FEATURE

Model Railway Circuits

ROBERT PENFOLD

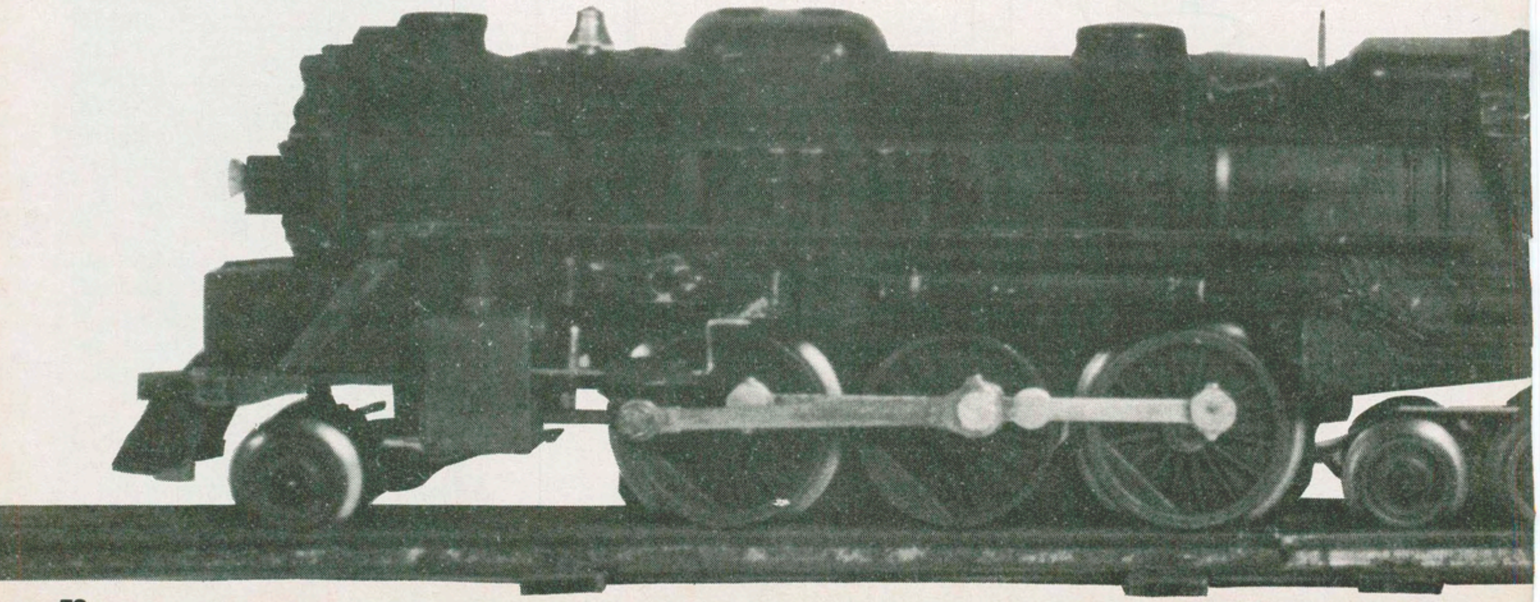
This is a pulse type train controller that is primarily intended for computer control. Although the range of available speeds is rather limited (stop, full speed, and two intermediate) the transition from one speed to another has been made very gradual to avoid any unrealistic jumps in speed. The circuit can easily be modified to provide a greater range of speeds if desired.

The unit provides a variable average output voltage by varying the mark space ratio of the output signal. Provided a suitable output frequency is used, this type of signal is suitable for driving DC electric motors. In fact, it gives very good results; fine speed regulation and immunity from stalling at low speeds. This circuit uses a standard pulse width modulator with IC1 to provide the triangular clock signal, and IC2 operating as the voltage comparator. The clock frequency is just over 200Hz, which seems to give good results with any small DC electric motor.

With the voltage at the noninverting input (pin 2) of IC2 halfway between the peak to peak voltages of the clock signal, the output signal is a square wave having perfect 1:1 mark space ratio. Taking this input voltage higher results in it being exceeded by the clock signal for a smaller percentage of the time, and the high output period becomes longer than the low output time. Reducing the input potential has the same effect. This gives the desired result, with an average output voltage that is proportional to the control voltage.

