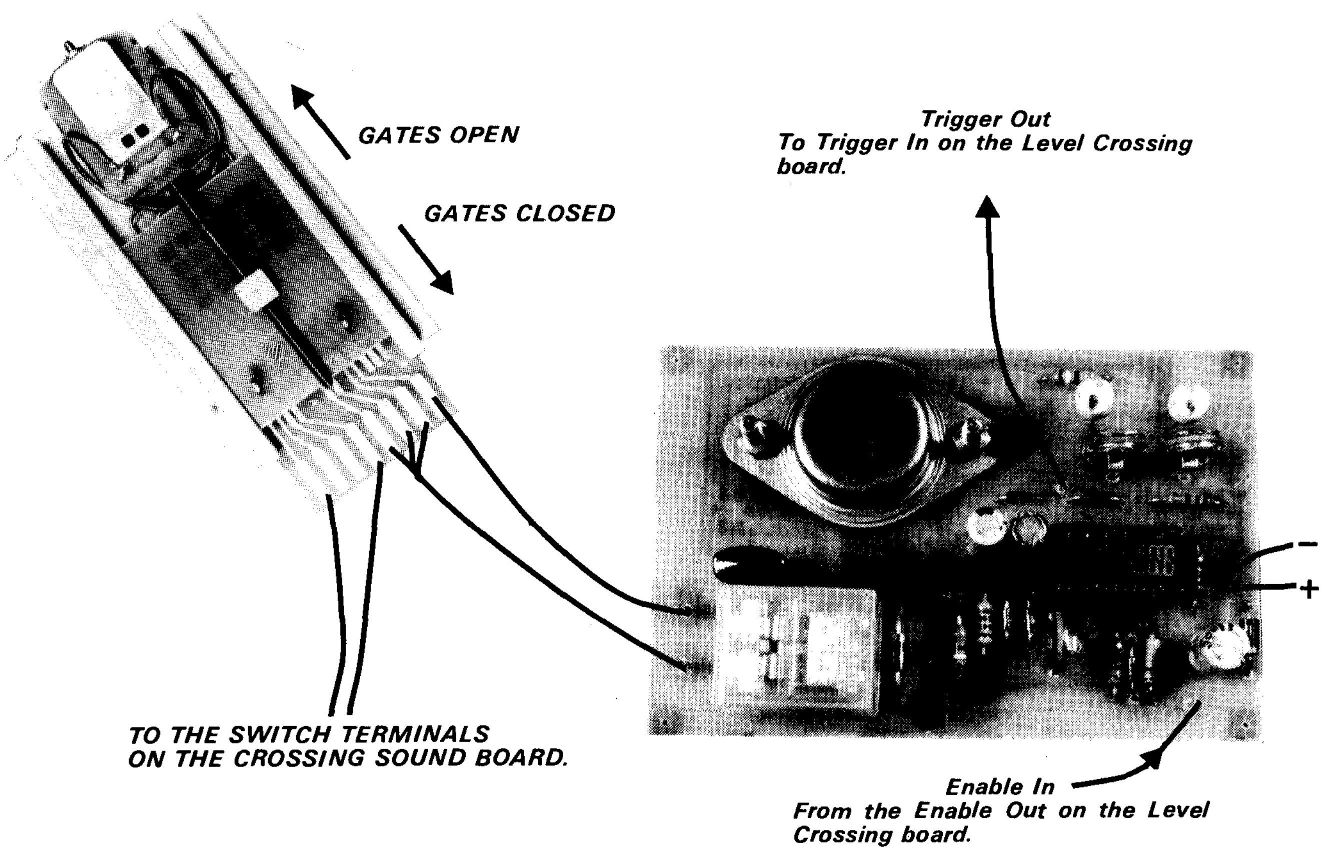




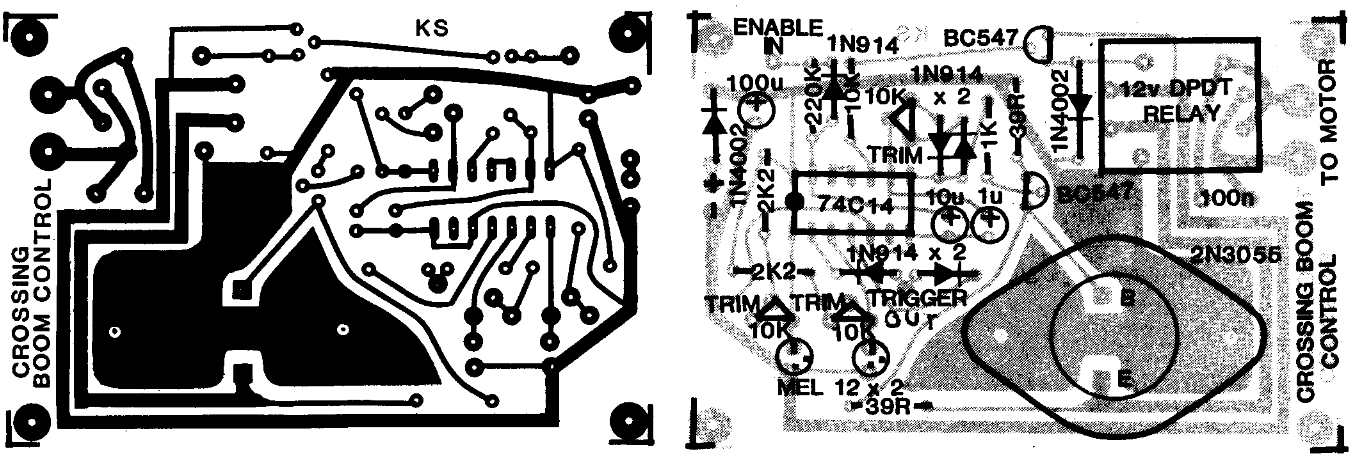
Some modellers may like to include the three lamps that are on the boom itself. These lamps can be mounted under or over the booms. I have seen one crossing on which one set was under and the other set was over. The photo on the previous page shows a set on which both sets are under the booms.



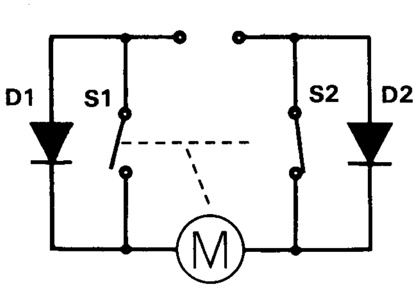
This diagram shows where to break one track and to join the other to modify the Crossing Sound board so that the amplifier switches off when the bells are not ringing. See page 41.



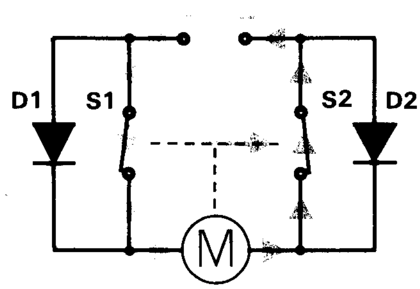
How to wire the point drive to the Crossing Boom Control board.



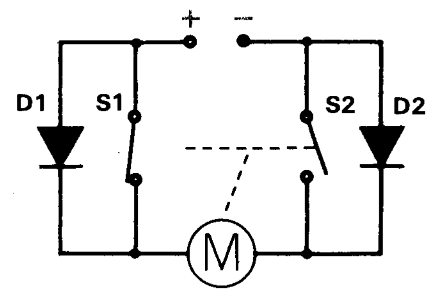
This series of drawings is to help you understand how the 'point drive' works. It should also help those who want to build their own from parts they have on hand.



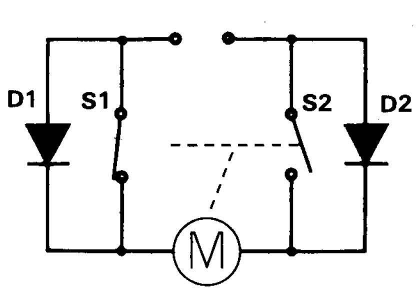
The 'point drive' consists of a motor, two diodes and a plate containing limit switches. The plate is pushed back and forth by the motor depending on the polarity connected to the point drive. Power is always connected to the point drive and is switched by the limit switches.
Consider the polarity to the unit has just been reversed. This diagram shows how the power is connected now. Current flows through diode 1 and switch 2 allowing the motor to start. (In this explanation, conventional current is being used.)



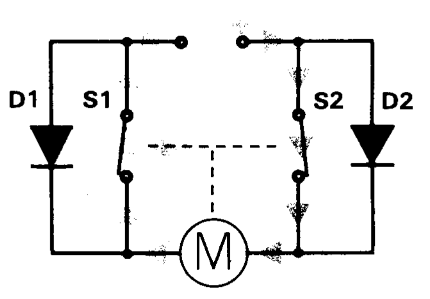
As the motor drives the plate across, switch 1 closes shorting out diode 1. The current is now flowing through both switches.



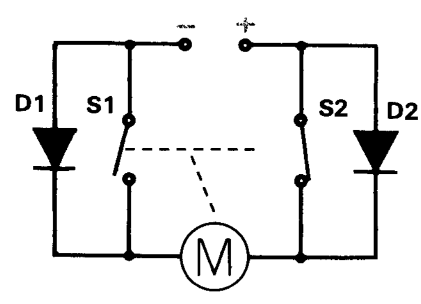
The plate reaches the other end of its travel and the motor stops. This is because limit switch 2 has just opened. Current cannot flow through diode 2 because it is reverse biased.



The polarity on the circuit is reversed. Current can now flow through diode 2 and the motor starts to drive the plate back in the other direction.
The motor used must reverse when the polarity to it is changed or the unit will not work. This means motors with field coils will not work. Care must also be taken to make sure the motor is connected the right way around.



As the plate moves switch 2 closes shorting diode 2.



The plate continues to move until limit switch 1 opens and the motor stops. This is because diode 1 is now reverse biased. If the polarity is reversed again the plate will start moving back in the opposite direction.

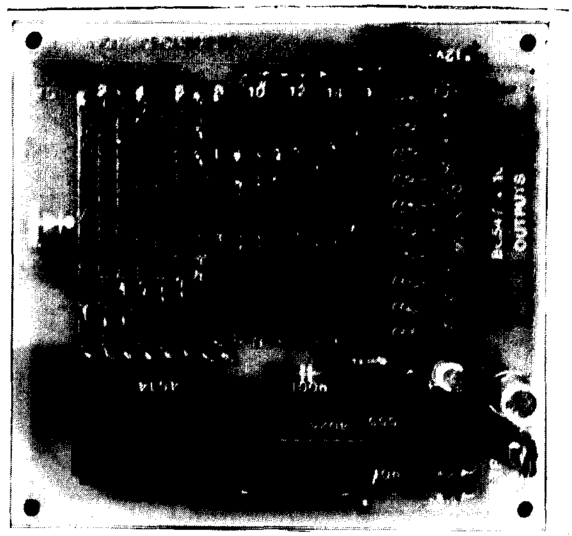
Control light displays, switching sequences and traffic lights with this programmable . . .

LIGHT SEQUENCER

Have you ever wanted to model a set of traffic lights and got as far as looking at the circuitry needed? Or have you ever thought of having the lights in a model building switch on and off as if someone inside was moving from room to room? Perhaps you just want a light chaser that is more versatile than those that have already been described. If so, this is the project for you.

It is a programmable light sequencer that is easy to build and more importantly, easy to program. It has ten transistor buffered outputs that are driven by a sixteen step, diode programmed sequencer.

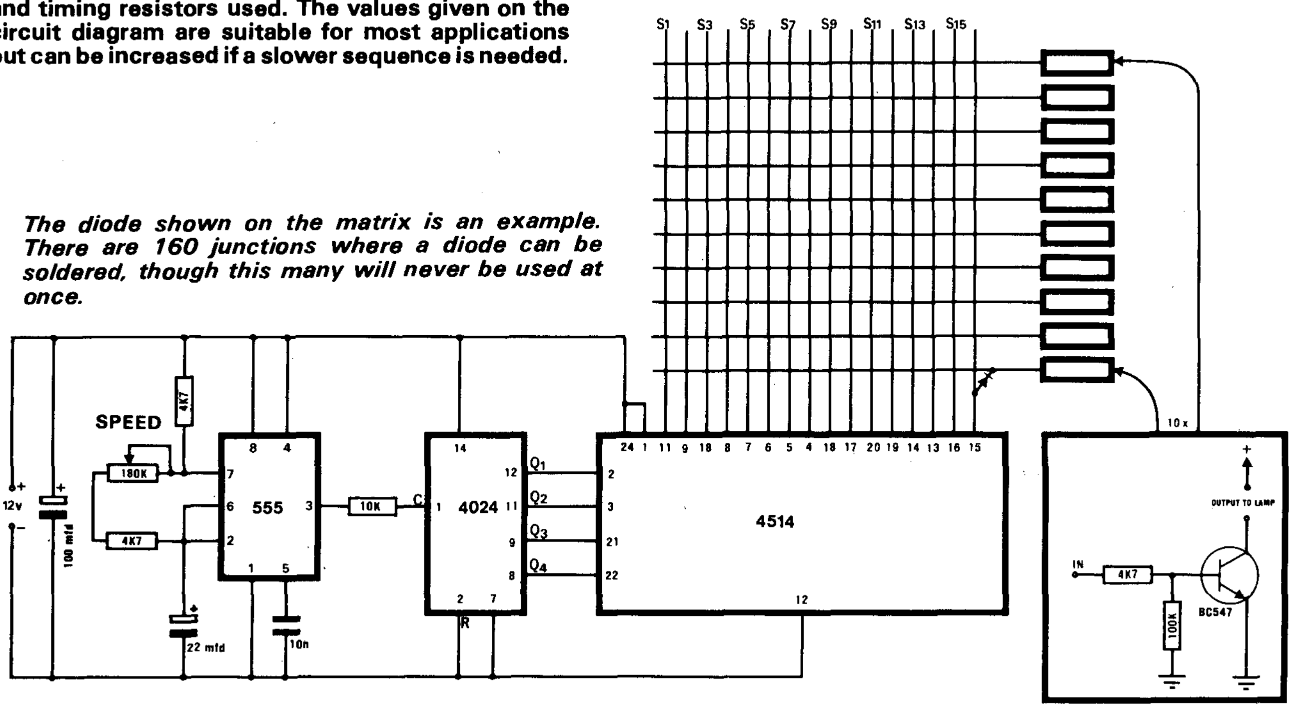
Each output can be either on or off for each of the sixteen steps depending the program the user selects. Programming is simple. If output one is required to switch on at step three, a diode is soldered at the junction of the two lines on the matrix. The same applies for every other one of the 160 junctions on the matrix.



This Light Sequencer is programmed to drive a set of model traffic lights.

How it works

The time of each step in the sequence is determined by the frequency at which the 555 timer is oscillating. The frequency is set by the electrolytic and timing resistors used. The values given on the circuit diagram are suitable for most applications but can be increased if a slower sequence is needed.



The diode shown on the matrix is an example. There are 160 junctions where a diode can be soldered, though this many will never be used at once.

The output driver transistors are all wired as shown in the box.

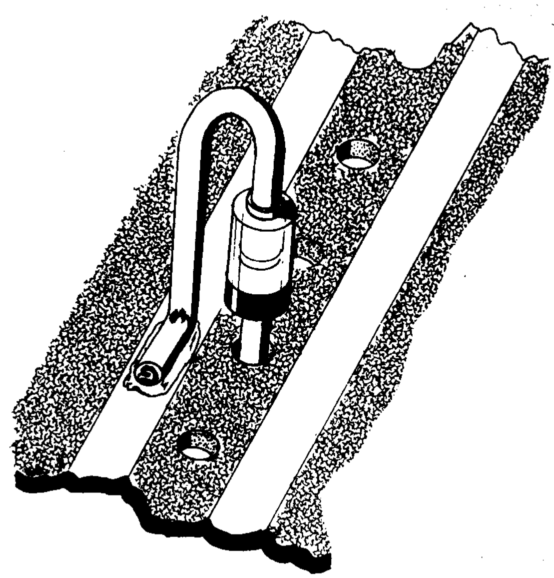
The output of the oscillator is fed via an isolating resistor to the 4024 which is a seven stage binary counter. Four of the outputs of the 4024 are fed to the 4514 which is a 4 to 16 line decoder with active high outputs. This means the line that is selected will go high while the other fifteen lines remain low. As the 4024 counts, each of the outputs of the decoder will come on in turn. These lines are the sixteen vertical lines of the matrix, as shown on the circuit diagram.

Using signal diodes connected as the sample diode on the circuit diagram, it is possible to create many different sequences. The horizontal lines of the matrix are fed to the output buffer transistors.

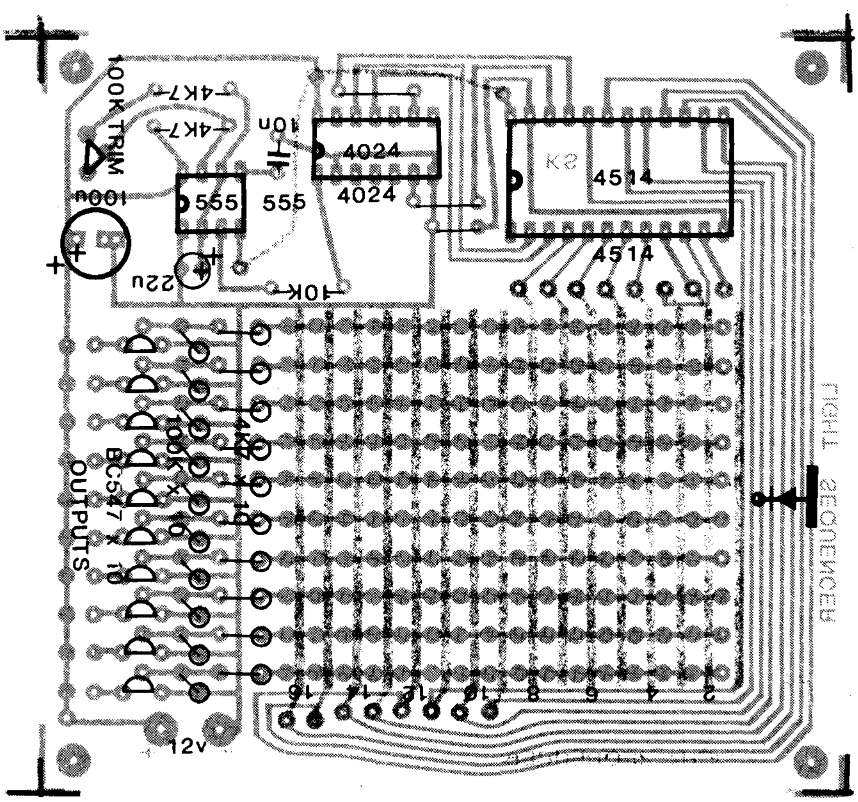
Construction

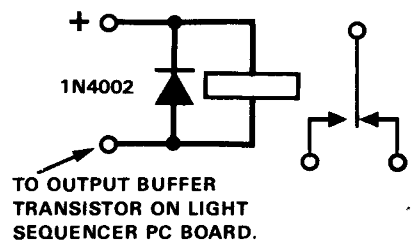
The Light Sequencer is constructed on a double sided printed circuit board because it makes the matrix a lot easier to build. This circuit board is not through hole plated so short lengths of wire will need to be inserted through the holes connecting the lower tracks with the upper tracks. Without these feed-throughs the circuit will not work. To save space, the resistors associated with the driver transistors have been stood on end. Their orientation has been marked on the PC overlay.

The resistors can be soldered into the circuit in either direction. It is only the physical mounting that matters in this case, as one way is neater.



This drawing shows how each diode is mounted on the PC board. First the anode lead is bent back parallel to the cathode lead of the diode. It is then bent at a right angle and trimmed. Place the PC board on a piece of expanded polystyrene foam. Locate the junction at which you wish to place the diode. Push the cathode lead down the hole in the PC board and into the foam. This will hold the diode while you solder the anode lead onto the track on the top of the PC board. Turn the PC board over then solder and trim the cathode lead of the diode. All other diodes are mounted in the same way.



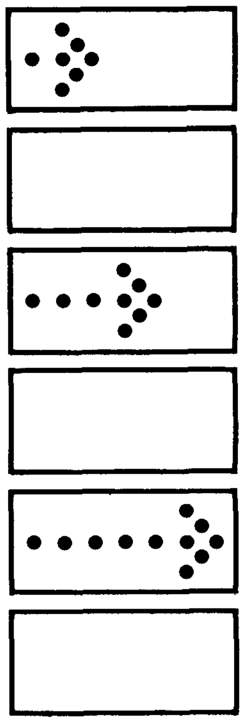


The Light Sequencer is not limited to driving lamps. Because the outputs are buffered, it is possible to drive relays. The relays should have 12 volt coils. 1N4002 diodes must be connected across each relay coil to protect the transistors from the back-emf generated by the coils.

