'Current trip' car alarm features exit/entry delay and no false alarms

This car alarm uses the battery earth strap as a sensor to detect when a 'courtesy' light or other electrical load occurs when a thief enters a vehicle. The circuitry is simple and immune from false triggering problems.

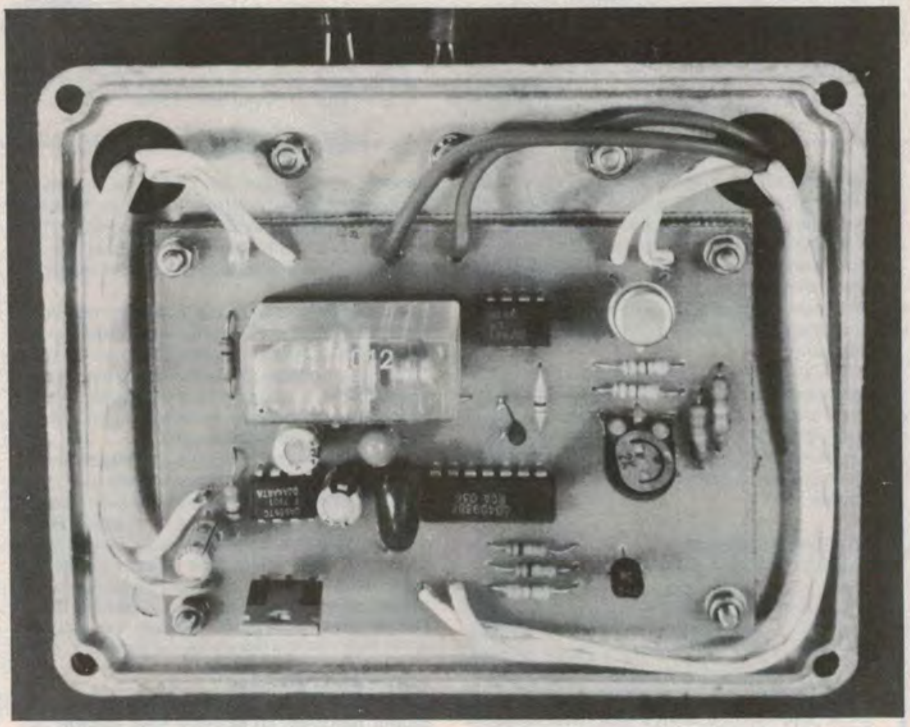
Phil Wait

A SIGNIFICANT proportion of cars are stolen at least once in their lifetime. The thieves are generally 'joyriders' who use them for a few hours and then abandon them after vandalising such items as wheels, seats, stereo/radios etc. If you fit a good, reliable alarm you're bound to deter all but the most determined of criminals — who are usually professionals out to 'redo' the car or strip it completely for parts. There's almost nothing that will stop the latter type of thief — alarms, steering locks or any other deterrents notwithstanding.

Early car alarms were electromechanical by nature. They generally had a balanced cantilever or a pendulum with a switch contact attached. Any movement of the vehicle would close the contact and latch on a relay sounding the horn. Simple and effective — but prone to false triggering. They've all but disappeared. Others operated from a series of hood and door switches, but installation often proved a major undertaking.

Later alarms became more sophisticated — one type sensed the slight voltage-drop pulse that appears across the vehicle battery's terminals when a load is connected — such as a 'courtesy' light being operated when a door is opened. Reliability often proved a problem with these alarms as they depended on the internal resistance of the battery, which causes the voltage-drop pulse following the connection of a load (the battery terminal voltage drops momentarily and then rises again). Any variation in the terminal clamp resistance produces the same effect — giving rise to false triggering problems.