Q1 and Q2 form a complementary emitter follower output stage that enables the unit to handle output currents of up to a couple of amps. Q2 is not strictly necessary but with D1 it helps to suppress voltages generated by the motor when Q1 is switched off. As Q1 operates in a switching mode it only requires a small bolt on heatsink. Q2 does not require a heatsink at all. For a straightforward manual control, a potentiometer circuit to drive pin 3 of IC2 is all that is required. For computer or digital control a DAC is needed, and a very simple and inexpensive 2-bit circuit can be used. The state of the signal inputs 1 and 2 alter the resistive network determining the signal fed into IC2, and therefore the speed of the train. With both inputs at 0, Q3 and Q4 are off so that R8 and R9 provide a high enough control voltage to keep the controller output continuously high. Applying a logic 1 signal to input 1 or input 2 shunts either R10 or R13 across R9, giving a lower voltage and a lower average output voltage. As R10 and R13 have different values, the two logic inputs provide different speeds. Taking both inputs to logic 1 produces a very low average output voltage, and the train halts.

More transistor drivers and shunt resistors can be added to give greater range of speeds. The transition time between speeds is proportional to the value of C4 and is easily changed. A reasonably smooth and stable 15V supply, with current limiting to protect the unit against the inevitable short circuits on the output, is provided by a simple smoothing and regulator circuit fed from the raw 12V DC output of a train controller. Direction con-



trol can be provided manually via a DPDT switch, or under computer control via a relay and driver circuit.

Two Colour Signal

This two colour red/green signal is automatically operated by the train via sensors on the track. There are several ways of sensing the train as it passes but the two most simple and reliable methods are to use micro or reed switches. I prefer reed switches positioned just under the track, activated by a magnet mounted just above track level on one of the pieces of rolling stock. Sometimes the DC motors used in locomotives will activate the reed switches but in most cases a small bar magnet must be added to each train by the constructor. Note that the reed switches are activated when parallel to a bar magnet and not when one pole of the magnet is applied to them. Switches should be mounted lengthwise along the center of the track, with the magnet mounted lengthwise along the middle of the floor of a piece of rolling stock. The distance between them probably needs to be about 10 millimeters or less—this shuld be possible without continual derailment. The purpose of the sensors is to set the signal to the red as it is passed by a train and then to reset it to green when the train has progressed to some point further along the track. The circuit is basically just a S-R flip flop built around IC1b and IC1c. The other two gates of IC1 are wired up as inverters and used as buffers at the outputs of the flip flop.

SW1 is the reed switch near the signal and when this is activated it sends the output of IC1a high. This switches on Q1 and the red signal LED1. SW2 is further along the track, and returns the output of IC1a to the low state. It also sends IC1d high activating LED2, the green signal.

Problems with spurious triggering due to switch bounce or stray electrical noise in connecting cables are counteracted by R4, C2 and R6, C3. If manual override is required, add push button switches in parallel with SW1 and SW2. It should be possible to control a ready-made signal, but LED types will probably incorporate current limiting resistors and R1 and R8 will then be unnecessary. The unit should also be able to control sub-miniature 12V filament bulbs in the same way, but the bulb current should not exceed about 200mA.

A 9 or 12V battery is the easiest source of supply. IC2 and C4 to C6 are only needed if the unit is fed with the raw 12V DC output of a train controller.