The relays can then be used to switch much heavier currents than the transistors are capable of switching. Motor driven accessories can then be controlled by the Light Sequencer.

The Matrix

Before the matrix can be built a program is needed. The first step in programming is determining the sequence needed on a piece of paper. Several examples are shown below to help you understand the principles of programming. They are the sequence for traffic lights, the sequence for a more accurate roadworks arrow sign using the arrow display from the Shop Displays board and simple advertising sign sequence. There is also a blank grid supplied for you to photocopy to work out your sequence on.



STEP 1

STEP 2

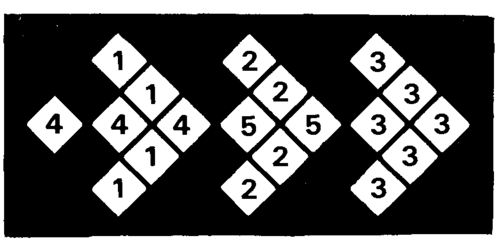
STEP 3

STEP 4

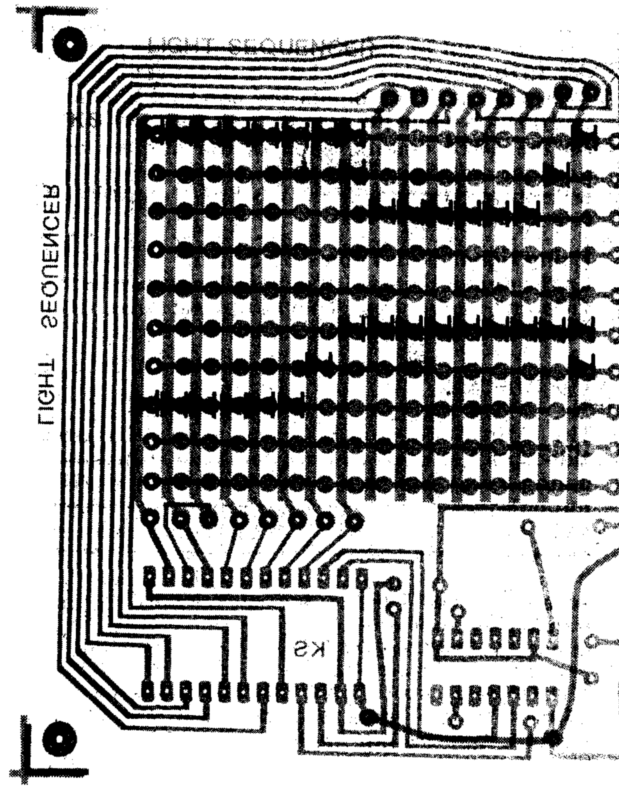
STEP 5

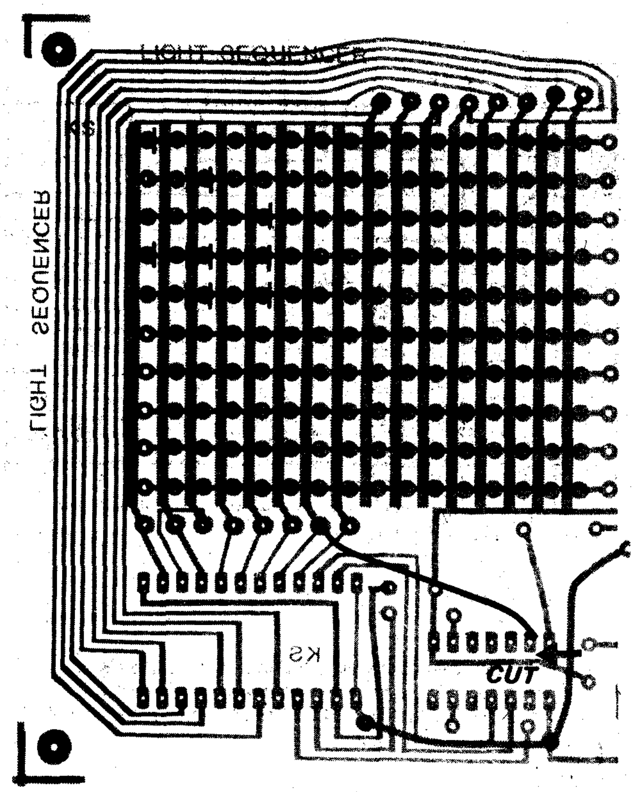
STEP 6

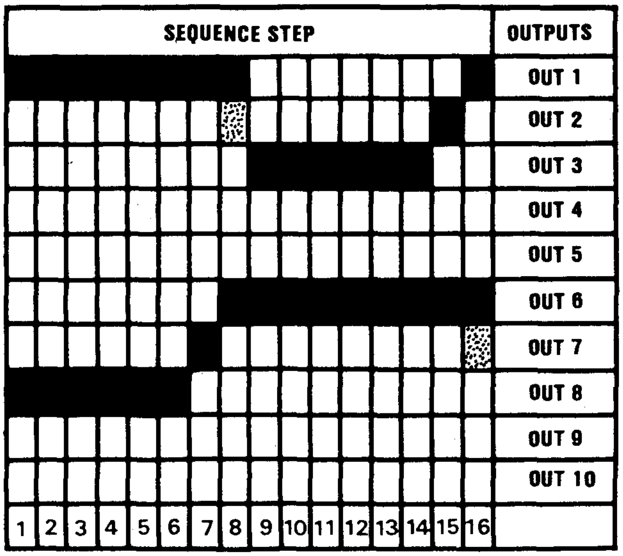
This diagram shows each of the steps of the roadworks arrow sign. It resets after six steps. To reset the Light Sequencer, cut the track that connects pin 2 of the 4024 to earth and solder a length of hookup flex between it and the output of the 4514 that corresponds to the step after the last step required by your sequence. In this case it is step seven. You can either solder to the vertical track of the matrix or directly to pin 5 of the 4514.



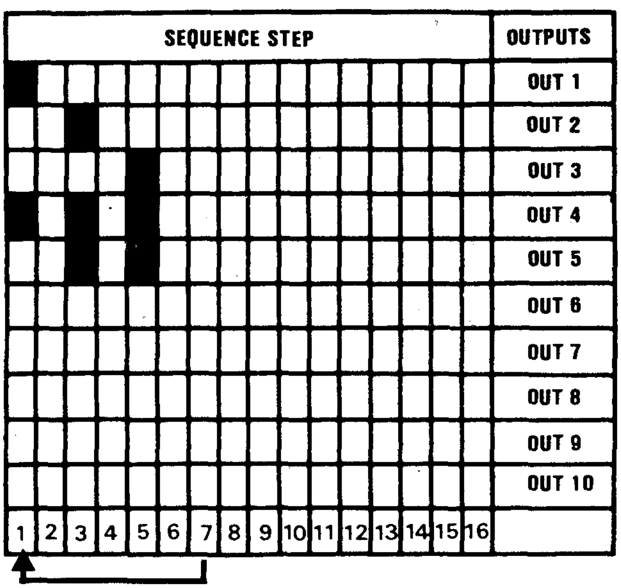
The LEDs on the arrow display can be divided into groups. There are some that will light every step, some that will light every six steps and some that light twice every six steps. There are five different groups, so only five outputs of the sequencer are needed. On this diagram, all LEDs have been numbered. These are the numbers of the outputs from which each LED will be driven.







LEFT: This component overlay of the diode matrix shows the positions in which the diodes for the traffic lights should be soldered. Compare the diode locations to the black boxes on the grid above. This should help you to work out the positions of the diodes on your own sequences. There are four outputs that are not being used in this sequence. They could be used to drive WALK and DON'T WALK signs.



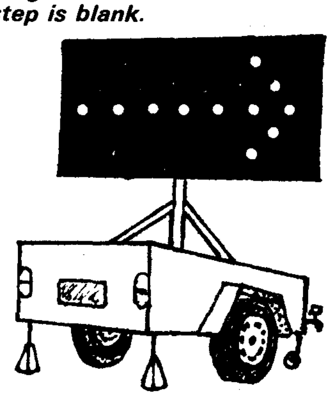
LEFT: This component overlay of the diode matrix shows the positions of the diodes for the roadworks arrow sign. Note the cut in the PC track and the link soldered in its place.

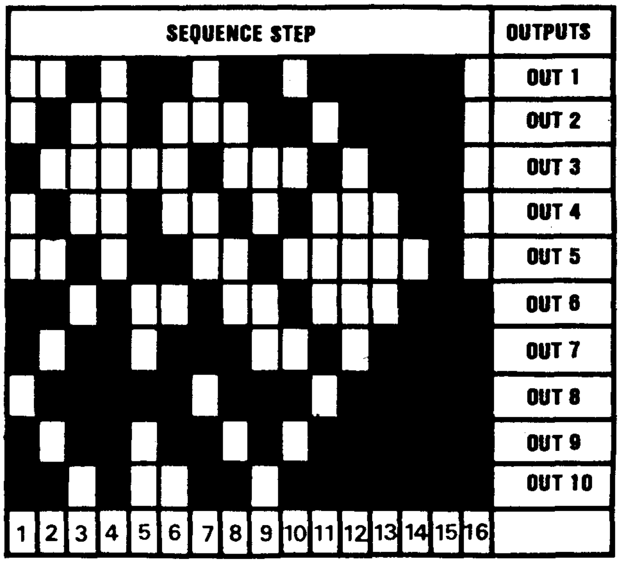
LEFT: This grid shows the positions of all of the diodes necessary to duplicate the traffic light sequence. A filled-in box means that a diode is at that junction. An empty box means no diode is at that junction. The two boxes shown shaded are for Victorian traffic signals. These diodes switch the amber lights on at the same time as the red lights just before the sequence goes to green.

You may think that the traffic lights cycle too fast, but there are two good reasons for this. To compensate for the less-than-scale miles used on model railways, clocks are run faster. Also, how many people are going to stand around for two minutes to watch a model traffic light change?

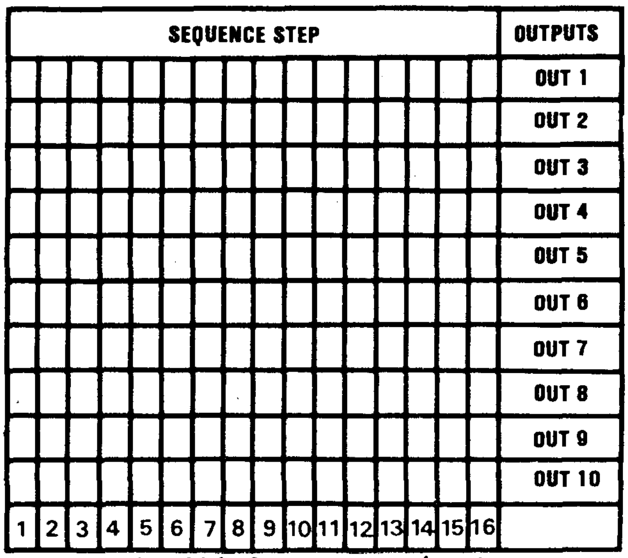
Out 1 = RED direction 1
Out 2 = AMBER direction 1
Out 3 = GREEN direction 1
Out 6 = RED direction 2
Out 7 = AMBER direction 2
Out 8 = GREEN direction 2

LEFT: This grid shows the diodes needed to reproduce the roadworks arrow sign. The arrow sign presented in the shop displays, though simpler, is not correct for the roadworks sign. It shows one, then two, then three arrow heads lit at a time. With the real roadworks sign, only one arrow head is lit, but its tail gets longer as it moves across the screen. Every second step is blank.

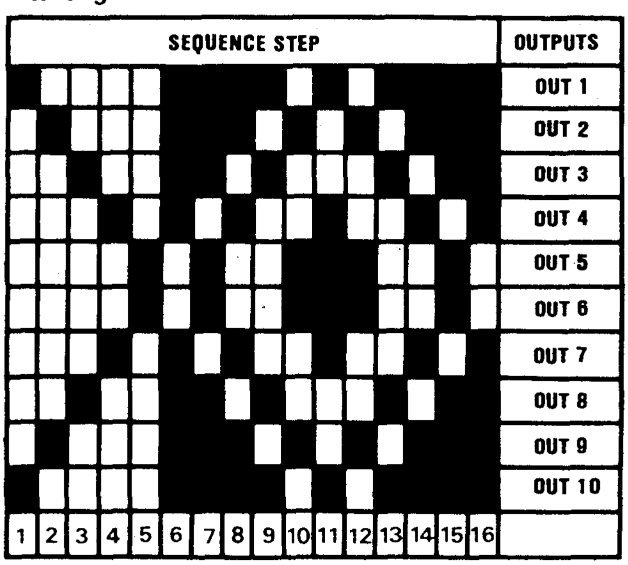




Left: This is an example of the type of shop displays that can be driven by the Light Sequencer. Each output is connected to a lamp or LED that is one of a string of ten. The variation in patterns that can be generated is almost limitless.



This blank grid is for you to work out your own sequences on. It may be photocopied to save writing in the book.



Left: This is another example of a shop display sequence that is possible with the Light Sequencer. There is something wrong with it.
It will work but it could have been built a lot simpler. The sequences programmed on one half of the matrix are a mirror image of the sequences on the other half of the matrix. It would be easier to run two lamps off each output than to have the sequence repeated on the matrix. This is a detail to be aware of when writing your sequences.

LED Resistors PCB

The LED Resistors PC board has been designed to simplify the wiring between the Light Sequencer and the LEDs it drives. It would have been impractical to have these resistors on the Light Sequencer PC board because the number and arrangement of them will vary from project to project.

The LED current limiting resistors are soldered onto the PC board. 24 of them will fit. They should be 470R to 1K. The resistors are connected together at one end. This common line can be taken to positive or negative depending on whether a common anode or common cathode type display is required by the driver circuit. The Light Sequencer requires a common anode type display. This will work nicely with individual LEDs but what happens when a display like the arrow sign is used? This display already has a common anode line.

Instead,the cathode lines from all the LEDs are soldered to the ends of the resistors that are not connected to each other. They are soldered in groups. For example, all the 1's on the arrow sign are soldered next to each other. The common track at the other end of the resistors is then cut, and one line, representing all the 1's is taken to the output on the Light Sequencer. The other LEDs are also wired this way.

Because of this, the LED Resistors PC board will always be drawn copper side up so that the cut tracks can be shown on the diagrams.

This board also has two short power rail busses to simplify wiring power between units. The best way to use these is to solder PC pins into all of the buss holes so that the units can quickly be connected and disconnected. A common rail for the LEDs is also included on the PC board. This can be made common anode (positive) or common cathode (negative) simply by soldering a link between it and one of the power busses. There are three holes on the PC board specially for doing this.

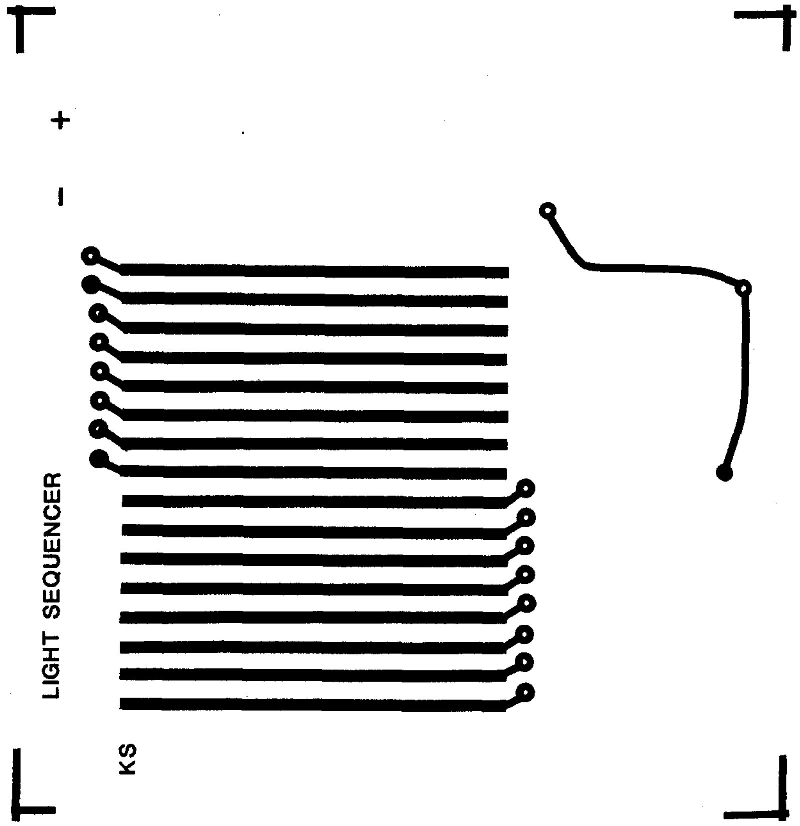
Light Sequencer Parts List

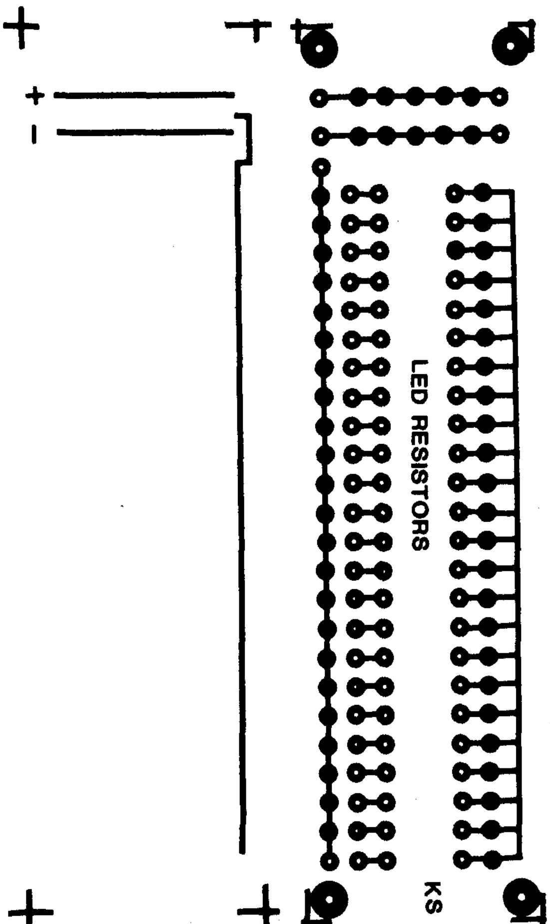
12 - 4K7
1 - 10K
10 - 100K
1 - 100K Mini trim pot

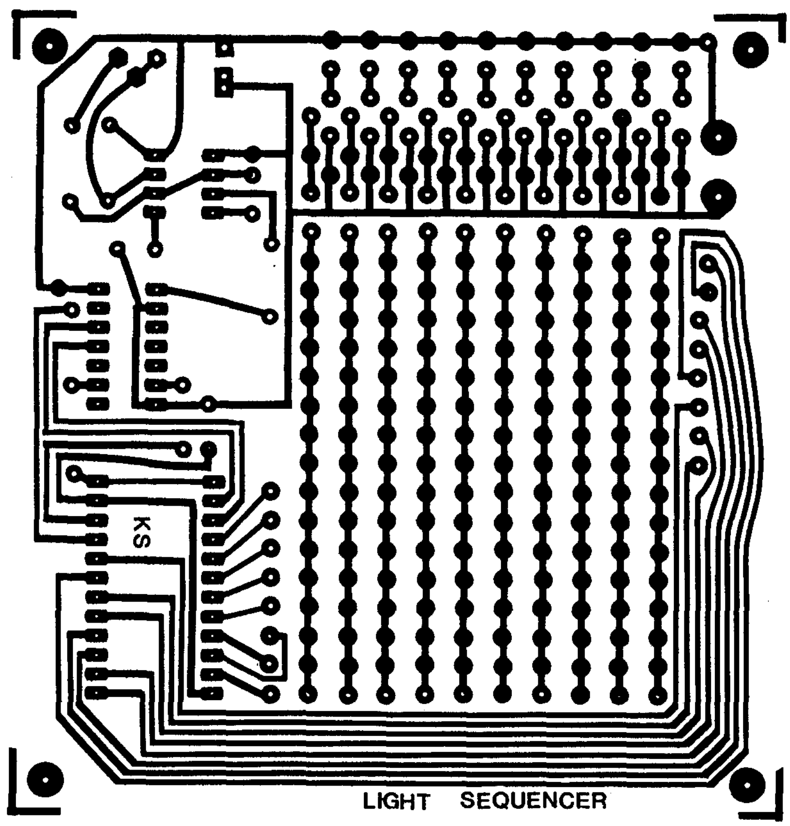
1 - 10n greencap
1 - 22 mfd electro
1 - 100 mfd electro