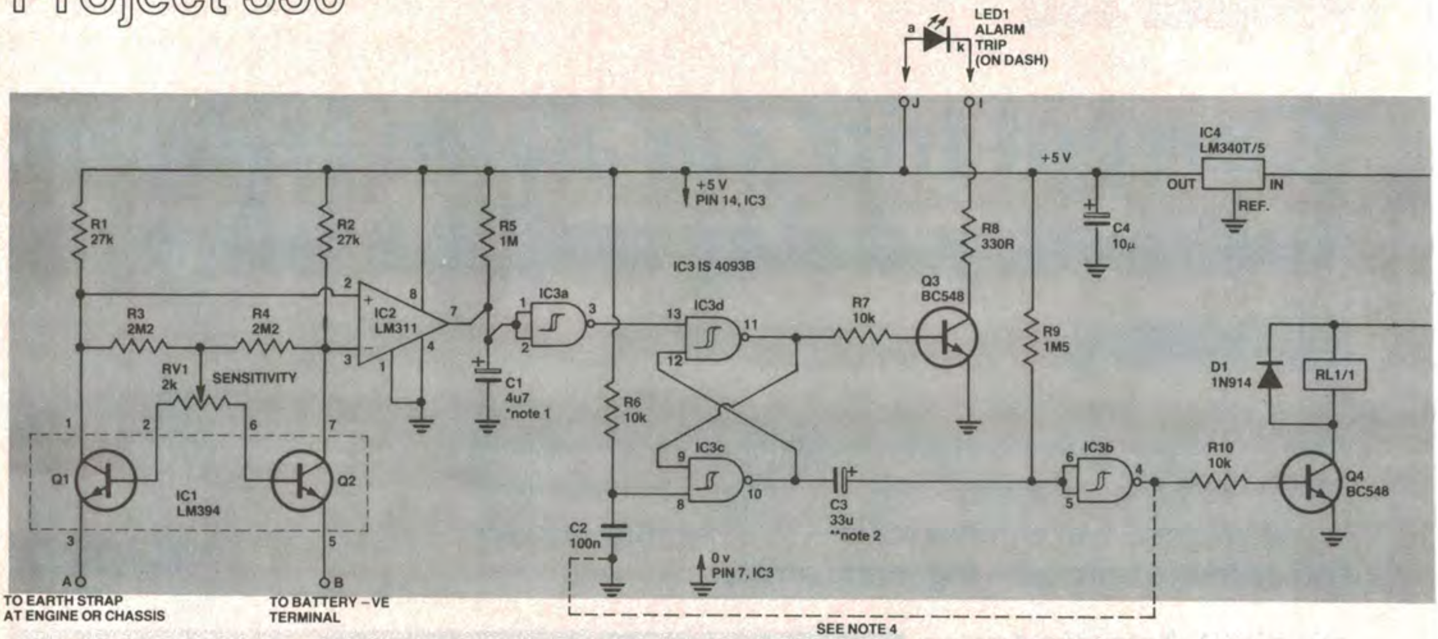
A cunning variation on this is to detect a voltage drop anywhere in the vehicle's electrical system. We published the design for such an alarm some time back in our book 'Project Electronics' (ETI-084). Whilst a popular project, many constructors reported problems with false triggering. In addition, the alarm did not include entry and exit delay times, which many constructors have requested over the years.



The completed unit was mounted on the lid of a diecast box with a scrap of blank pc substrate underneath as an insulating spacer. The external leads are passed through two grommeted holes.

This project employs a similar principle to the ETI-084, but rather a different technique. The battery 'earth' strap has a small, but finite, resistance. Any load on the battery will cause a current to flow through the earth strap (since the vehicle's chassis is used as the return circuit). The current causes a small voltage drop across the earth strap resistance. This is detected and used to trip the alarm. As the 'sensing' input is essentially a very low impedance input, false triggering from magnetic induction or other sources is avoided. Other voltage drop sensing schemes essentially have a medium to high input impedance, hence their susceptibility to false triggering.

Additional measures are incorporated in this project to further reduce the possibilities for false triggering. ▶



*NOTE 1: Value of C1 sets entry and exit delay times.

**NOTE 2: Value of C3 sets alarm-on time.

***NOTE 3: Value of C5 sets flash and horn pulse rate.

NOTE 4: If you wish the alarm to reset itself after 45 seconds following tripping, lift the 'earthy' end of C2 and connect it to pin 4 of IC3b as shown by the dotted line.