Two Tone Horn

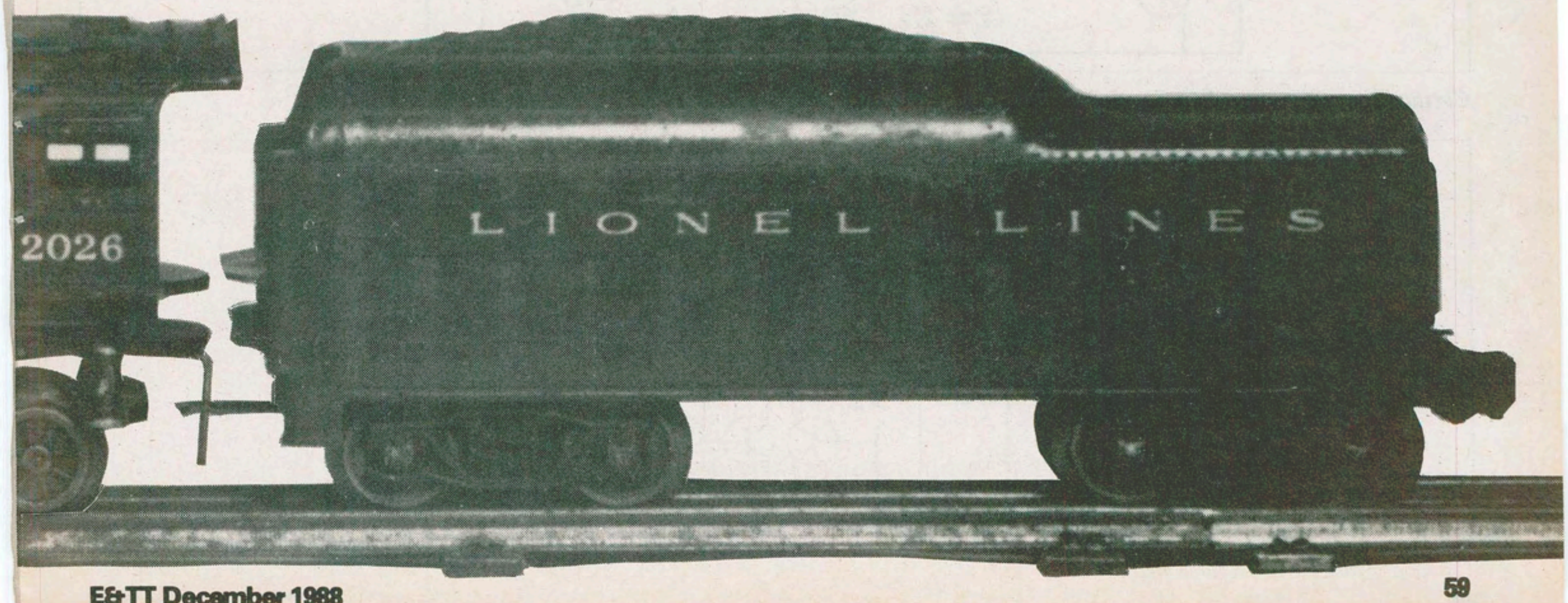
This sound effects unit is designed to simulate the sound of a two tone horn, as used on many diesel and electric locomotives. This is the type of horn that goes up about a fifth in pitch (about 50% higher in frequency) after the initial tone. The basic sound is not just a simple tone, and is actually a quite complex signal.

Accurately simulating an intricate sound of this type is far from easy but results here are about as good as you are likely to obtain from a simple circuit and a loudspeaker of about 65mm in diameter. Unless you are a steam only fanatic, it should certainly add a bit more realism to your railway layout.

The basic audio signal is generated by a 555 timer (IC1) used in the standard astable circuit. It drives a miniature high impedance loudspeaker via common emitter amplifier Q2. LS1 must have an impedance of 64R to 80R and must not be a low impedance type. The oscillator's operating frequency works out at approximately 550Hz but we are using frequency modulation applied via pin 5 of the device and it does not always operate at this frequency.

The horn starts fractionally flat, and moves up to the normal operating pitch over a period of around 200ms, regulated by C1 changing up through R1. Pin 5 of IC1 must be pulled lower in voltage in order to raise the output frequency and give the two-tone effect. This is provided automatically just under a second after switch-on by IC3, a quad 2 input NOR gate which has three of its gates connected to operate as a monostable wiith an output pulse duration of around 800ms. This is triggered by a switch-on by C7 and R8 but, as it provides a negative output pulse, Q2 is initially switched off. It is turned on when the output pulse ends and it then pulls pin 5 of IC1 lower in voltage by an amount that is controlled using RV2. In practice RV2 is adjusted by ear to give the correct second tone from the unit. C5 gives a smoother transition to the higher pitch for a slightly improved effect.

The second 555 oscillator is used to enrich the sound and its output is mixed with the main tone signal at a much lower level, frequency modulated in exactly the same way as the main tone generator. It is probably best to initially leave one terminal of R9 unconnected so that RV2 can



be adjusted with only the main oscillator driving the loudspeaker. With R9 connected, RV1 can be adjusted for the best effect. This will probably be with the second oscillator just slightly off-tune from the main one, or perhaps with the second oscillator set about a fifth higher.