10 - BC547 transistors
1 - 555 timer
1 - 4024 counter
1 - 4514 decoder
40 - 1N914 diodes or more as needed

1 - 8 pin IC socket
1 - 14 pin IC socket
1 - 24 pin IC socket
1 - Light Sequencer PCB

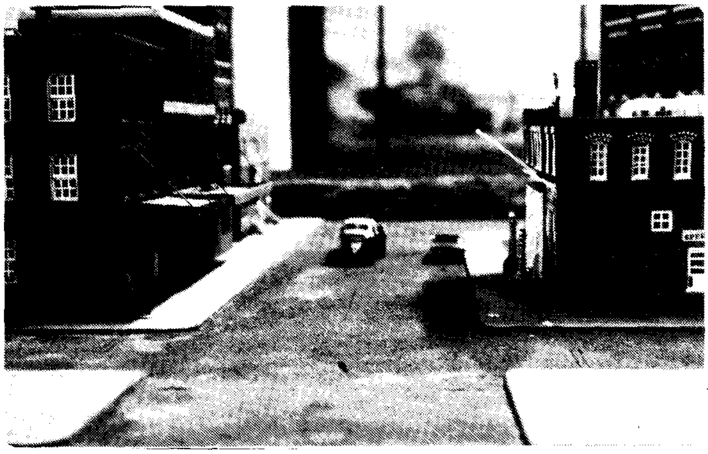






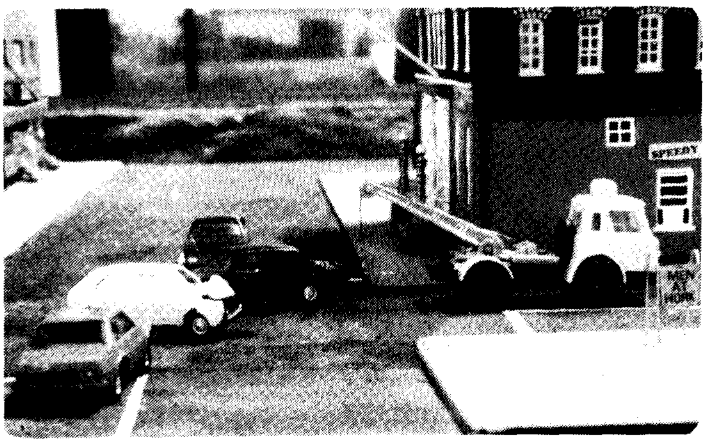
Up to 24 resistors can be mounted on the LED RESISTORS PC board. It is designed to be used with the Light Sequencer but can be used with any other circuit that drives LEDs such as the Pedestrian Crossing or the Shop Display Driver.

The Light Sequencer PC board is double sided. Those who are adventurous might like to try etching the board themselves, but the best way is to buy a ready made PC board.

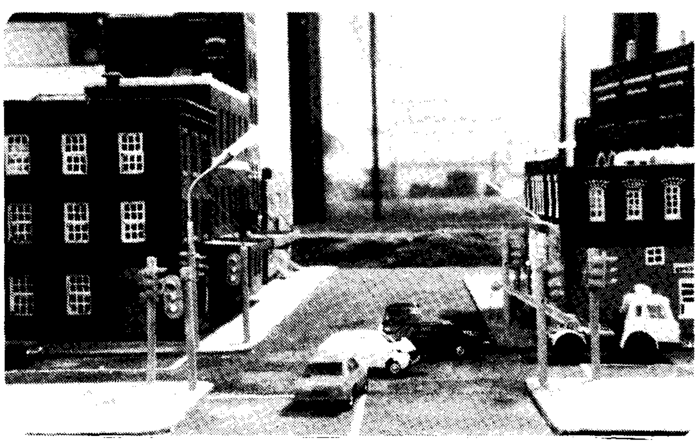


The first thing that is needed when modelling a set of traffic lights is an intersection. My layout is too small to include one so I decided to put the lights at the intersection on the club layout at the Victorian branch of the Australian Model Railway Association (AMRA).

Holes have been drilled for the traffic lights.



It is not a very good idea to place model cars at a set of traffic lights because when the lights change, the cars don't move off. This usually brings a smart remark from one of the viewers. The obvious solution to this is to give the cars a reason to stay put! One of the choices is to model an accident scene.



This is what the intersection looked like after the installation of the traffic lights. If you want to see them, call into the club and have a look. The address and meeting times are at the front of this book.

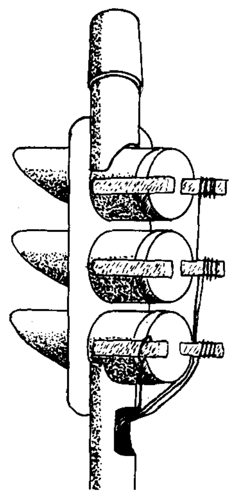
Modelling the Traffic Lights.

Now that you have completed the circuit board, the traffic lights have to be made. There are two ways of doing this; they are the hard way or the expensive way.

The hard way involves making all of the signals from scratch. This may seem easy to some but it wasn't for me. The easier way is to use the heads of commercial three aspect signals. These signals cost about four dollars each. At least eight signal heads are required to make a decent set of traffic lights, so this is where it becomes expensive!

The bulbs are removed from the signals and put in the junk box. If the signal posts do not resemble the posts of traffic lights, they are removed too.

Scrape the paint off the back of the signal heads. The next things to consider are the posts. If you look at the set of model traffic lights shown in the photographs, you will notice that the heads are mounted to one side of the posts. This is because the heads are a lot thicker than their real counterparts. The posts used on these models were pieces of ⅛" brass tubing. Instead of mounting the heads beside the posts, it would be possible to include them as part of the posts as shown in this drawing.



This drawing shows how it is possible to make the head of the traffic signal part of the post to compensate for the thickness of the LEDs. It also shows where to cut the hole for the wires.

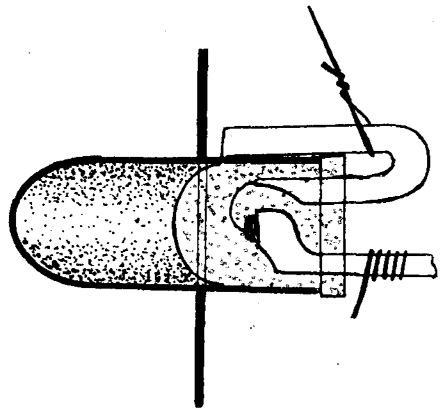
Before the head is attached to the post, there is something else that must be done. The lamps have to be installed. Actually, they aren't lamps, they are LEDs. LEDs were chosen because they don't draw much current, they don't get hot, and more importantly, they look more like the traffic light lenses than bulbs do. 3mm LEDs are used, and if you are careful which brand you choose, they should slip straight into the back of the signal heads. If they don't, try pushing a little harder. If they still won't fit, file them a little.

The traffic lights have to be wired as common anode if they are to be used with the Light Sequencer. Trim the anode lead of the LED and bend it back so that it touches the side of the signal head. See the drawing. Repeat this with all of the LEDs.

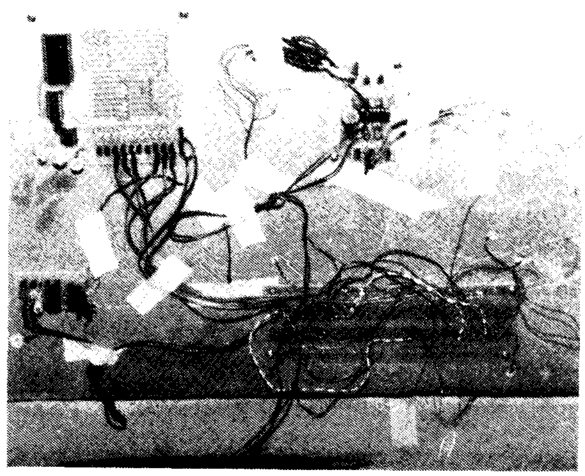
Solder the anode leads of the LEDs to the signal heads. Trim the cathode leads to about 5mm. Solder some fine enamel coated wire to each cathode. This piece of wire should be long enough to pass down the post of the traffic light and then be wired to the resistor board. A wire can be taken from the anode of one LED to serve as common. Alternately, the post itself can be used as common. These wires are twisted together and fed down a hole cut in the side of the post. Solder the signal head to the post and paint it. The head may be painted yellow or black, depending on the era being modelled. The post should be yellow. Several coats of paint may be needed to stop the light from the back of the LEDs shining through the paint.

WALK and DON'T WALK signs can also be modelled on the traffic lights. See the article on Three Coloured LEDs. Signal heads can also be mounted on street lights as they are sometimes in prototype practice.

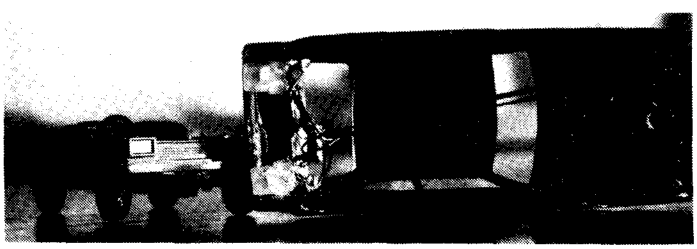
I have often seen model roads painted black. This is not very realistic. I have seen real asphalt roads ranging from light grey to dark grey and from green to red but I have never seen a black one.



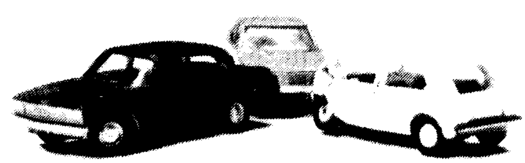
This drawing shows a cutaway of the signal head when viewed from below. Note the way that the anode lead of the LED is bent. Note also the way in which the wires are attached to the LED.
Take care when bending the leads of the LED, as it is very easy to damage the LED.



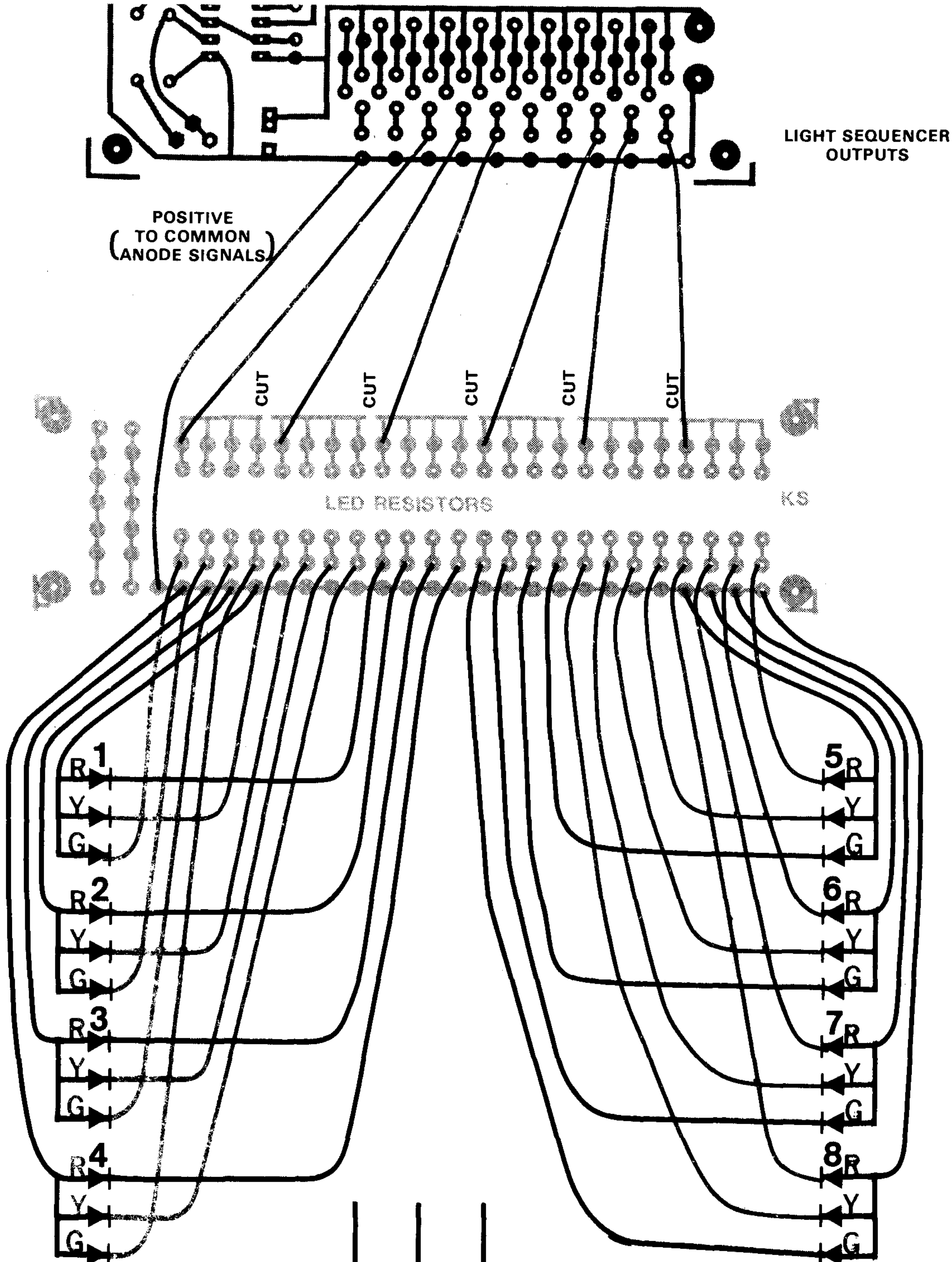
This is the under side of the traffic light and accident scene. The four boards are the Light Sequencer, the Warning Lamp Flashing Unit, the Rotating Light (see the next project) and an early version of the LED Resistors board. All boards except for the LED Resistors board have been wired with quick connect terminals.

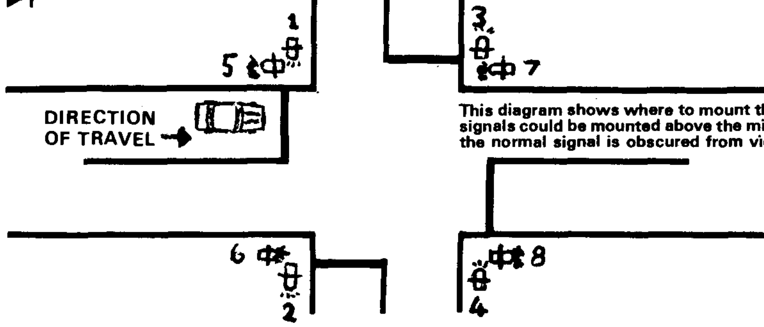


This model Capri has brake lights, rear hazard lights and front hazard lights fitted. They were made by filing down red and yellow 3mm LEDs. The LED resistors are mounted under the layout.



How to wire the traffic signals to the Light Sequencer board.

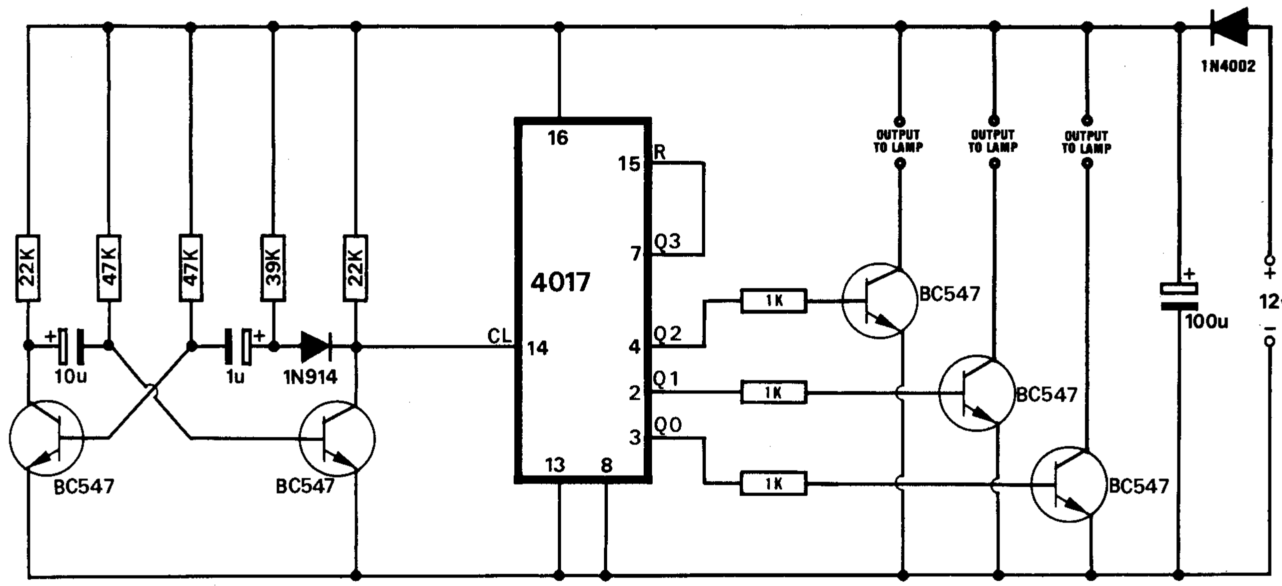




This diagram shows where to mount the eight traffic signals. Some extra signals could be mounted above the middle of the road. This is done when the normal signal is obscured from view by a hill.

ROTATING LIGHT

Add a little life to the accident scenes on your model railway.



The Rotating Light Unit is a dedicated version of the Shop Display Driver.

Quite a few people have modelled accident scenes. These scenes look very 'static' and are easily overlooked by viewers, unless placed strategically.

Some modellers have overcome this problem by putting flashing lights in the emergency vehicles at the scene. Ambulances and fire-trucks often use red LEDs driven by simple flashing circuits. Tow trucks use yellow LEDs, but due to the absence of a blue LED in the LED range, police cars have to use coloured lamps.

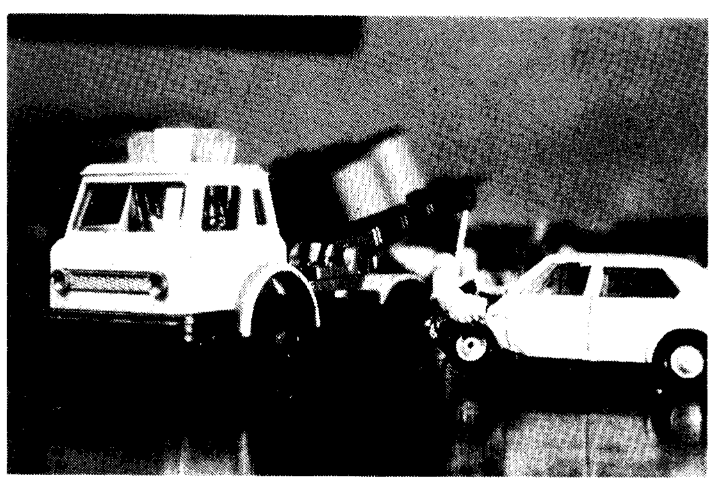
With a simple circuit it is possible to simulate the rotation of these emergency lights. Due to the small size of rotating lights on models it would be impossible to make them operate mechanically, so the easiest way to simulate them is to use a small circular light chaser.

The circuit.

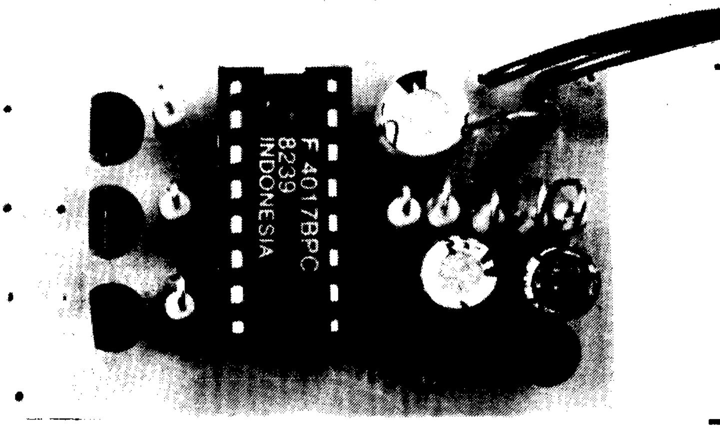
The rotating light circuit is a three step chaser. Compare the circuit diagram above with that of the Shop Display Driver on page 28. The two are almost identical. From this it can be seen that the Rotating Light is a dedicated version of the Shop Display Driver.