NOTE 5: Capacitors C1, C3 and C5 may be either tantalum types or so-called 'low leakage' electrolytics such as the Elna RBLL, or similar.

HOW IT WORKS — ETI 330

Any load on the electrical circuit of a vehicle will produce a voltage drop across the small, but finite, resistance of the vehicle battery's 'earth' strap. This unit detects that voltage drop and trips an alarm circuit that operates the vehicle's horn. A thief entering the vehicle will inevitably operate a 'courtesy' light or something that draws current, thus tripping the alarm.

The circuit can be divided into five sections: the sense circuit, entry and exit delay circuit, latch circuit, alarm timing circuit and horn pulsing circuit. In addition, a three-terminal regulator provides a 5 V supply to most of the electronics, avoiding problems with false alarms.

THE SENSE CIRCUIT

The current in the earth strap is sensed by a pair of transistors connected in a common base configuration. These two transistors, Q1 and Q2, are encapsulated in an integrated circuit package and are on a single chip of silicon, ensuring that they have very closely matched characteristics. The device is known as an LM394. This device was used in much the same way in our Expanded Scale Vehicle Ammeter, ETI-329, published in the February '81 issue. The base-emitter voltages of each transistor will track within 50 microvolts of each other, a characteristic which is exploited here.

When no current is being drawn from the battery there will be no potential drop across the resistance of the battery earth strap (ignoring the miniscule current drawn by this alarm). Thus, the emitters of each transistor in IC1 will be at the same potential. As the base-emitter voltage of each is virtually identical the collector currents will be identical. Thus initially, the collector-emitter voltage of each will be the same.

When current is drawn from the battery (when a courtesy lamp is operated, for example), a small voltage drop will appear across the battery earth strap. Thus, point A (emitter of Q1) will be raised to a *higher* potential than point B (emitter of Q2). That is, point A will be more positive than point B. The voltage on the collector of Q1 will thus rise (a common base amplifier is a *non-inverting* amplifier).

The voltage difference between the collectors of Q1 and Q2 is monitored by a differential input comparator, IC2 — an LM311. When the voltage on its non-inverting input exceeds the voltage on its inverting input the comparator's output switches high. What happens next we'll get to shortly.

The voltage on the collector of each transistor in IC1 (Q1 and Q2) is initially set by a trimpot, which varies the current fed to each base. This compensates for any slight mismatch between Q1 and Q2 (the dc gain of this circuit is very high) and also acts as a 'sensitivity threshold' control by introducing a preset offset which must be overcome by a certain level of current through the battery earth strap before the alarm will trigger.

ENTRY AND EXIT DELAY

The comparator IC2 has an open collector output requiring an external load resistor — this is R5. When the output of IC2 is low the timing capacitor, C1, is held discharged by IC2's output circuitry. When the alarm is tripped and the output of IC2 goes high C1 starts to charge through R5. After a time determined by the time constant of R5 and C1 the Schmitt gate IC3a toggles over and its output, pin 3, goes low.

LATCH

The Schmitt gates IC3c and IC3d form a latch circuit. On power up, the latch is automatically reset by the time constant of R6 and C2, placing a momentary low on pin 8. The output of IC3c is high and the output of IC3d is low, Q3 is turned off and LED1 is not lit.

When the output of IC3a goes low the latch (IC3d and c) toggles over. The output of IC3d goes high, turning on Q3 and lighting LED1. The output of IC3c goes low at the same time.

The latch remains in this state until it is reset when the power is turned off and then on again.

ALARM TIME PERIOD

Before the alarm is triggered the output of IC3c is high and the input of IC3b is held high by R9. As IC3b is wired as an inverter its output is low and Q4 is turned off. When the alarm is triggered the output of IC3c goes low, and since C3 is discharged, the input of IC3b is pulled low, its output goes high and Q4 is switched on, allowing the relay to operate.