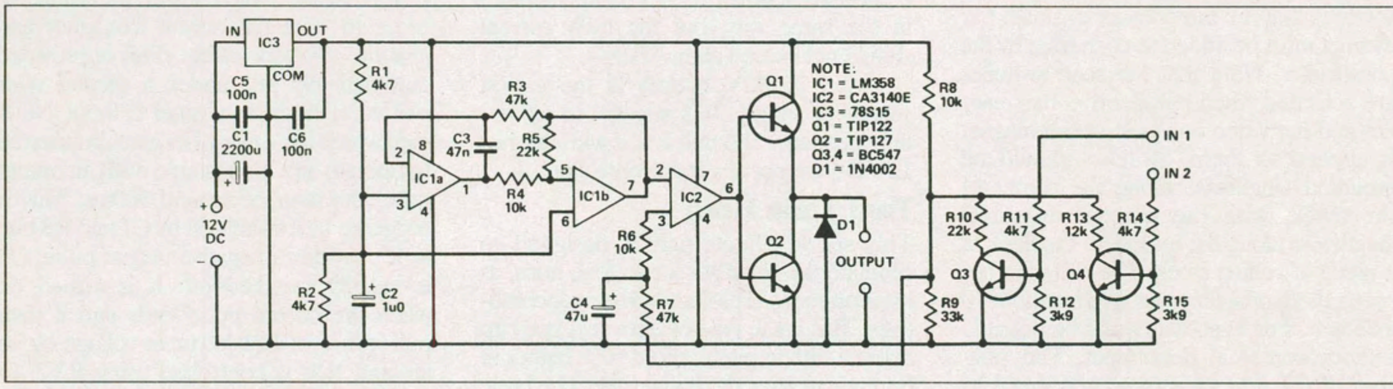
Three Colour Signal

This signal is similar to the two colour type but controls a three colour (green, amber and red) signal and requires an additional track sensor. The signal changes from green to red as the train passes the sensor next to the signal. The sensor further along the track sets the signal to amber, and a third sensor still further along the track brings it back to green again. Like the two colour signal, the sensors can be micro or reed switches. The circuit is based on a CMOS 4017BE. This can provide a standard divide by ten action, but it has ten more outputs (0 to 9), each of which go to logic 1 for one clock cycle, in sequence.

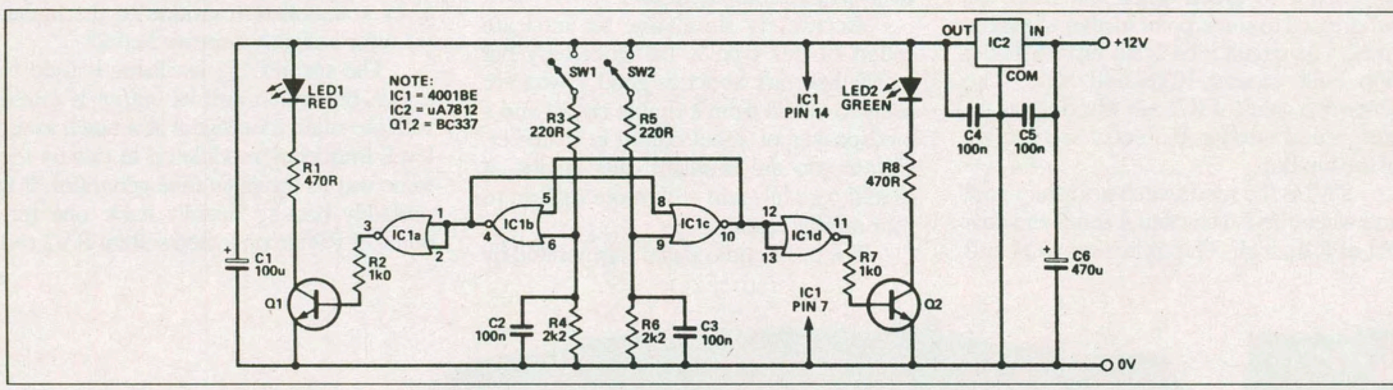
C3 provides a reset pulse at switch-on, taking output 0 high driving Q1 into conduction and turning on the green signal LED1. The track sensors (SW1 to SW3) provide a positive pulse to the clock of IC1 each time the train is detected. R1 and C2 provide switch debouncing and help avoid problems with electrical noise.

Note that with this circuit it does not matter which track switch is used in which position on the line – the circuit merely requires a clock pulse each time. A switch to permit manual setting of the signal might be useful since, if the train does not pass the signal's switch first, the lights will be out of sequence. A push button switch in parallel with SW1, 2 and 3 can be used to sequence the circuit through to the desired colour.