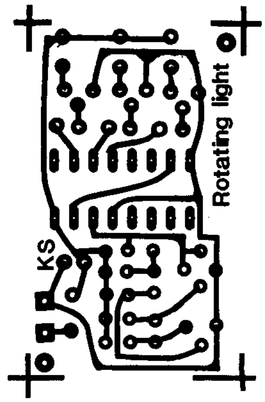
The Rotating Light circuit board is a lot more compact than the Shop Display Driver board for two reasons. The first is that a lot of the Shop Display Driver components are not required. The second is the Rotating Light was originally designed to fit on a ⅙ scale petrol driven buggy where space was limited.

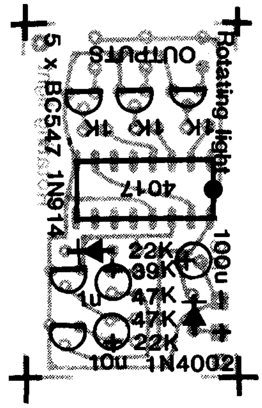
The circuit can drive two grain-of-wheat lamps off each output. This will be useful where LEDs are not practical. When LEDs are used, current limiting resistors are required but they can be shared, one between three LEDs, as explained on page 29.



The tow truck in the accident scene is a modified Viking model. The rubber-band and wire hook towing arrangement was replaced with something that looked a little more realistic. The single orange dummy rotating light was replaced with the twin rectangular unit described in this article.







Construction

Due to the small size of the PC board many of the components are mounted vertically.

Solder in the IC socket first as it is the lowest component on the PC board. Make sure all the pins go through the PC board.

I have repaired several projects in which constructors had accidentally bent a pin under the IC socket. They then soldered the socket without noticing the absence of a pin through one of the holes. This creates a fault that is very difficult to trace as it is not obvious on a visual inspection of the project.

The easiest way to repair this fault is to drill a small hole beside the socket near the bent pin. A small link is then soldered between the pin on the chip and the copper pad on the PCB. If at anytime you need to remove the chip, simply unsolder the link.

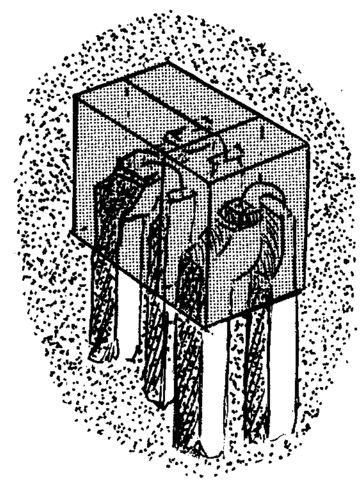
When inserting the resistors you will find they will fit better in one direction than the other. Refer to the photograph for the best orientation of them.

The next obvious step is to model the rotating lamp. Various methods will no doubt be tried, as there are several styles of rotating lamp in use. The easiest one to model is the dual rectangular style that is sometimes used on tow trucks.

To make this rotating lamp, six yellow 3mm LEDs are required, three per side. Each LED must be filed down until it is about 3mm by 1.5mm. The top is also filed flat. When selecting the LEDs, choose LEDs that have their internal structure low in the package as this will make it possible for you to shorten the LED to a reasonable height. Be careful not to file away the tiny wire inside the LED. Test each LED as you finish filing it. If it fails, throw it away and try again.

The next step is to glue the LEDs together using a clear epoxy. Plastic solvent will not hold the LEDs together as the LEDs are made of epoxy. Glue the LEDs together in groups of three, as shown in the drawing. Have the anodes of the LEDs in the centre as this will make wiring easier because the Rotating Light circuit drives common anode type displays. When soldering wires to the LEDs, take care because any stress on the pins of the LED could destroy it. Also, the heat of the soldering iron is enough to soften some epoxys, causing your assembly to fall apart.

Red LEDs can be filed to represent the emergency lights on ambulances and fire trucks, but as these lights are usually round, it may be easier to use 5mm LEDs with only the top showing through the top of the vehicle. There are no blue LEDs available and you can't file globes so I will leave the construction of police car lights to your imagination.



Three 3mm LEDs were filed down and glued together to form each of the rotating lights.

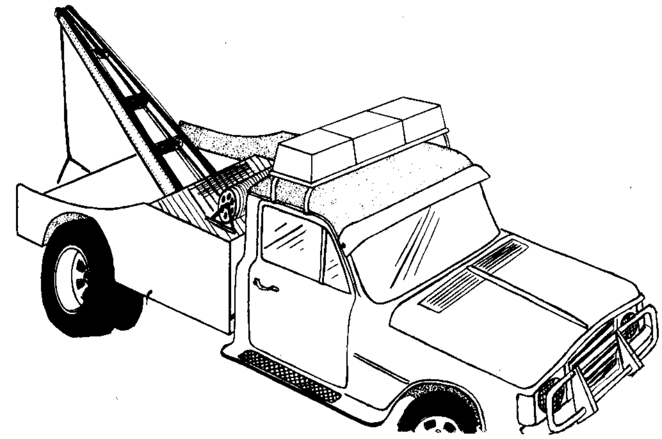
ROTATING LIGHT PARTS LIST

3 - 1K
2 - 22K
1 - 39K
2 - 47K

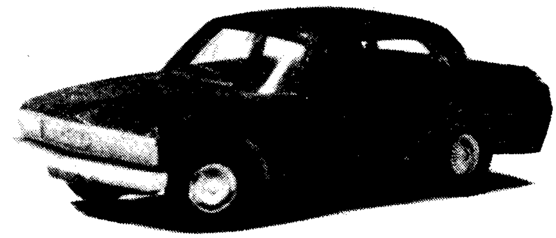
1 - 1 mfd electro
1 - 10 mfd electro
1 - 100 mfd electro

1 - 1N4002 diode
1 - 1N914 diode
5 - BC547 transistors
1 - 4017 chip

1 - 16 pin IC socket
1 - Rotating Light PCB

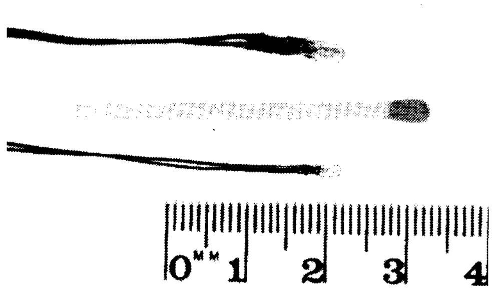


This drawing shows the twin rectangular rotating lights that are sometimes used on tow trucks.

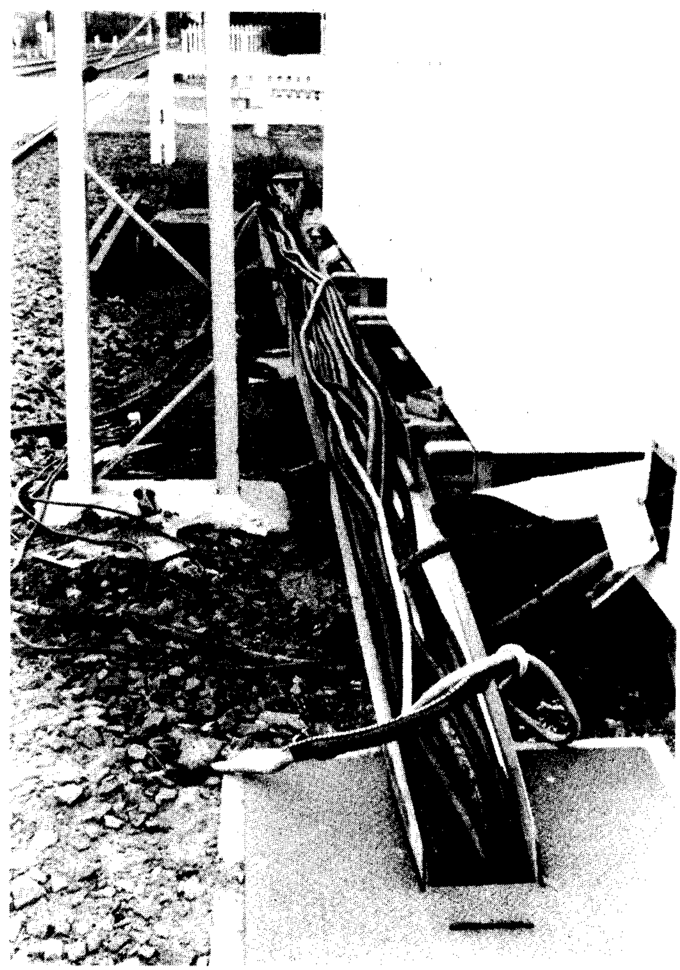


Two Viking cars were 'modified' for the accident scene. The modifications included sandpapered windows to simulate shattering, tyres flattened against a warm (not hot) soldering iron, doors knocked off their hinges and various dints inflicted with a small saw, a soldering iron and a knife. The cars were also modified to right hand drive.

The tow truck is at the accident scene on the AMRA club layout. Tow trucks usually get to an accident scene faster than the police or ambulance.



For those who want to model police cars, these tiny 1.5 volt globes should be ideal. The minature globe is pictured above with a normal grain of wheat globe to give you some idea of size.



Does **your** wiring look realistic?

A SIMPLE SINGLE BOARD

THROTTLE

Most commercial train controllers contain a transformer and a wire wound rheostat. These transformers often have an uncontrolled DC or AC output as well. Extra control units can be added to these train controllers, allowing independent control of two trains, on different tracks, simultaneously. This simple throttle is ideal as an add-on throttle for the control of shunting yards or a second main line. It can also be mounted in a box with its own transformer, as a stand-alone unit.

Construction has been kept very simple by the use of a printed circuit board. Nearly all of the components, including the heatsinked power transistor, have been mounted on the PC board, leaving only minimal external wiring. The only external components are the switch for changing the direction of the train, the speed control pot and the transformer.

The circuit operates very simply. The AC from the transformer is rectified by the diode bridge then smoothed by the two 1000 mfd capacitors. The current is then passed to the speed control circuit. A carbon pot has no chance of being able to supply the current needs of a motor directly so the answer is to buffer its output using transistors. The voltage on the pot wiper is fed to the base of the BC547 transistor. This transistor is wired as an emitter follower, so the voltage at the emitter of the transistor will 'follow' the voltage applied to the base of it. The transistor can supply more current than the pot, so now we have a buffered output. This output is still not enough to drive a motor, so we have to buffer it again. The principles are the same but this time a bigger transistor is used. The controller can now supply a variable voltage that is reasonably independant of the current being drawn through it.

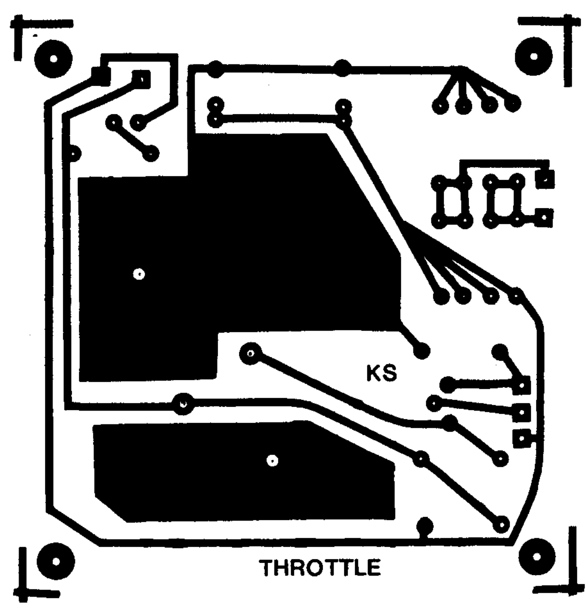
All components of the throttle except for the speed control pot and the direction switch are mounted on the printed circuit board. Construction is greatly simplified by the use of an on board heatsink.

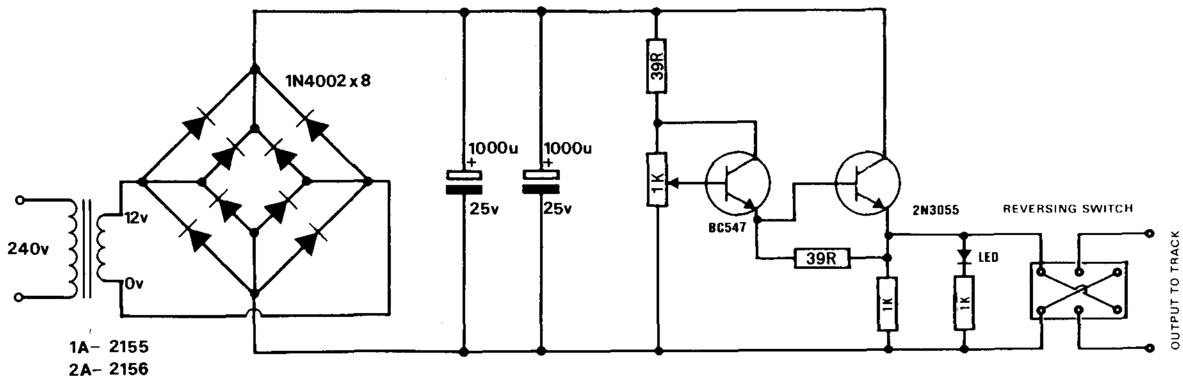
The throttle can supply 1 to 2 amps depending on the transformer being used. All diodes in the diode bridge have been paralleled to form a 2 amp bridge. The electrolytics will not be needed in all applications of the throttle and in most cases can be omitted. The pulse action of the unsmoothed DC can be beneficial to the starting of some motors.

This throttle does not have any overload protection built into it. If you feel that protection is necessary, there are two simple ways of providing it. One way is to put a 1 or 2 amp fuse in line with the output, depending upon both the transformer rating and the maximum current that your engines should draw. The other is to put a 12 volt car headlamp or brakelight bulb in line with the output. The best way to chose a bulb for this application is to try one or two of them.

Construction

Solder all of the small components onto the PC board first. Cut two pieces of insulating sleeving, each about 2mm long, and slip them onto the leads of the 2N3055 transistor. These pieces of tubing





will prevent the transistor from shorting against the heatsink.

Bolt the transistor and heatsink onto the PC board. No insulating kit is needed. Care must be taken to make sure that the heatsink does not come into contact with anything.

The final wiring of the unit can now be completed and the unit tested. When you are mounting the throttle unit in a box, make sure that the heat sink is well ventilated.

Throttle Parts List

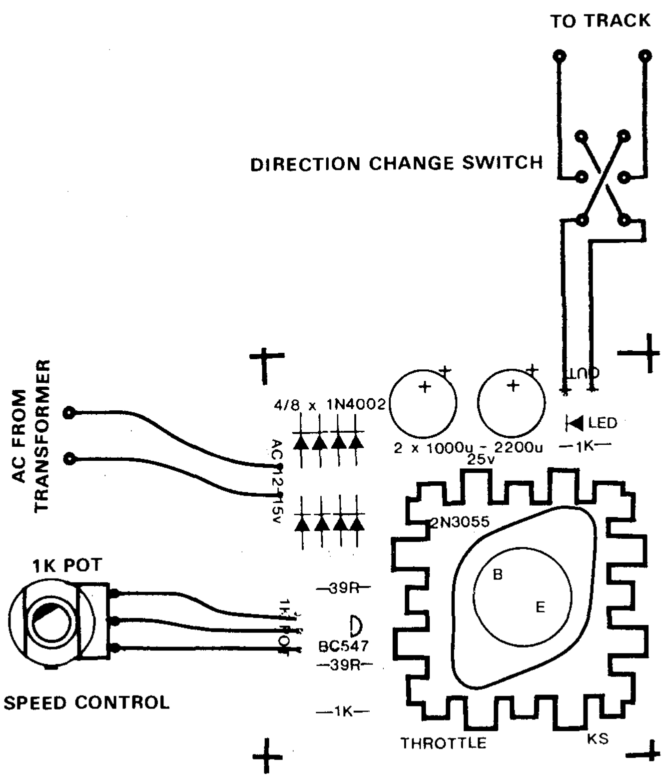
2 - 39R
2 - 1K

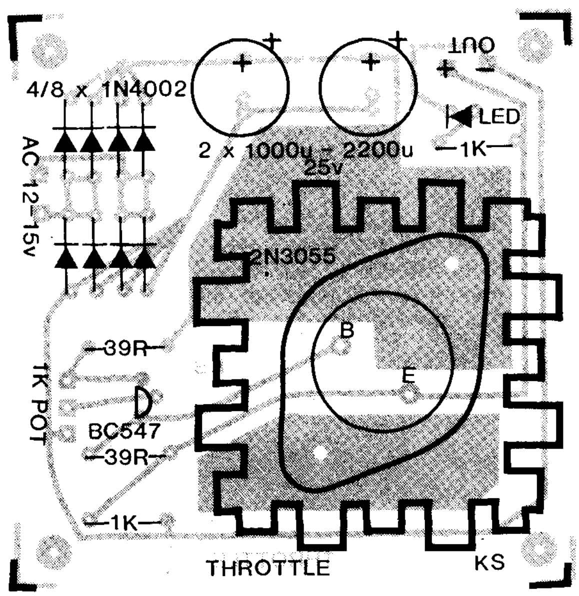
1 - 1K pot

2 - 1000 mfd electro's

8 - 1N4002 diodes
1 - red LED
1 - BC547
1 - 2N3055

1 - T03 Minifin heatsink
2 - nuts & bolts
1 - DPDT Switch
1 - Throttle PCB
1 - transformer 2155 or 2156





For simplicity, the external wiring of the throttle has been kept to a minimum. The wiring needed to complete the throttle is shown in this diagram.

TRAIN DETECTORS

Two simple light activated train detectors that can be used to trigger other circuits or to drive LEDs on a remote panel.

On a large model railway with numerous tunnels and stretches of track that are hidden from the operators view, knowing exactly where a train is can be a problem. This is why train detectors were invented.

Train detectors have been used for years on real railways for the same reason.

There are two train detectors presented in this article. One is simple and cheap. The other offers better operation but at a higher price.

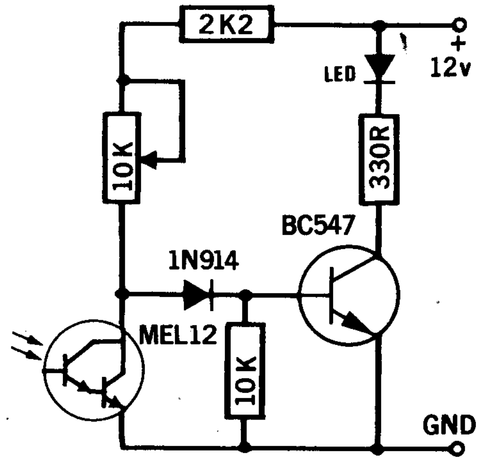
The first train detector PC board has provision for five of the simpler sensors. The board can be cut up and the sensors separated if required. Each sensor consists of three resistors, a trim pot, a diode, a transistor, a LED and a darlington photo-transistor. This photo-transistor is an MEL-12.

How each detector works

Normally the MEL-12 will be placed between the sleepers of the track in a position where light falls on it. The trimpot should be adjusted to a value where this amount of light is enough to switch the MEL-12 on hard enough to pull LOW the voltage at the juntion of its collector and the trim pot. This voltage is fed through a signal diode to a transistor.

The purpose of the signal diode is to drop the voltage from the junction of the MEL-12 and the trim pot by .6 volts to make sure the transistor switches off when the MEL-12 is conducting. When darkness covers the MEL-12 (a train is blocking the light) it switches off, allowing the trimpot to pull the base of the transistor HIGH. This turns the transistor on which in turn drives the LED. A relay could be driven if connected across the LED and resistor. A protection diode would be needed to stop the back EMF from the relay coil damaging the transistor.

Usually neither the LED or the MEL-12 will be mounted on the PC board. The MEL-12 will be between the tracks as mentioned previously, and the LED will be on a display panel remote from the layout. For this reason the LEDs are wired as a



This is the circuit diagram of the simple sensor. There are five of these units on the Train Detector PC board. If the detectors are to be used in a poorly lit area, the sensitivity can be increased by replacing the 10K pot with a 50K pot, or by increasing the value of the 2K2 stop-resistor.