The timing capacitor, C3, slowly charges through R9 and, after a period determined by the time constant of C3/R9, IC3b switches over, turning Q4 off again and stopping the horn.

HORN PULSING CIRCUIT

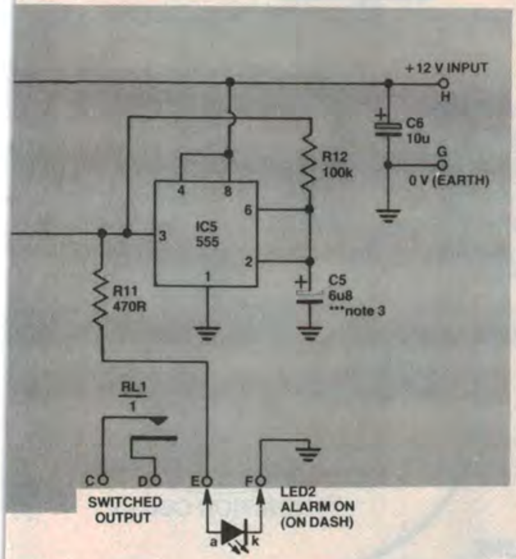
The relay RL1, and therefore the horn, is pulsed on and off about once per second during the horn timing period. IC5 is a 555 timer wired as a free-running oscillator. The frequency of oscillation is determined by the time constant of R12 and C5. As the 555 is capable of driving quite high currents it is connected directly to the relay, which is then switched by Q4. In other words, the 555 pulses the supply to the relay.

The output from the 555 is also used to pulse LED2 (mounted on the dash) as a warning to would-be car thieves and as an indication that the alarm is on.

REGULATOR

A three-terminal regulator, IC4, drops the battery voltage down to 5 V to supply the sense and timing circuits. This protects against false triggering from battery voltage variations and also helps to remove noise from the supply.

Using a Schmitt-triggered input quad NAND gate for IC3 provides further noise immunity and reliable timing due to the precise switching action of its inputs.



Design

A block diagram of the alarm is shown in Figure 1. The Sense and Trigger circuit detects when the voltage drop across the battery earth strap rises above a predetermined amount. When triggered, this then arms the entry/exit delay. If the alarm does not remain triggered after the delay period nothing further will happen. If it does remain triggered, the delay circuit will trip the Latch and start the Alarm Period Timer. The Alarm Trip Indicator will also light. When the Alarm Period Timer is activated the Relay Driver is also activated. The Relay Pulser will then turn the relay on and off at one-second intervals, pulsing the horn on and off too.

The Relay Pulser circuit operates continuously and flashes a dash-mounted light to indicate that the alarm unit is 'armed'.

After the Alarm Period Timer completes its period, the Relay Driver is turned off and the horn will cease pulsing on and off at one-second intervals. Car alarms are required by law to turn off within ten minutes of being triggered, but can automatically re-arm.

If someone attempts to steal your car, trips the alarm and then abandons the attempt, the Alarm Trip Indicator will remain on, telling you that the alarm was tripped during your absence.

Construction

Our prototype was constructed on a printed circuit board, the artwork for which is reproduced elsewhere in this article. While this is not absolutely necessary — the project could be constructed on matrix board — a pc board does reduce the possibility of wiring errors, which have to be sorted out when you first power up the project.

There is no particular order for assembling the components to the pc board but it is usually easier to solder the resistors and capacitors in place first. Take care with the orientation of the tantalum and electrolytic capacitors. Follow with the semiconductors. Again, watch orientation of these components. The relay should be mounted last of all.

The completed pc board can be mounted in any convenient case — we housed ours in a diecast box measuring 120 x 40 x 95 mm. A diecast box was chosen because it can be effectively sealed against the ingress of dirt, moisture and other undesirable substances.

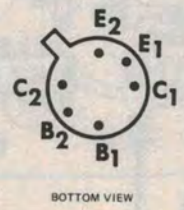
We mounted the pc board on the underside of the diecast box's lid and fitted a 10-way terminal block on the outside of the lid for all the external connections. Leads from the pc board to the 10-way terminal block are passed through grommetted holes. These were later sealed with Silastic.