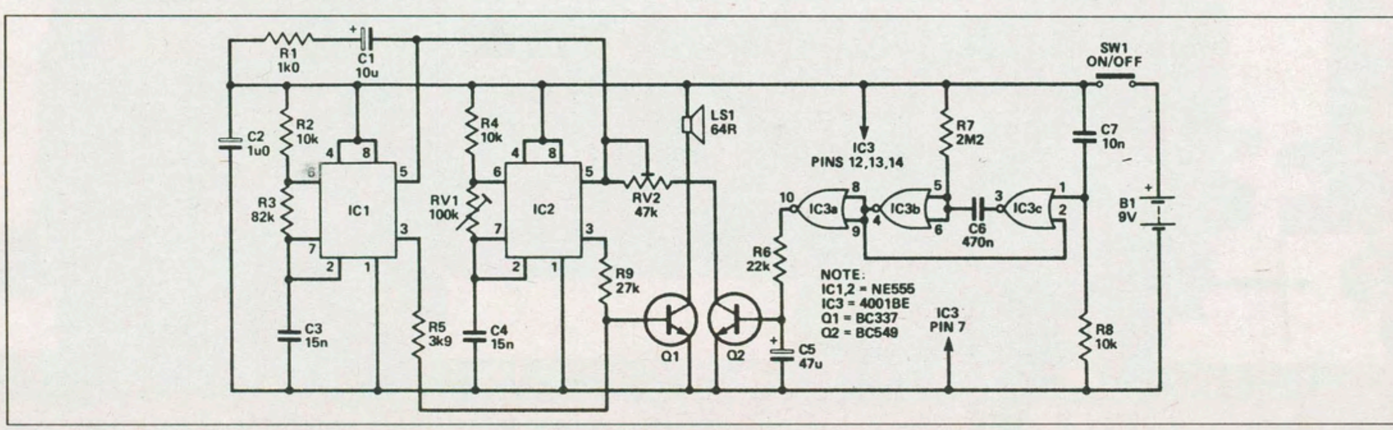
The final clock pulse of each sequence takes output 3 high but this is



Circuit diagram of the digital train controller.



Circuit diagram for two colour signal.



Circuit diagram for two tone horn.

coupled to the reset input of IC1 by way of D1 and it takes the circuit back to the beginning of the sequence. If the signal is a home made type, a yellow LED will suffice for LED3 or an orange type might be considered better (orange LEDs certainly seem to be generally much brighter than the yellow variety). The circuit can be powered from a 9 or 12V battery or from the 12V DC output of a train controller using the smoothing regulator circuit from the two-colour signal circuit.

Switch Controller

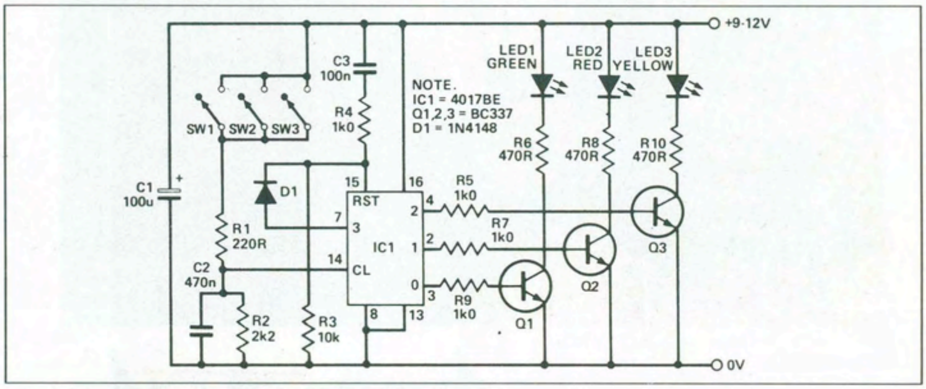
Some model railway switches are purely mechanical but electrical switches are now a standard accessory. These are mostly very basic and are really just a manual switch with the addition of a couple of solenoid mechanisms giving the option of manual operation or electric remote control using a form of changeover switch plus a 12V DC supply.

The switches have three terminals, one of which is a common terminal wired to one supply rail. The other terminals are wired to the other supply rail via the changeover switch which selects the desired solenoid. By alternating this switch the switches can be repeatedly set and reset.