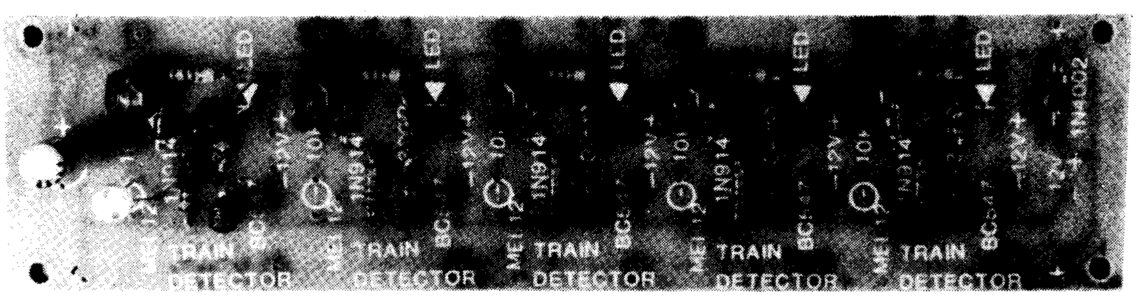
common anode display. Only the cathode of the LED need be taken back to the Train Detector PC board. All the anodes can be connected to positive.

Construction

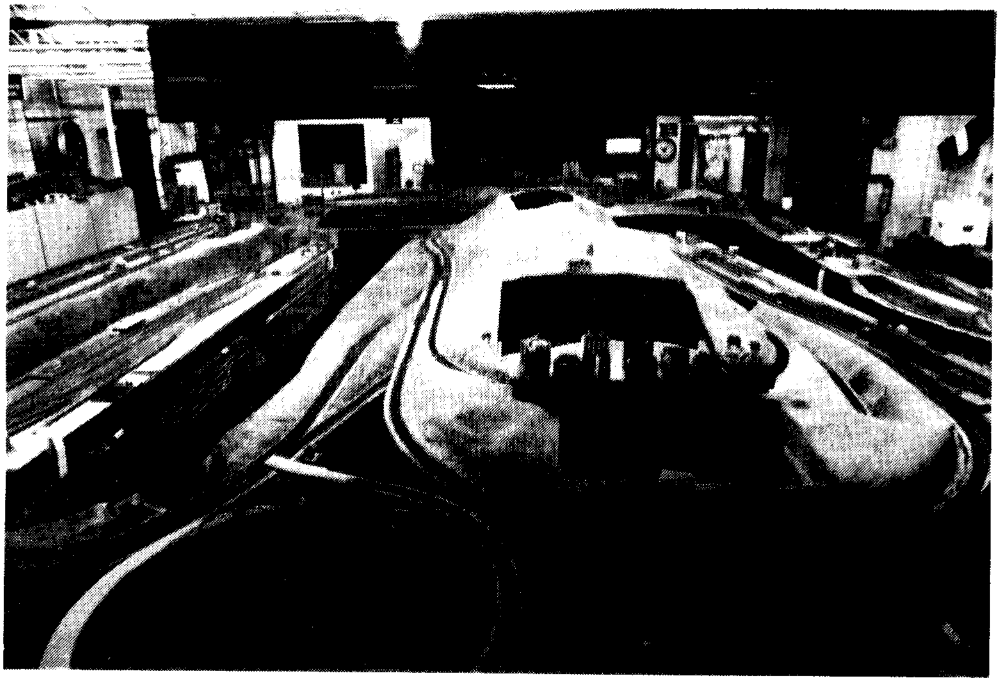
Check that the holes for the five trimpots are large enough. If not, enlarge them a little with a drill. Solder in all the resistors and diodes first, followed by the electrolytic, the trimpots and the transistors.

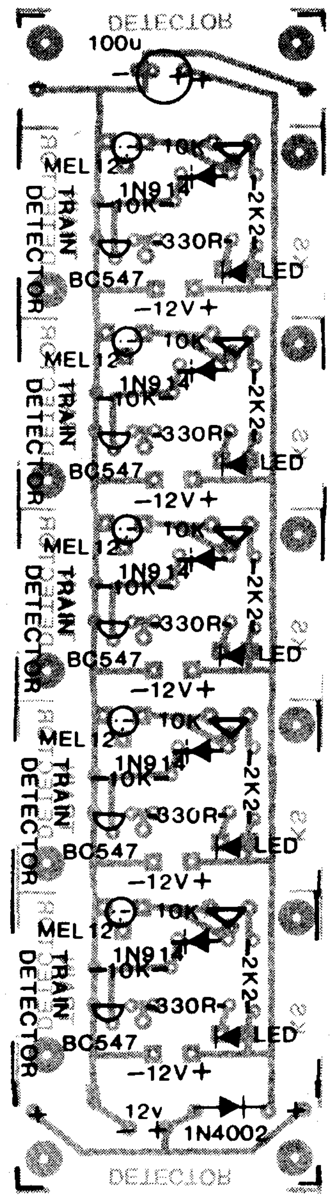
The LEDs and MEL-12s may be tacked into position for testing purposes but it is not necessary, as the circuit can easily be aligned when installed into the layout.

The board has been designed in such a way that several of them can be mounted side by side. The power rails between boards can then simply be connected using very short links, making

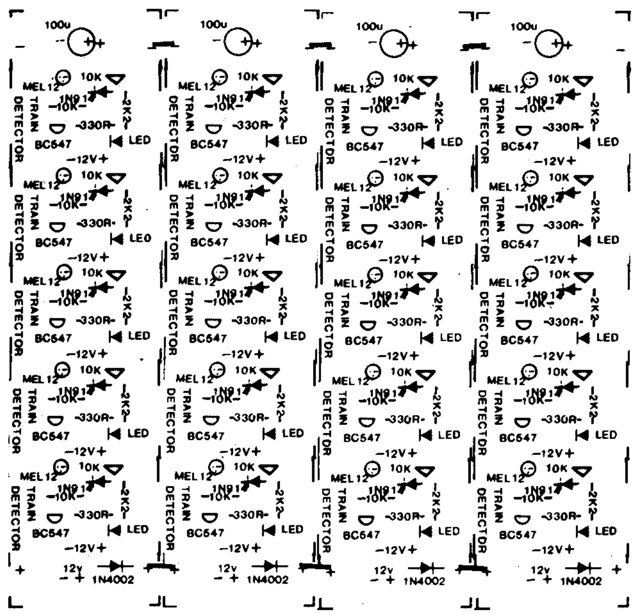


There are five detector circuits on the simpler Train Detector unit. They may be separated if necessary.





On a large layout with tunnels and hidden stretches of tracks, it is difficult to know the location of one train, let alone several. Signals, point positions and train locations are all indicated on the track plan above the layout at the Victorian branch of AMRA.



Train Detector Parts List

5 - 330R
5 - 2K2
5 - 10K

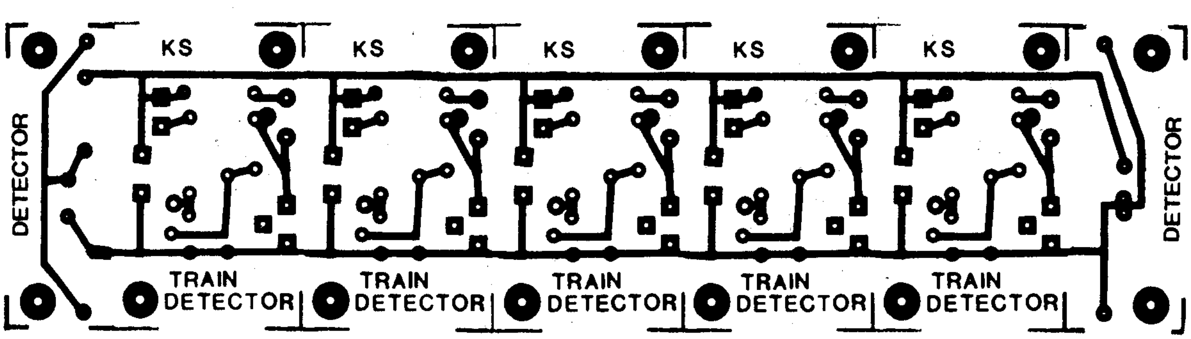
5 - 10K minitrim

1 - 1N4002 diode
5 - 1N914 diode
5 - 5mm LEDs
5 - BC547 transistors
5 - MEL-12 photo-tran.

1 - 100 mfd electro

1 - Train Detector PCB

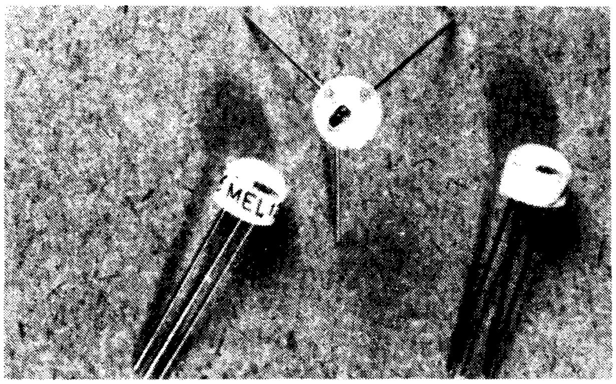
LEFT: The Train Detector boards can be mounted side by side with the power rails connected by short links. This makes centralized mounting very neat.



centralised mounting neat. Of course the LEDs and MEL-12s would have to be connected via long leads.

The LEDs can be mounted on a panel displaying the track plan of your layout, to give an indication of the location of your trains.

The MEL-12s should be mounted between the tracks about a train length apart, so that there is always a LED lit on the panel.



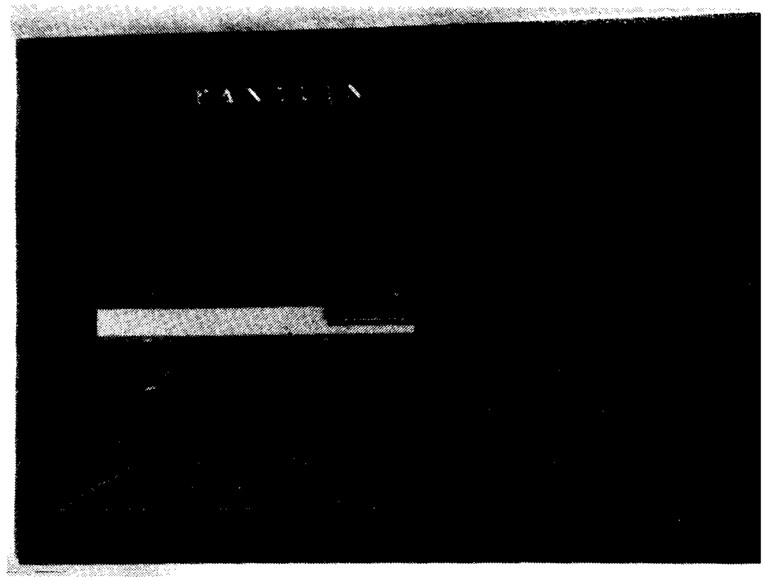
Three MEL-12 photo-transistors. The darlington transistor can be seen inside the top of the device. The collector is the lead with the transistors mounted on it. Fine wires join the other leads to the transistors.

The Train Sensor with Delay

Although this is the more complex of the two sensors, it is still very simple. It is based on the 74C14 hex Schmitt inverter. As each sensor only needs one inverter, there are six sensor circuits on the PC board, thus the name 'Hex Train Sensor (with delay).'

How it works

When light is falling on the MEL-12, it switches on, pulling the input to the delay circuit LOW. The capacitor will be charged slowly via the 100K



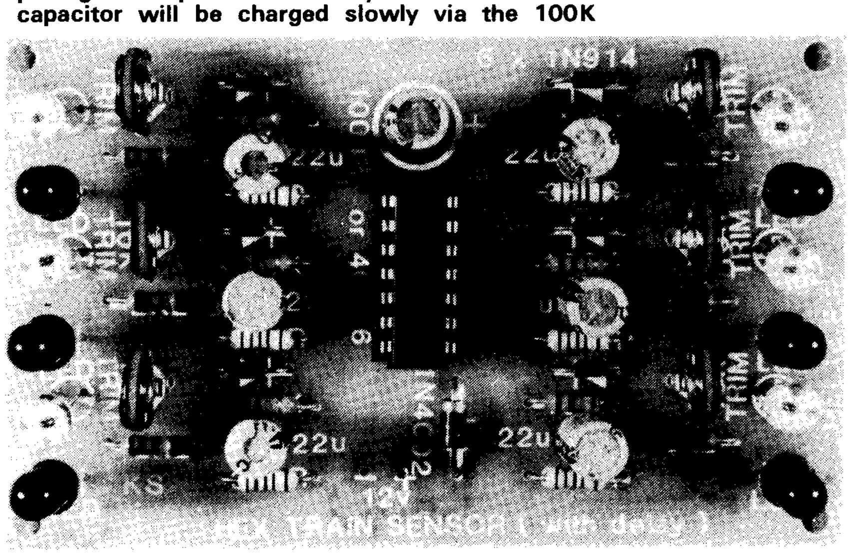
A close up of the track plan, showing the LEDs.

resistor. When the voltage on the capacitor reaches the lower threshold of the Schmitt inverter, its output will go high and switch off the LED. This indicates that there is no train above the sensor.

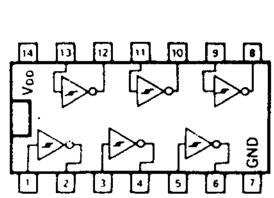
When a train does pass over the MEL-12, its shaddow switches off the MEL-12. The 22mfd capacitor then rapidly discharges through the 1N914 diode, and the trim-pot and its stop-resistor. This pulls the input of the Schmitt inverter HIGH. The output of the Schmitt inverter then falls LOW and switches on the LED.

When the train has passed and light falls on the MEL-12 again, it switches on and slowly recharges the 22 mfd capacitor.

The result is that the LED will switch on as soon as a train covers the MEL-12, but will remain on for a short while after it has passed. This is so the gaps



The LEDs and MEL-12 photo-transistors were mounted on the PC board to test the Train Sensors. The 10K pots can be placed with 50K pots if more sensitivity is needed.



Pinout of the 74C14

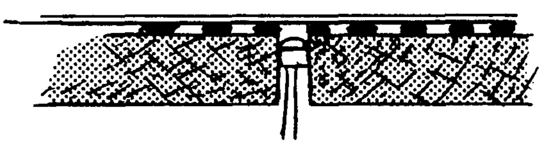
between the wagons or coaches on a train will not cause the LED to flicker as occurs on the first sensor described.

It is important to note that this circuit can not drive a relay directly. This is where the Remote Relay Unit would be ideal.

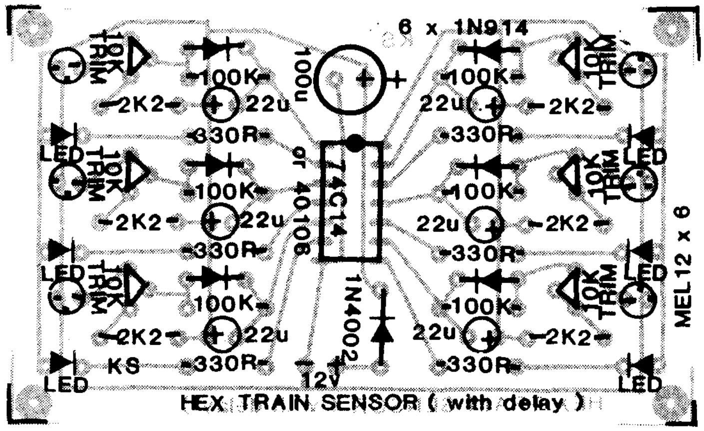
Construction

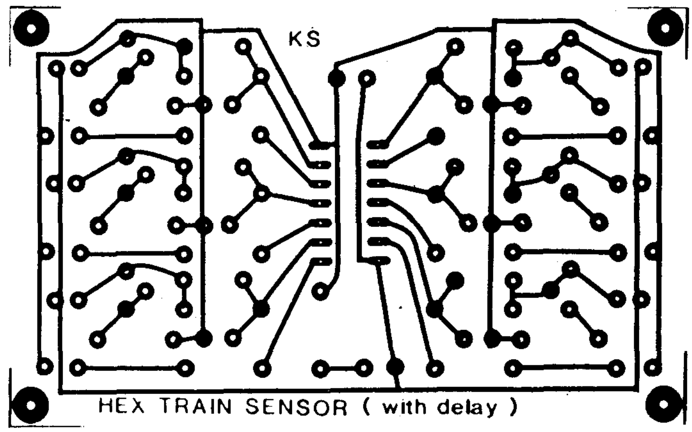
The Hex Train Sensor is a repetitive circuit. Excluding the 74C14, the power diode and the 100 mfd electrolytic, every other component is present six times on the PC board.

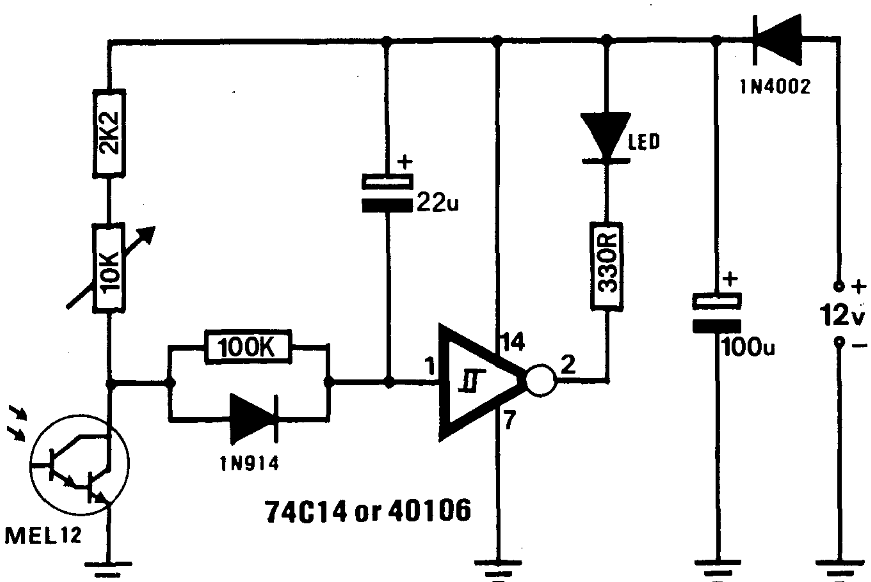
The first component to install is the IC socket. Then solder in all of the low components. The trim-pots are next, followed by the electrolytics. The LEDs and MEL-12s need not be installed unless you want to test the unit before wiring it into your layout. Quick connect terminals would help greatly in both the wiring and testing of the unit, as one LED and one MEL-12 could be tried on each Sensor in turn. The base lead of the MEL-12 is not needed, so it can be trimmed short.



To mount the MEL-12 photo-transistors, drill a hole between the sleepers. Push the MEL-12 up the hole from below and secure it with some tape. With it connected to the circuit, adjust its position in the hole so that only light from directly above will fall on the MEL-12. If light falls on the MEL-12 from too low an angle, the train will not have enough shaddow to trigger the unit. It is important to remember that it is darkness that triggers the train sensors. Disconnecting the delay capacitors while aligning the unit will make the job a lot easier.







The 100 mfd electrolytic and the 1N4002 power diode are common to all of the sensors on the PC board, as are the chip's power rails. Look at the pinout of the 74C14 for the connections to the other schmitt inverters.

Hex Train Sensor (with delay)

Parts List

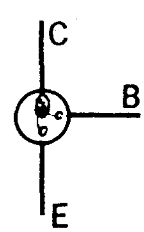
6 - 330R
6 - 2K2
6 - 100K

6 - 10K minitrim

6 - 22mfd electro's
1 - 100mfd electro

6 - 1N914 diodes
1 - 1N4002 diode
6 - 5mm LEDs
6 - MEL-12 photo-trans.
1 - 74C14 chip

1 - 14 pin IC socket
1 - Hex Train Detector (with delay) PCB

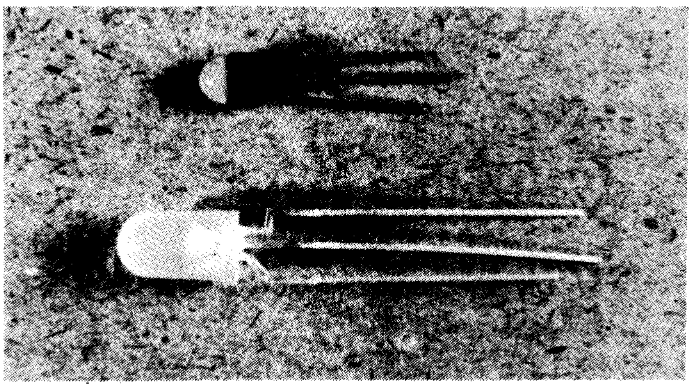


Pinout of the MEL-12

HOW TO USE

THREE COLOURED LEDS.