THE LM394 FAMILY AND ALTERNATIVES

There are a number of devices in this monolithic npn dual transistor 'family', each characterised by different tolerance specifications. The LM194 is the mil-spec version which has the tightest specifications and top price. It's also hard to get and its use is not really necessary in this application. The LM394 is available in 'H' and 'C' versions. The LM394H has tighter tolerance specifications than the LM394C and is more expensive. The cheaper LM394C is recommended for use in this project as it is the least expensive member of the family and generally obtainable in good quantities.

Philips manufacture an npn dual transistor family, designated BCY87, BCY88, BCY89, and any of these could be pressed into service in this project, although their V_{be} tolerance specifications are somewhat wider than for the LM394 family. There should be sufficient adjustment available with RV1 to compensate for the wider tolerance in V_{be} offset. The BCY89 is the least expensive, widest tolerance device. Note that the package pinout for the Philips devices is different — see the diagram following.

A further alternative would be to use two transistors from a transistor array IC. The CA3045/46, manufactured by RCA, is a general purpose transistor array IC containing three isolated transistors and one differentially-connected transistor pair. Any two of the isolated transistors may be used. However, this device is encapsulated in a 14-pin DIL package which would have to be glued to the pc board in a suitable place, upside down, and connecting wires run from the appropriate holes in the pc board to the device pins. RV1 should be able to compensate for the wider tolerance in V_{be} offset here too.