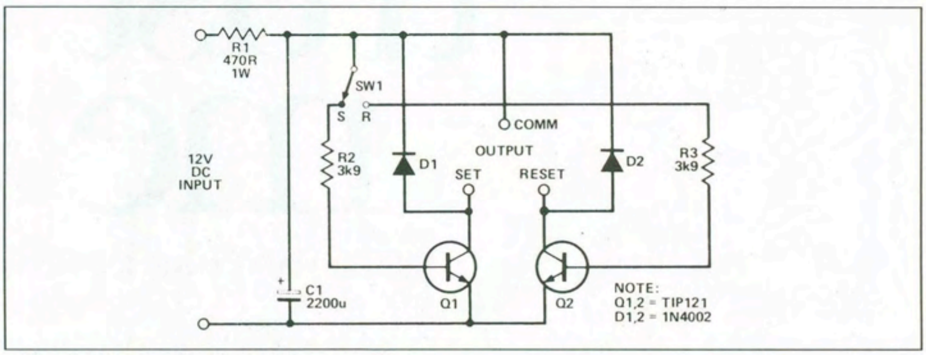
The changeover switch is slightly non-standard in that it is springloaded to a central off position, so that ordinarily it does not supply power to either solenoid. This is an important point, as the solenoid currents are quite high. Applying power for more than a second or two risks burning the solenoid out. These switches are not always totally reliable in operation and the addition of a simple capacitive discharge circuit improves this and totally removes the risk of applying excessive power to the solenoids in an attempt to force operation.

In this switch controller circuit the input supply is fed to a high value capacitor C1 by way of current limiting resistor R1. R1 keeps the current at no more than about 25mA, which should be well short of the current need to drive the switch from one setting to the other. This does not matter though, because C1 will charge to virtually the full input supply voltage, and can supply a large enough burst of current to reliably operate the switches. The extremely low source impedance of a capacitor means that the large pulse of current normally removes any tendancy for the points to stick.

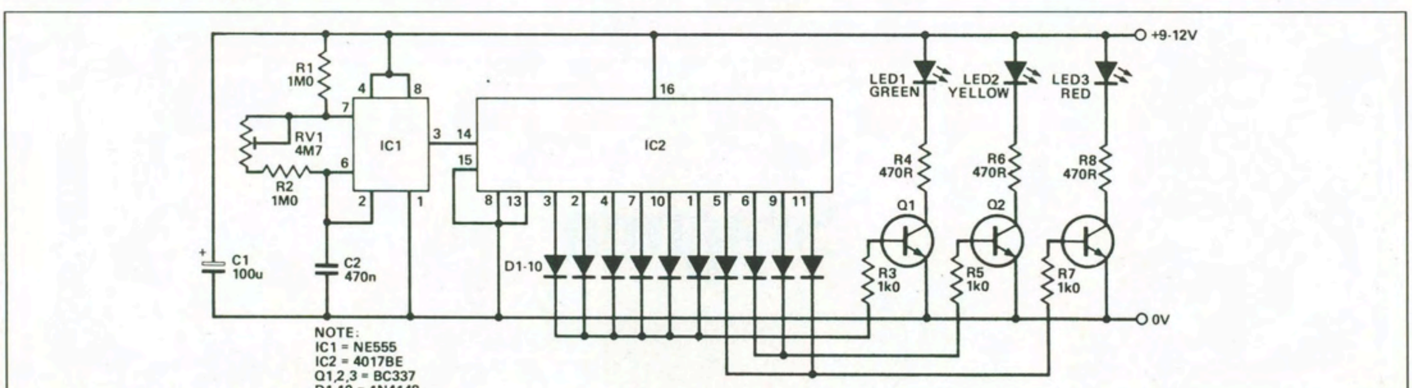
The solenoids can simply be driven from across C1 by way of the changeover switch. However, things can be refined a bit further, as in this circuit. The switch selects one of two Darlington power devices (Q1 or Q2) which control the solenoids. R2 and R3 limit the base currents and result in the switch only handling very small currents. This eliminates an problems with contact sparking reducing the operation life of the switch. A miniature toggle type which is springloaded to a central off position is perfectly suitable for SW1. D1 and D2 protect Q1 and Q2 against any high reverse voltage spikes generated across the solenoids as they are switched off. Q1 and Q2 do not require heatsinks. Also note that it takes a second or so for C1 to recharge after the unit has been used and that the controller cannot function until C1 has almost fully recharged. ■



Circuit diagram for three colour signal.



Circuit diagram for the switch controller.



Circuit diagram for cycling three colour signal.