ON MODEL RAILWAYS.

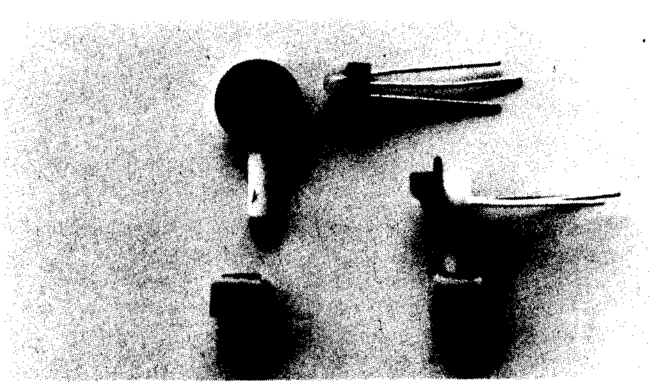


The two types of Dual LED mentioned in this article. The top one is from the F&G kit, the bottom one is from Dick Smith Electronics.

Tri-colour LEDs became available a few years ago. They did not prove to be too successful. The first problem with them was that they only had two leads. This meant that if you wanted to change between red and green you had to reverse the polarity on the LED. The third colour had to be generated by alternating between the red and green LEDs quickly. The amount of circuitry needed to switch between these three colours and also provide an off state, was not worth while. The third colour which was meant to be yellow or orange was very poor because the green and red used to generate it did not mix very well.

There are now some dual LEDs available. These LEDs have both a red LED and a green LED mounted inside them, but the difference is that each LED has its own anode. Because of this, controlling the LED is a lot easier. The 'yellow' is still poor.

This DUAL LED can be of great advantage to the railway modeller. There are two sources of which I am aware. One is Dick Smith Electronics. His dual LEDs are 5mm LEDs. This makes them a little large for HO scale signals unless they are filed down. They can be adapted for other uses where the larger diameter is acceptable. One such use is the WALK/DON'T WALK signs for the Pedestrian Crossing. These LEDs are common cathode, so a little circuit adaption is needed before they will connect.



The F&G Operating Ground Light kit contains two dual LEDs and four painted metal castings, which is enough to make two ground signals.

The other source of dual LEDs is F&G Models. Their dual LED is not available by itself, but comes in a kit. Two of these dual LEDs are supplied along with some painted metal castings. These make up two small ground signals. They are short 3mm LEDs and when built into the ground signals, do not look at all overscale.

From a DICK SMITH ad.

Want some of these?
We'll LED you have em!
New! Dual Colour (RED/GREEN) in standard 5mm (3 lead) pack great for model train signals!!!
Cat Z-4070 **60¢**

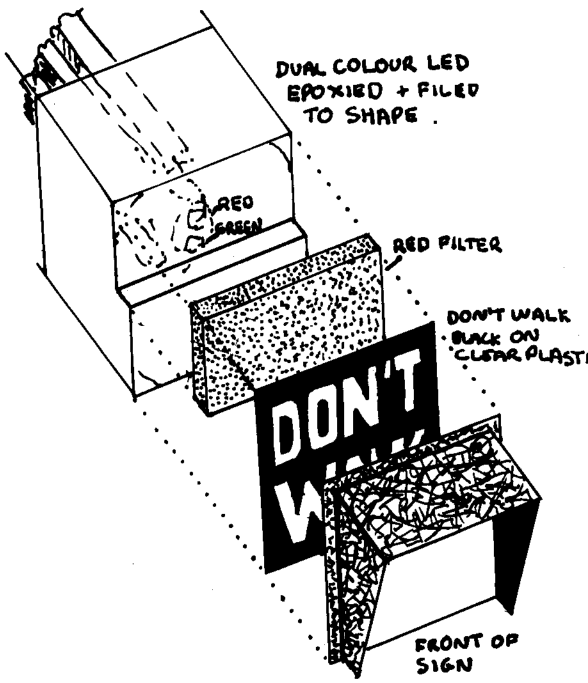
F & G MODELS

BRING YOUR LAYOUT TO LIFE

with our quality painted cast detail parts eg. train crew, machinery, boom gates sacks, bins, boxes, barrells & many more at your hobby shop or send SAE for list

P.O. Box 149 KILSYTH 3137
(03) 754 5758

These are the only two sources of dual LEDs of which I am aware. The dual LED from Dick Smith Electronics is a 5mm device, while the one from F&G is 3mm.



A very compact WALK/DON'T WALK sign can be made using a dual LED. The LED is filed until it is square. A little epoxy might be needed on the corners. A recess is filed into the front of the LED so that a piece of translucent red plastic can be glued there. The LED should be orientated so that the RED LED wafer is behind this filter, at the top, and the GREEN LED wafer is at the bottom. A piece of film with 'DON'T WALK' written on it is then stuck on the front, along with the sun shield. The DONT WALK sign can be made by carefully scribing the letters on a piece of black photographic film, such as a developed piece of unexposed slide film. Those with good cameras might even like to try making the signs photographically.

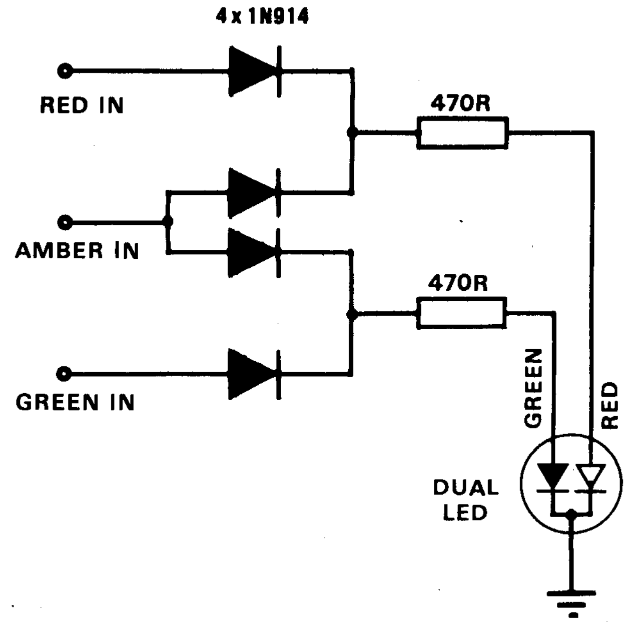
Driving these dual LEDs from your existing signal system is the next problem. If you have a two aspect system, then you will be quite pleased with the dual LED signals. If you have a three aspect signal system, you will have to put up with the poor yellow colour. These LEDs are advertised as being two coloured so the yellow is a bonus anyway.

The next thing to consider is that some signal systems use a common earth for the signal while others use a common positive. As the dual LEDs are common cathode they can be connected very easily to a common earth system.

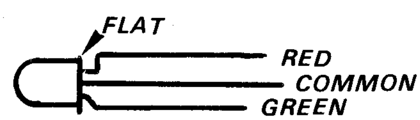
If your signal system is two aspect and uses a common earth, the only components needed to connect the dual LED into the circuit are two 470R to 1K resistors. The old bulb signal is removed and a resistor is soldered to each of the active lines. The anodes of the dual LED are then soldered to the other ends of the resistors, making sure that the red line goes to the red LED and the green line goes to the green LED. The cathode is then soldered to the earth line.

If you have a three aspect common earth system, then wiring is not that much more difficult. Four signal diodes can be used to adapt the three line system to the two line system needed by the dual LED. These diodes are really forming two simple diode OR gates.

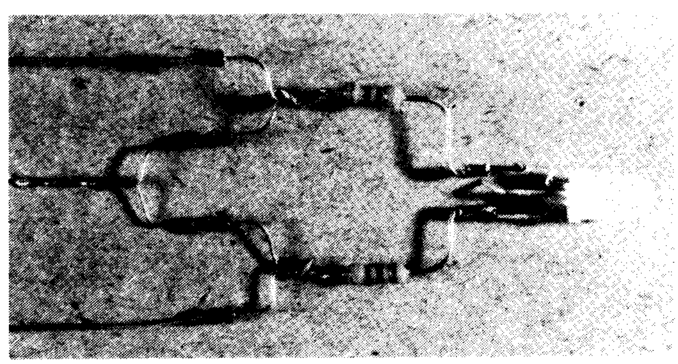
Construction is so easy that the use of a printed circuit board is not worth while. Look at the photo that shows how I wired a dual LED to the diodes and resistors. As the LED would normally be remote from the components, you may find it convenient to solder the components onto a piece of matrix board.



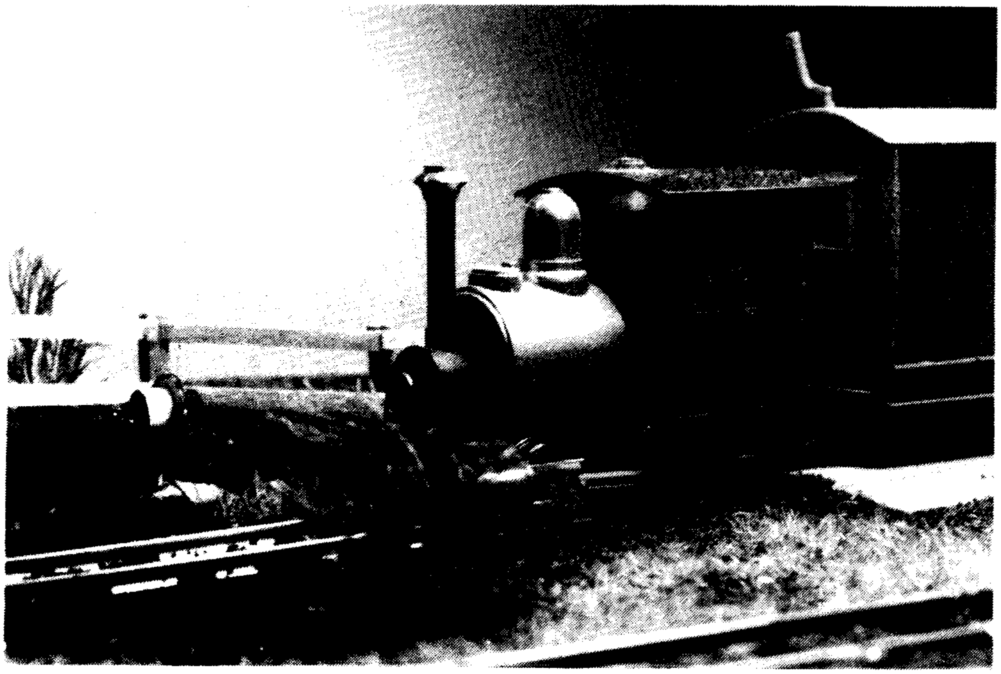
Connecting a dual LED to a three line common earth signalling system is very easy. Only four diodes and two resistors are required.



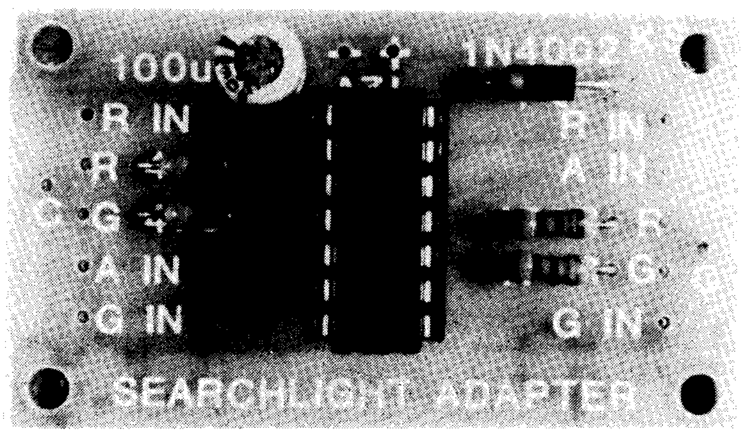
Pinout of the Dick Smith LED.

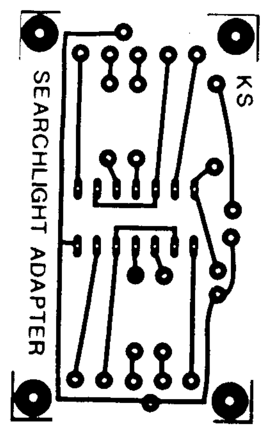


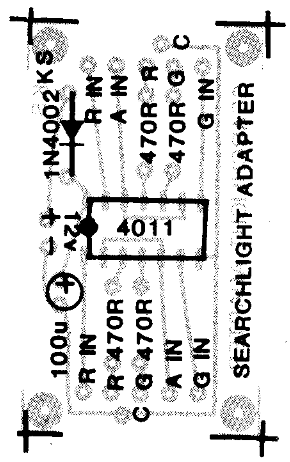
The three line to two line conversion circuit is so simple that no PCB is needed.

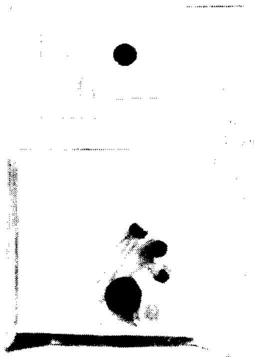


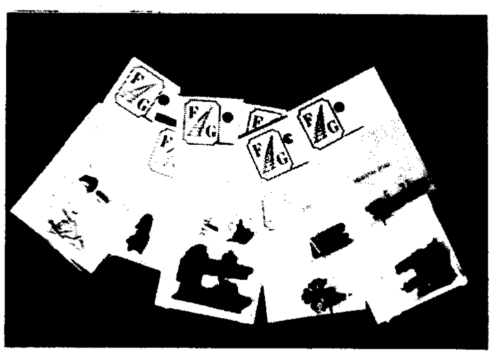
A narrow gauge locomotive pauses, waiting for the ground signal to turn green. The locomotive is about 4cm long.











The Operating Ground Light kit comes neatly packed on a small card. Some wiring instructions are included. The kit is one of a range of excellent metal castings offered by F&G models.

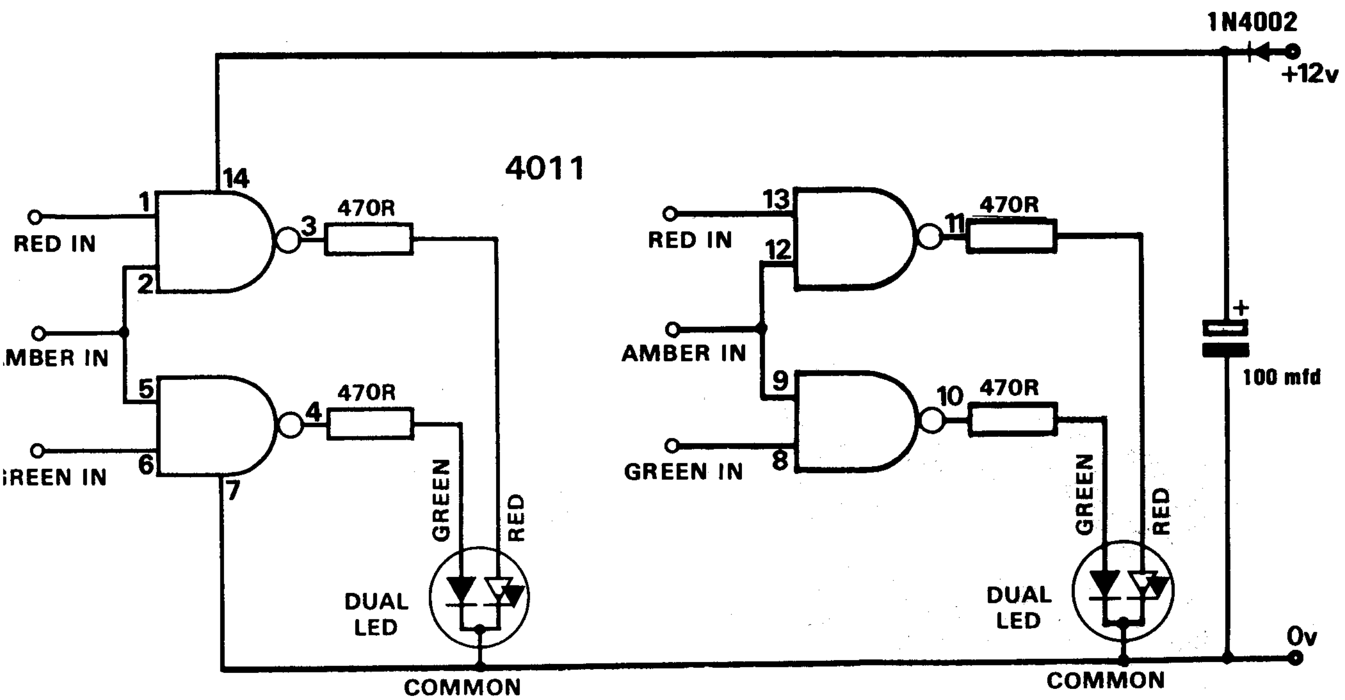
SEARCHLIGHT ADAPTER PARTS LIST

4 - 470R
6 - 100K

1 - 100 mfd electro

1 - 1N4002 diode
1 - 4011 quad NAND

1 - 14 pin IC socket
1 - Searchlight Adapter PCB



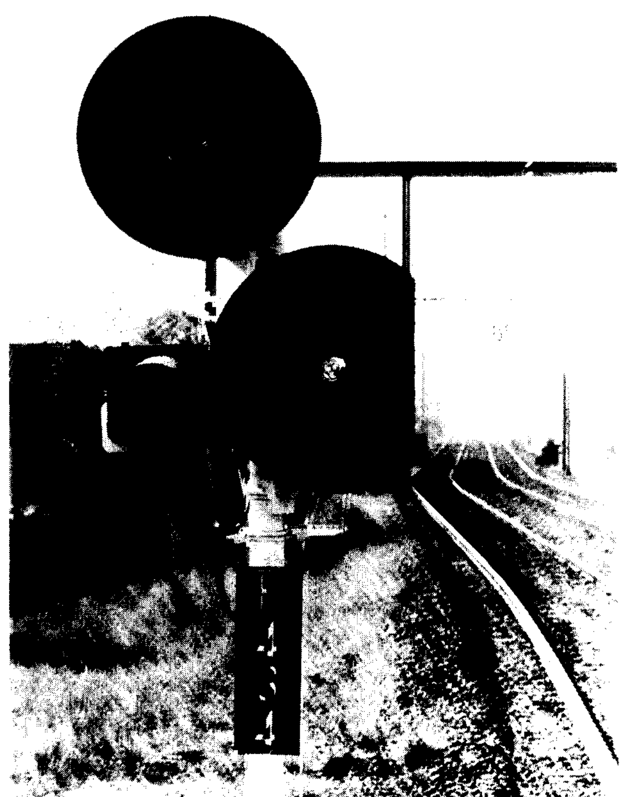
There are two adapter circuits on the Searchlight Adapter PC board. Pull-up resistors are needed on each input of the circuit, if they are being driven by a relay or an open collector transistor driver.

Connecting a dual LED to a common positive system is not as easy. It requires a little extra circuitry. Look at the circuit diagram of the Search Light adapter. All of the signals from the common positive signal drivers need to be inverted. This is because each time a lamp is to be turned on, the active line to it goes LOW. This means that the active lines of all lamps that are not lit will be HIGH. If your system is only two aspect, this may not seem to be such a problem. Sometimes all that you have to do is swap the red and green wires around and wire the common of the dual LED to earth instead of positive. Resistors will be needed in each active line again. However, this will not work for all two aspect systems. If the output to the signal lamps is from a relay or transistor, it is likely that the circuit is not capable of taking the anode of the LED to positive. Now a chip is needed to invert the signal to the dual LED. This is what the Search Light Adapter does. It also works on three aspect signals.

The three lines from your existing system are connected to the corresponding inputs on one of the two adapters that are on the Searchlight Adapter PC board. An external 100K pull-up resistor is needed on each input of the adapter if the signal system uses relays or open collector transistor drivers. If the signal system uses digital chips the pull-up resistors can be omitted.

Wire the dual LED to the output of the adapter and test the signal. If you only have a two aspect signal, take the input of the colour not in use to positive. On a HOME signal, this will be Amber and on a DISTANT signal it will be RED.

The dual LEDs can also be mounted on the track plan display, to give a novel indication of signal status.



PRELIMINARY

USING COMPUTERS ON MODEL RAILWAYS.

This article gives a preliminary look at computers in model railways. An in depth article will be presented in a future publication. Computers look very complicated, especially when information on them is presented in thick, hard to understand books. Computers are more easily understood if they are looked at in small modules. Software also has simple 'modules' or concepts that can be explained one at a time. The computer was invented to help us, so why not use them?

When a computer is mentioned to a railway modeller, the first thing he thinks of is automatic train control. Computers can be used to control the running of trains, but there are also a lot of other uses for computers on model railways. If you enjoy running your trains, why give the job to a computer?

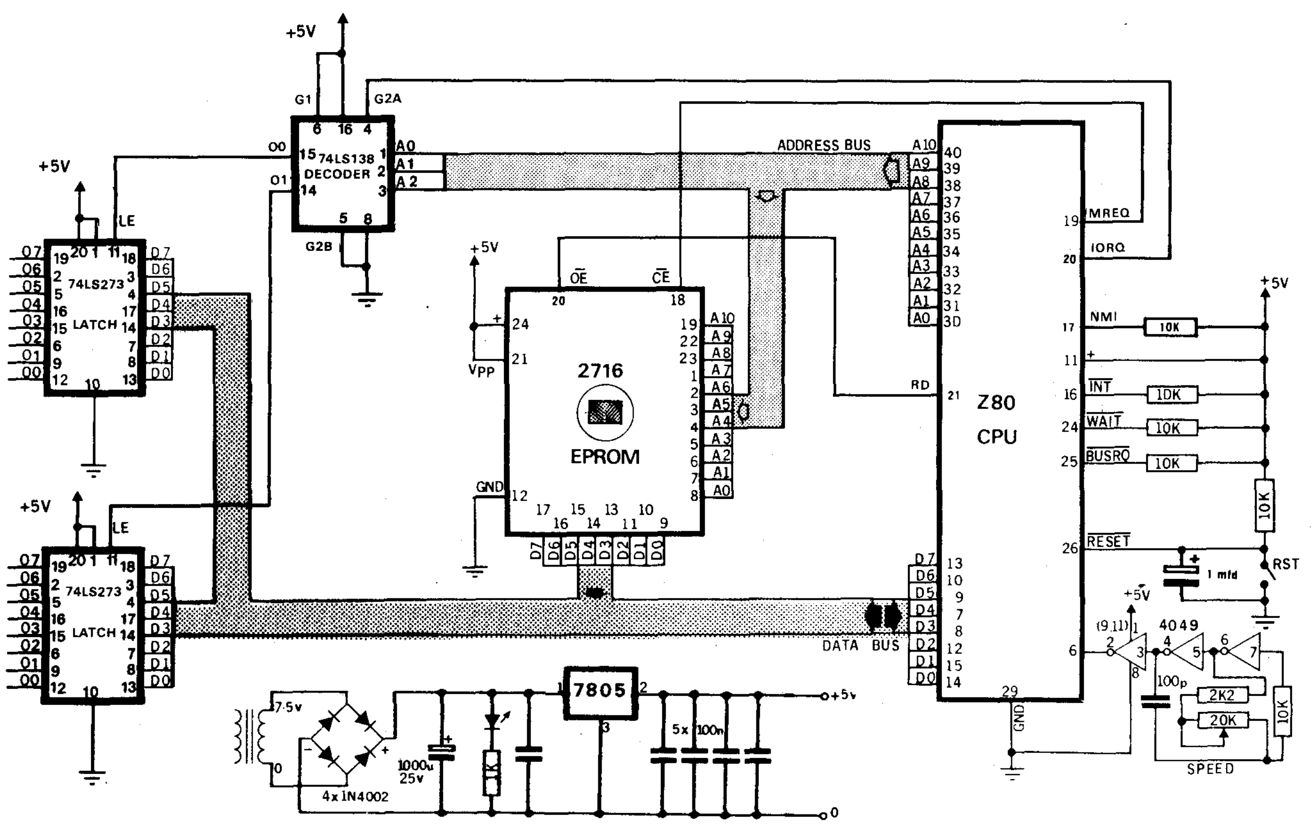
Computers can also be used to control signalling systems or to look after complex sequencing operations. They can be used to perform menial tasks around the layout, such as switching street lamps on when it becomes dark, or controlling small solenoid or motor driven accessories. These minor details make a layout interesting.

Depending on the complexity of the task to which the computer is assigned, the complexity of the computer itself will vary. A lot can be accomplished with a small computer, because the efficiency of a computer depends on the software or program used.

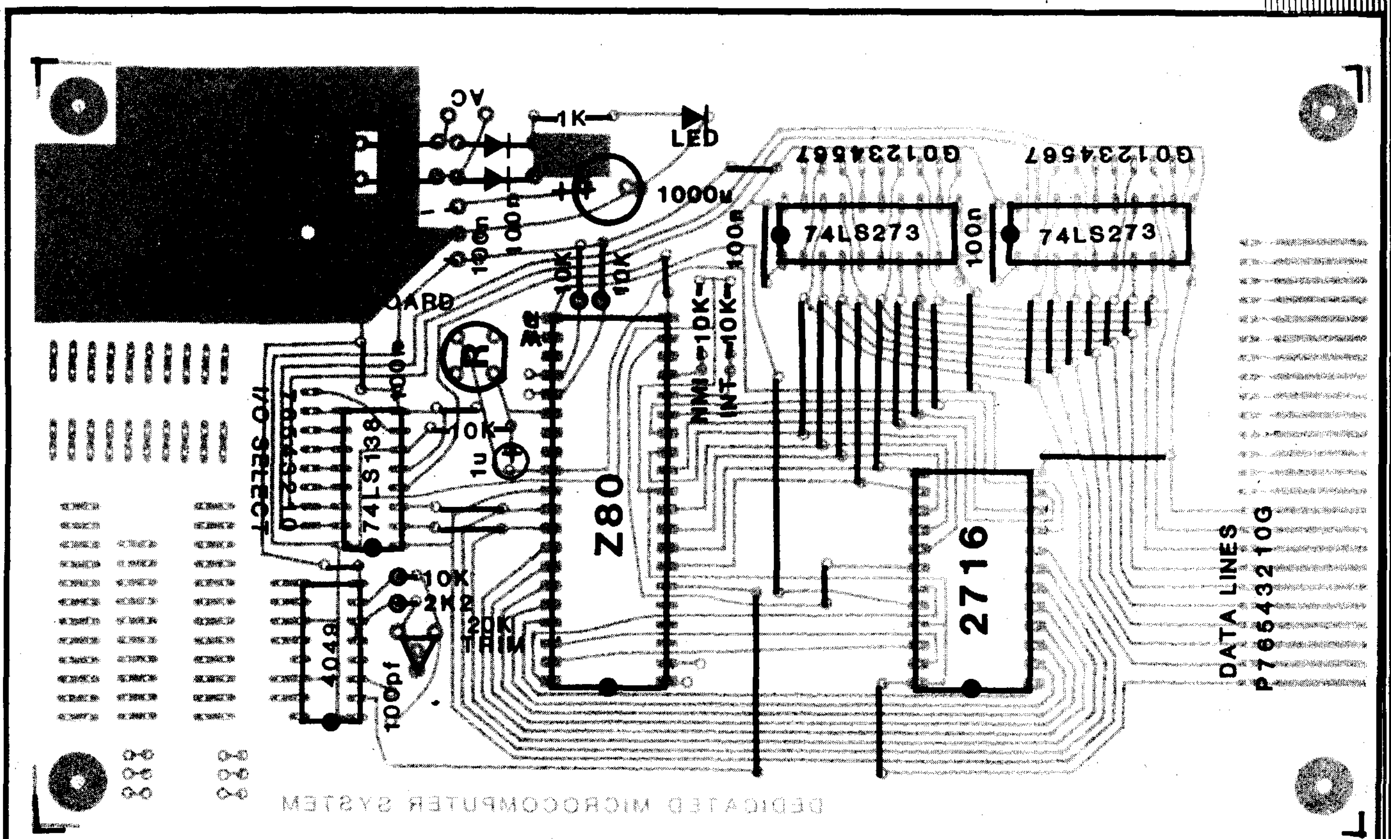
Home computers with video displays and typewriter keyboards are ideal for the control of trains and signals because they can display information to the operator during the course of the program. Smaller computers such as the TEC computer by Talking Electronics can also be used for control of trains and signals. Being simple to build and program, they are a lot easier to connect to a model railway than home computers, which are primarily games machines and are therefore lacking in suitable interfacing.

Often, software that has been developed on a TEC computer can also be run on a smaller dedicated microcomputer such as the one outlined in this article.

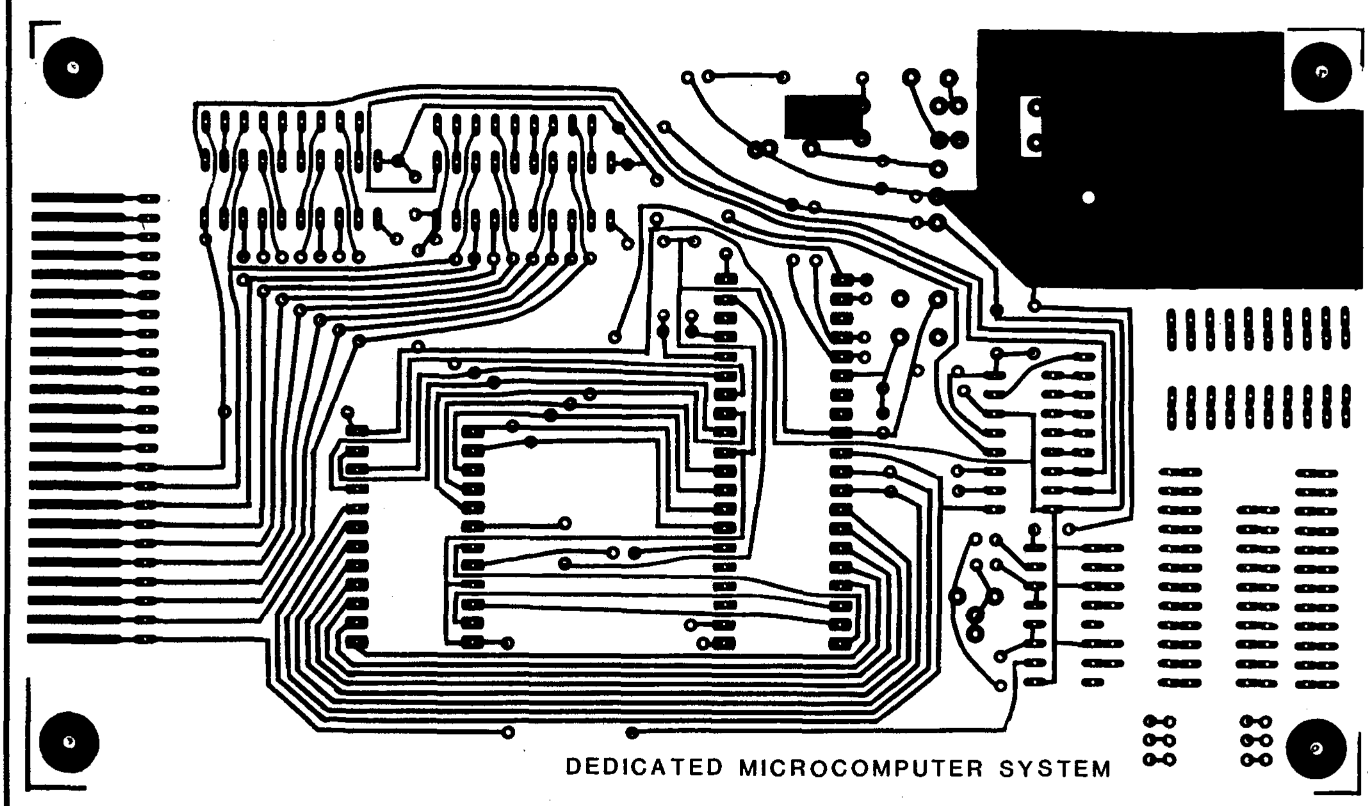
The Dedicated Microcomputer System is a minimum-parts microcomputer. Anything that can

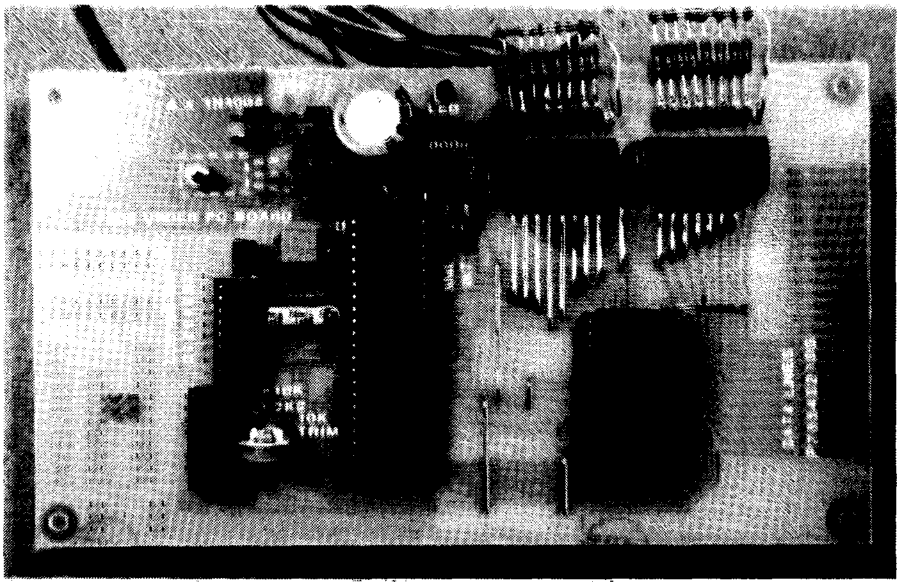


POWER SUPPLY


0V
AC
1K
LED
1000u
74LS273
74LS273
100n
10K
NMI
INT
Z80
2716
74LS138
I/O SELECT
4049
10K
2K2
20K
TRIM
100pf
1u
DATA LINES
P76543210G
G01234567
DEDICATED MICROCOMPUTER SYSTEM

EEK!


DEDICATED MICROCOMPUTER SYSTEM



be left out has been left out to keep costs down. Due to the minimal amount of random access memory (RAM) that would be used on a dedicated micro, the RAM was omitted as these chips can cost over $10.

Memory decoding has also been kept to a minimum as there is only one chip used. This memory chip is the read only memory or ROM. It contains the program and the data used by the program. The program and data has to be programmed into the chip by you. Sometimes, pre-programmed ROMs will be available, but with these you will have to adapt what you want to do to suit the computer because without the necessary equipment, you cannot adapt the program to suit yourself.

The Central Processing Unit (CPU) chosen for the dedicated micro was the Z80. It was chosen for several reasons. It is cheap, it has a large set of instructions, it is compatible with the TEC computer, and it has enough internal registers to make operating without a RAM possible.

The other chips are the Master Clock, the Input/Output Decoder and two latches. The speed of the Master Clock is variable, making it possible to change the speed at which any of the programs run. The Input/Output Decoder allows selection of up to eight input ports or output ports. Two of the port locations are already occupied by the output latches.

The power supply is a simple regulated supply using a 5 volt regulator. It can be powered from a plug-pack or from an existing power supply that supplies about 8.5 volts A.C.

The operation of the dedicated microcomputer will not be looked at here as it could fill a book. See the articles on the TEC computer in issues 10 and 11 of Talking Electronics. They are available from T.E.; see the advertisement at the back of this book.

Construction

There is a printed circuit board available for the Dedicated Microcomputer System. It is a single sided board measuring 17.5cm by 10cm. Numerous links have been used. These should be soldered first.

Next solder in the IC sockets followed by the resistors, diodes and capacitors. The regulator is bolted below the PCB with its metal face hard against the copper. The area of copper serves as an adequate heatsink.

The computer resets automatically when the power is switched on. Pushing the RESET button will also initiate the computer. This button can be soldered directly onto the PCB or mounted in a more convenient location.

Solder in the remaining components and insert the ICs into the sockets.

The outputs of the latches can be connected to transistor buffers to drive relays, lamps or LEDs. The applications of this unit are limited only by your imagination. It can be used as a sequencer far superior than any presented in this book. Using only the latches that are on board, it can be used as a sequencer with 16 outputs that can have each individual step of a different length. The number of steps in the sequence can be in the hundreds.

The ROM supplied in the Dedicated Microcomputer System kit contains an example of this sequencer's possibilities. It is programmed to control a set of traffic lights including WALK signs, DON'T WALK signs that flash after the walk cycle, and right turn arrows.

The equivalent circuit made with standard chips would be more complex and cost more! That is the advantage of a microprocessor.

This kit is available from the company advertising on the inside back cover. It is a valuable learning tool and can be programmed to perform many functions.

```
0000 C3 JP 0100
0003 FF
0004 FF
0005 FF

0100 21 LD HL,0140
0103 01 LD BC,001E
0106 7E LD A,(HL)
0107 D3 OUT (00),A
0109 23 INC HL
010A 7E LD A,(HL)
010B D3 OUT (01),A
010D 23 INC HL
010E 7E LD A,(HL)
010F 1E LD E,00
0111 57 LD D,A
0112 1B DEC DE
0113 7A LD A,D
0114 B3 OR E
0115 C2 JP NZ,0112
0118 23 INC HL
0119 0B DEC BC
011A 78 LD A,B
011B B1 OR C
011C C2 JP NZ,0106
011F C3 JP 0100
```

Disassembly of the sequencer program.

DMS Parts List.

1 - 1K
1 - 2K2
6 - 10K

1 - 10K - 20K trimpot

1 - 100pf ceramic cap
5 - 100n monoblock caps
1 - 1 mfd electro
1 - 1000 mfd electro

4 - 1N4002 diodes
1 - red LED
1 - 7805
1 - CD4049†
1 - 74LS138
2 - 74LS273
1 - Z80 Microprocessor
1 - 2716 EPROM (programmed)

2 - 16 pin IC sockets
2 - 20 pin IC sockets
1 - 24 pin IC socket
1 - 40 pin IC socket
1 - length of tinned copper wire
1 - Dedicated Microcomputer System PCB
1 - nut & bolt for regulator.

† Fairchild 4049 must NOT be used.

This table shows the functions of the outputs of the latches when the traffic light program is being used. The outputs of one latch are for the North-South traffic, and the outputs of the other latch are for the East-West traffic. This set of traffic lights would be suitable for a major intersection.

LATCH OUTPUTS

0	***RED***
1	***AMBER***
2	***GREEN***
3	***AMBER R.T. ARROW***
4	***GREEN R.T. ARROW***
5	***DON'T WALK***
6	***WALK***
7	***NOT USED***

R.T. = RIGHT TURN

```
     0000 C3 00 01 FF

     0100 21 40 01 01
     0104 1E 00 7E D3
     0108 00 23 7E D3
Sequencer
program
     010C 01 23 7E 1E
     0110 00 57 1B 7A
     0114 B3 C2 12 01
     0118 23 0B 78 B1
     011C C2 06 01 C3
     0120 00 01 FF FF
     0124 FF FF FF FF
     0128 FF FF FF FF
     012C FF FF FF FF
     0130 FF FF FF FF
     0134 FF FF FF FF
     0138 FF FF FF FF
     013C FF FF FF FF
     0140 21 21 0A 23
     0144 21 0A 44 21
     0148 28 24 21 06
     014C 04 21 06 24
     0150 21 06 04 21
     0154 06 24 21 06
     0158 04 21 06 24
     015C 21 0A 22 21
     0160 0C 21 21 0A
     0164 29 21 08 31
Data
     0168 21 16 29 21
     016C 0A 21 21 0A
     0170 21 23 0A 21
     0174 44 28 21 24
     0178 06 21 04 06
     017C 21 24 06 21
     0180 04 06 21 24
     0184 06 21 04 06
     0188 21 24 0A 21
     018C 22 0C 21 21
     0190 0A 21 29 06
     0194 21 31 16 21
     0198 29 0A FF FF
     019C FF FF FF FF
```

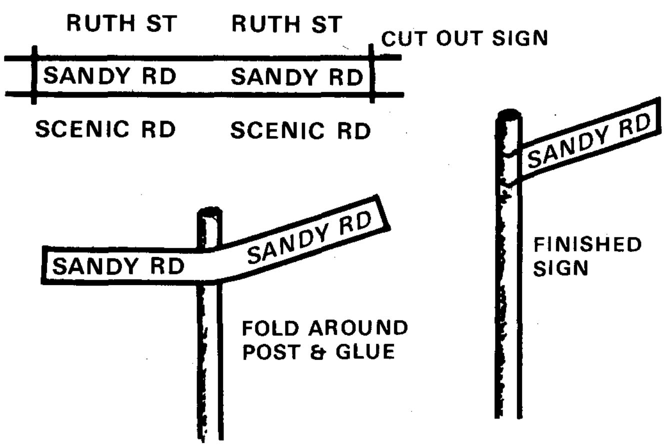
Complete listing of the traffic light sequence, including data.

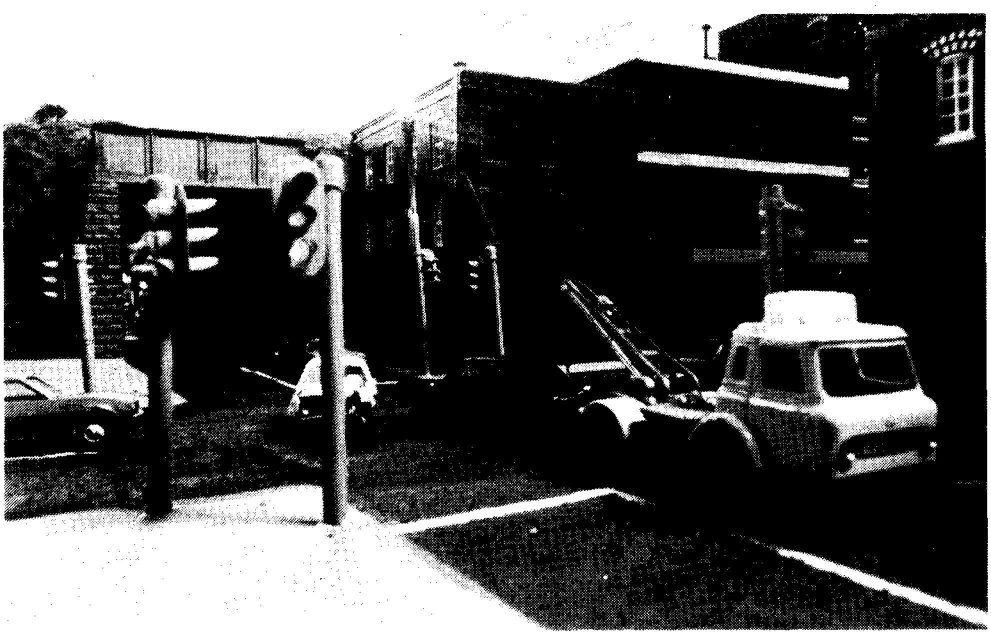
Add some

STREET SIGNS

to the intersections of your model streets

A minor detail that often makes itself conspicuous by its absence is the street sign. Due to the tiny proportions of these, many modellers will not even attempt to make them.
These two pages contain many little signs. They may not be exactly to scale, but if they were any smaller, you would not be able to read them. Each street sign is given only once. Photocopy the page a few times, and cut the signs off the photocopies. This way, you can always make another set of signs if you need them. Using a sharp blade or a craft knife, cut out the sign. Cut around both names without separating them from each other. Fold the sign around the post so that the two names are back to back. Put a little glue between the names, and on the post to hold the sign there.





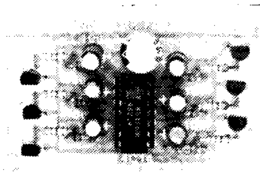
A scale pedestrian's view of the accident scene. There are two things missing: people and street signs.

ALBANY RD	ALBANY RD
ALBERT ST	ALBERT ST
ALEXANDER RD	ALEXANDER RD
ALLEN ST	ALLEN ST
ALLENBY AVE	ALLENBY AVE
ALMA RD	ALMA RD
AMBROSE ST	AMBROSE ST
ANDERSON ST	ANDERSON ST
ANNE ST	ANNE ST
APPLE GVE	APPLE GVE
ARGYLE ST	ARGYLE ST
ASHLEIGH CT	ASHLEIGH CT
ASHWDDD AVE	ASHWOOD AVE
AUBURN RD	AUBURN RD
BAILEY ST	BAILEY ST
BAKER ST	BAKER ST
BALCOMBE RD	BALCOMBE RD
BANK ST	BANK ST
BARKLY ST	BARKLY ST
BATMAN AVE	BATMAN AVE
BAY RD	BAY RD
BAYVIEW RD	BAYVIEW RD
BEACH RD	BEACH RD
BEDFORD ST	BEDFORD ST
BEGONIA AVE	BEGONIA AVE
BELL ST	BELL ST
BELMONT RD	BELMONT RD
BENDIGO ST	BENDIGO ST
BENT ST	BENT ST
BERRY AVE	BERRY AVE
BIRCH ST	BIRCH ST
BLACK ST	BLACK ST
BLACKWOOD AVE	BLACKWOOD AVE
BLUEGUM CT	BLUEGUM CT
BONO ST	BOND ST
BOUNDARY RD	BOUNDARY RD
BOURKE ST	BOURKE ST
BRIDGE ST	BRIDGE ST
BROWNS RD	BROWNS RD
BRUCE ST	BRUCE ST
BURNS RD	BURNS RO
BYRON ST	BYRON ST
CAMERDN ST	CAMERON ST
CAPELLA ST	CAPELLA ST
CAREY ST	CAREY ST
CASEY DR	CASEY DR
CASTLE ST	CASTLE ST
CEDAR GVE	CEOAR GVE
CENTER RD	CENTER RD
CHARLES ST	CHARLES ST
CHERRY AVE	CHERRY AVE
CHURCH ST	CHURCH ST
CITY RO	CITY RD

		HILL ST	HILL ST	LIVERPOOL ST	LIVERPOOL ST	PETER ST	PETER ST
CLIFF ST	CLIFF ST	HOLLY CT	HOLLY CT	LLOYD ST	LLOYD ST	PHILIP ST	PHILIP ST
COLLINS ST	COLLINS ST	HOMESTEAD RD	HOMESTEAD RD	LOCH ST	LOCH ST	PIER ST	PIER ST
COMO PDE	COMO PDE	HOPE ST	HOPE ST	LOGAN ST	LOGAN ST	PINE ST	PINE ST
COOK ST	COOK ST	HUGHES RD	HUGHES RD	LONSDALE ST	LONSOALE ST	PLENTY RD	PLENTY RD
COTTAGE ST	COTTAGE ST	HUME ST	HUME ST	LOUISE ST	LOUISE ST	PORTER ST	PORTER ST
CROSS ST	CROSS ST	HUME HWY	HUME HWY	LOWER RD	LOWER RD	POWER RD	POWER RD
CYPRESS AVE	CYPRESS AVE	HUNTER ST	HUNTER ST	LYNETTE ST	LYNETTE ST	PRICE ST	PRICE ST
DALE ST	DALE ST	HUON GVE	HUON GVE	LYONS ST	LYONS ST	PRINCESS ST	PRINCESS ST
DAVEY ST	DAVEY ST	IAN CT	IAN CT	McLEOO ST	McLEOD ST	PROSPECT RD	PROSPECT RD
DYNON RD	DYNON RD	INDUSTRIAL AVE	INDUSTRIAL AVE	MADDEN ST	MADDEN ST	PUNT RD	PUNT RD
EARL ST	EARL ST	IRENE CT	IRENE CT	MAIN RO	MAIN RD	QUARRY RD	QUARRY RD
EAST RD	EAST RD	ISLAND RD	ISLAND RD	MALVERN RD	MALVERN RD	QUEEN ST	QUEEN ST
EDWARD ST	EDWARD ST	IVY ST	IVY ST	MANOR GVE	MANOR GVE	RAILWAY AVE	RAILWAY AVE
EIGHTH AVE	EIGHTH AVE	JACKSON ST	JACKSON ST	MAPLE ST	MAPLE ST	RAILWAY PDE	RAILWAY PDE
ELIZABETH ST	ELIZABETH ST	JADE CT	JADE CT	MARGARET ST	MARGARET ST	RAYMOND ST	RAYMDND ST
ELM GVE	ELM GVE	JAMES ST	JAMES ST	MARKET ST	MARKET ST	REGENT ST	REGENT ST
EMERALD ST	EMERALD ST	JEANETTE ST	JEANETTE ST	MARTIN ST	MARTIN ST	RESERVE RD	RESERVE RD
ESSEX ST	ESSEX ST	JEFFREY ST	JEFFREY ST	MARY ST	MARY ST	RIDGE RD	RIDGE RD
EYRE RD	EYRE RD	JELLS RD	JELLS RD	MASON ST	MASON ST	RIVER ST	RIVER ST
FARVIEW AVE	FAIRVIEW AVE	JENNER ST	JENNER ST	MAX CT	MAX CT	ROSE ST	ROSE ST
FAIRWAY AVE	FAIRWAY AVE	JENNIFER ST	JENNIFER ST	MAY ST	MAY ST	ROSS ST	ROSS ST
FALCON ST	FALCON ST	JETTY RD	JETTY RD	MELANIE CT	MELANIE CT	RUSSEL ST	RUSSEL ST
FALLS RD	FALLS RD	JOHN ST	JOHN ST	MELROSE ST	MELROSE ST	RUTH ST	RUTH ST
FARM RD	FARM RD	JOHNSON ST	JOHNSON ST	MERTON ST	MERTON ST	SANDY RD	SANDY RD
FERN ST	FERN ST	JONES RD	JONES RD	MIDDLE RD	MIDDLE RD	SCENIC RD	SCENIC RD
FIELD ST	FIELD ST	JDY ST	JOY ST	MILES ST	MILES ST	SCOTT ST	SCOTT ST
FIFTH AVE	FIFTH AVE	JUNCTION RD	JUNCTION RD	MILLER ST	MILLER ST	SECOND AVE	SECOND AVE
FINCH ST	FINCH ST	JUNIPER CR	JUNIPER CR	MILLS ST	MILLS ST	SEVENTH AVE	SEVENTH AVE
FIR GVE	FIR GVE	JUSTIN AVE	JUSTIN AVE	MILTON ST	MILTON ST	SHORT ST	SHORT ST
FIRST AVE	FIRST AVE	KALIMNA ST	KALIMNA ST	MIRIAM ST	MIRIAM ST	SIXTH AVE	SIXTH AVE
FLINDERS ST	FLINDERS ST	KARA CT	KARA CT	MONTROSE ST	MONTROSE ST	SMITH ST	SMITH ST
FOREST RD	FOREST RD	KAY ST	KAY ST	MOORE ST	MOORE ST	SOUTH RD	SOUTH RD
FOURTH AVE	FOURTH AVE	KEATS ST	KEATS ST	MORRIS ST	MORRIS ST	SPRING ST	SPRING ST
FOX ST	FOX ST	KEITH ST	KEITH ST	MORRISON ST	MORRISON ST	STANLEY ST	STANLEY ST
GARDEN GVE	GARDEN GVE	KELVIN GVE	KELVIN GVE	MOUNTAIN HWY	MOUNTAIN HWY	STATION RD	STATION RD
GARDENIA RD	GARDENIA RD	KENDALL ST	KENDALL ST	MUIR ST	MUIR ST	STATION ST	STATION ST
GARFIELD ST	GARFIELD ST	KENT RD	KENT RD	MUNRO AVE	MUNRO AVE	STDNE ST	STONE ST
GARNET ST	GARNET ST	KERRI ST	KERRI ST	MURRAY ST	MURRAY ST	SUNSET AVE	SUNSET AVE
GIBSON ST	GIBSON ST	KEYS RD	KEYS RD	NASH ST	NASH ST	SUSAN ST	SUSAN ST
GLEN RD	GLEN RD	KILLARA ST	KILLARA ST	NEERIM RD	NEERIM RD	SWANSTON ST	SWANSTON ST
GOLDEN AVE	GDLDEN AVE	KING ST	KING ST	NELSON RO	NELSON RD	SYDNEY ST	SYDNEY ST
GOLDIE PL	GOLDIE PL	KINGSTON RD	KINGSTON RD	NEW ST	NEW ST	TARA AVE	TARA AVE
GOLF RD	GOLF RD	KNIGHT AVE	KNIGHT AVE	NEWTON ST	NEWTON ST	THIRD AVE	THIRD AVE
GRACE ST	GRACE ST	KNOX ST	KNOK ST	NORTH RD	NORTH RD	THOMAS ST	THOMAS ST
GRAHAM ST	GRAHAM ST	LACHLAN DR	LACHLAN DR	NORWOOD ST	NORWOOD ST	TI-TREE GVE	TI-TREE GVE
GRANDVIEW AVE	GRANDVIEW AVE	LAKE RD	LAKE RD	OAK AVE	OAK AVE	TOWER RD	TOWER RD
GRANGE RD	GRANGE RD	LANSELL RD	LANSELL RD	OCEAN RD	OCEAN RD	TWELTH AVE	TWELTH AVE
GRAY ST	GRAY ST	LANTANA ST	LANTANA ST	OLIVE GVE	OLIVE GVE	UNION ST	UNION ST
GREEN ST	GREEN ST	LATROBE ST	LATROBE ST	ORANA ST	ORANA ST	VALLEY RD	VALLEY RD
GUM ST	GUM ST	LAURA ST	LAURA ST	ORANGE GVE	ORANGE GVE	VICTORIA ST	VICTORIA ST
HAIG ST	HAIG ST	LAUREL ST	LAUREL ST	ORCHARD ST	ORCHARD ST	VIEW ST	VIEW ST
HALL ST	HALL ST	LAWSON ST	LAWSON ST	OUTLOOK DR	OUTLOOK DR	VINE ST	VINE ST
HAMILTON ST	HAMILTON ST	LEE ST	LEE ST	OWEN ST	OWEN ST	WALKER ST	WALKER ST
HAMPTON ST	HAMPTON ST	LEILA ST	LEILA ST	OXFORD ST	OXFORD ST	WALNUT ST	WALNUT ST
HARDY ST	HARDY ST	LEMON GVE	LEMON GVE	OZONE ST	OZONE ST	WARATAH AVE	WARATAH AVE
HARDLD ST	HAROLD ST	LESLIE ST	LESLIE ST	PAGE ST	PAGE ST	WATTLE ST	WATTLE ST
HARRIS ST	HARRIS ST	LEVER ST	LEVER ST	PALM ST	PALM ST	WEST ST	WEST ST
HARROW ST	HARRDW ST	LEWIS ST	LEWIS ST	PALMER ST	PALMER ST	WHITE ST	WHITE ST
HASTINGS RD	HASTINGS RD	LEXIA ST	LEXIA ST	PARK AVE	PARK AVE	WILCOX ST	WILCOX ST
HAYES RD	HAYES RD	LILAC ST	LILAC ST	PARK ST	PARK ST	WILLIAM ST	WILLIAM ST
HEATH RD	HEATH RD	LINCOLN RD	LINCOLN RD	PARK RD	PARK RD	WILLOW GVE	WILLOW GVE
HEATHER GVE	HEATHER GVE	LINDEN ST	LINDEN ST	PATTERSON ST	PATTERSON ST	WILSON ST	WILSON ST
HELEN ST	HELEN ST	LINDSAY ST	LINDSAY ST	PAUL ST	PAUL ST	WOOD RD	WOOD RD
HENDERSON ST	HENDERSON ST	LINK RD	LINK RD	PEACE ST	PEACE ST	Y ST	Y ST
HENRY ST	HENRY ST	LINTON AVE	LINTON AVE	PEARL ST	PEARL ST	YARRA ST	YARRA ST
HIGH ST	HIGH ST	LITTLE ST	LITTLE ST	PEMBRDKE AVE	PEMBROKE AVE	YORK ST	YDRK ST

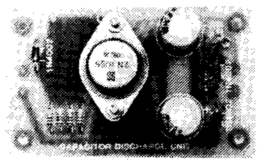
COMPLETE RANGE OF KITS:

WARNING LAMP FLASHING UNIT



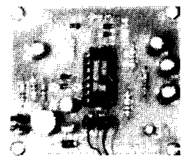
PC: $2.50 Parts: $5.70
Complete kit: $8.20

CAPACITOR DISCHARGE UNIT



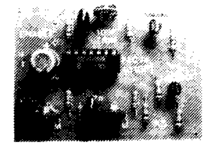
PC $2.80 Parts: $4.60
Complete Kit: $7.40

FLUORESCENT SIMULATOR



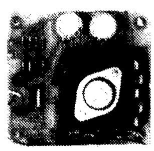
PC: $2.60 Parts: $4.50
Complete Kit: $7.10

AIR HORN



PC: $2.70 Parts: $6.60
Complete Kit: $9.30

POWER SUPPLY

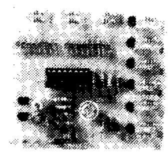


PC: $3.00 Parts: $8.65
Complete Kit: $11.65

REMOTE RELAY UNIT

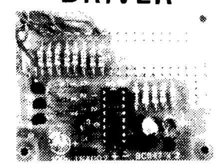
PC: $1.50 Parts: $3.10
Complete Kit: $4.60

PEDESTRIAN CROSSING



PC: $3.30 Parts: $9.50
Complete Kit: $12.80

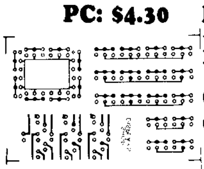
SHOP DISPLAY DRIVER



PC: $2.90 Parts: $5.60
Complete kit: $8.50

SHOP DISPLAYS

PC: $4.30 LEDs:

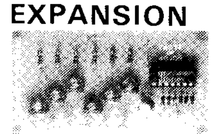


Red 15¢
Yellow 30¢
Green 25¢
Orange 30¢

LEVEL CROSSING

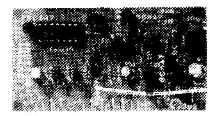
PC: $2.60 Parts $9.50
Complete kit: $12.10

CROSSING EXPANSION



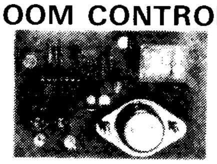
PC: $2.60 Parts:$10.30
Complete kit: $12.90

CROSSING SOUND



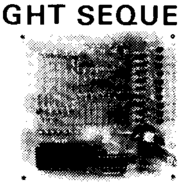
PC: $2.50 Parts: $8.25
Complete kit: $10.75

CROSSING BOOM CONTROL



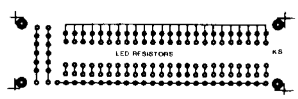
PC: $2.70 Parts: $10.50
Complete kit: $13.20

LIGHT SEQUENCER



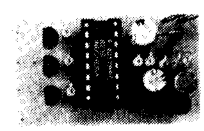
PC: $5.50 Parts:$13.50
Complete kit: $19.00

LED RESISTORS



PC & 470R resistors: $3.00

ROTATING LIGHT

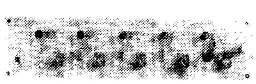


PC: $1.60 Parts: $4.30
Complete kit: $5.90

THROTTLE

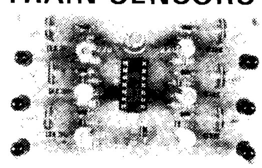
PC:$2.60 Parts: $8.80
Complete kit $11.40
Includes pot & sw.

TRAIN DETECTOR



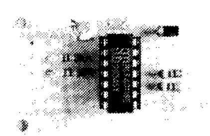
PC: $3.10 Parts $9.50
Complete kit: $12.60

HEX TRAIN SENSORS



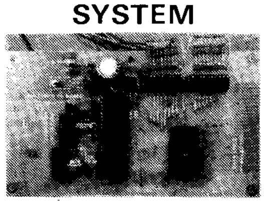
PC: $2.80 Parts: $13.50
Complete kit: $16.30

SEARCHLIGHT ADAPTER



PC: $1.50 Parts: $1.70
Complete kit: $3.20

DEDICATED MICROCOMPUTER SYSTEM



PC: $8.00 Parts: $29.45
Complete kit: $37.45

incl. seq program.

BOOKS:

STAGE - 1:	**$2.95**
TE No 10	**1.80**
TE No 11:	**1.80**
Notebook 1:	**2.40**
Notebook 2:	**2.60**

Pack and post: 90¢ each.

The complete range of kits is stocked by TALKING ELECTRONICS. Kits contain all parts which mount on the PC board, unless specified.

TALKING ELECTRONICS,
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