BCY87/88/89 FAMILY PINOUT

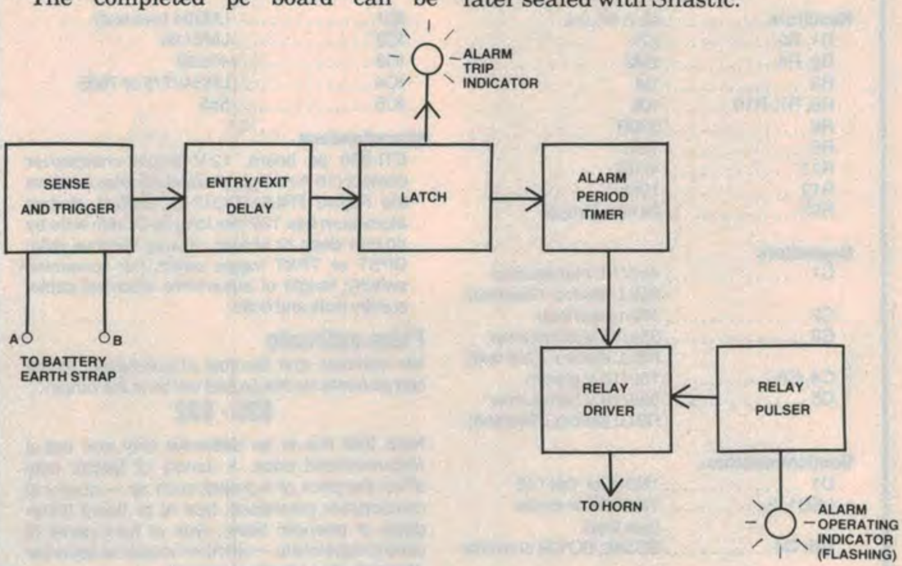
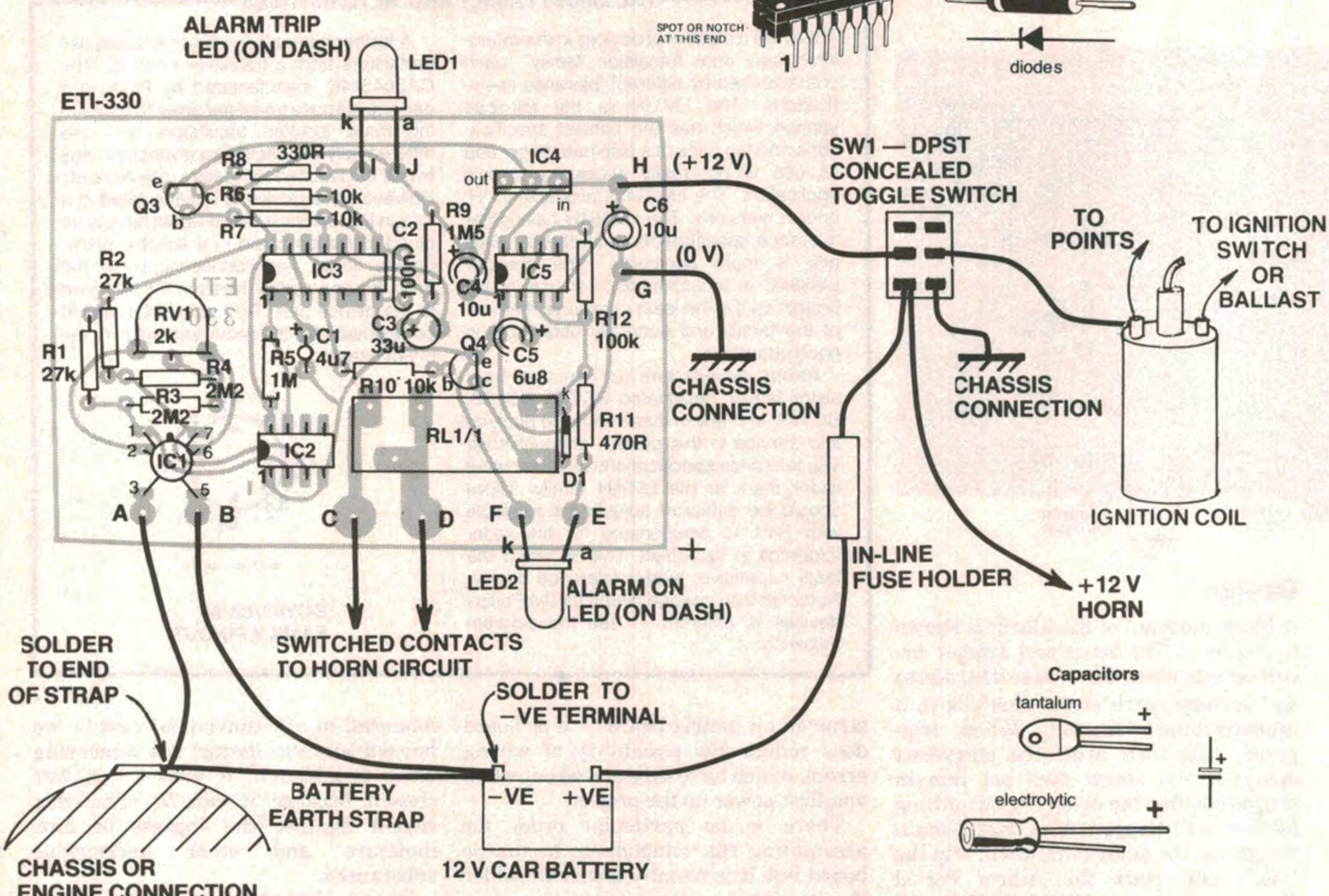
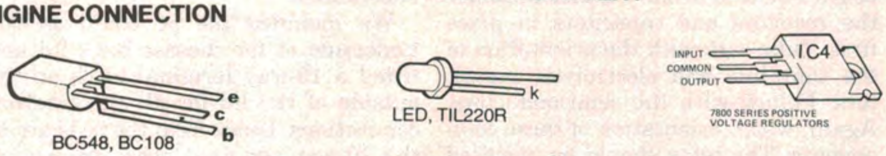


Figure 1. **Block diagram of the ETI-330 car alarm showing the basic functional blocks of the circuit.**





PARTS LIST — ETI 330

Resistors . . . . all ½ W, 5%

R1, R2	27k
R3, R4	2M2
R5	1M
R6, R7, R10	10k
R8	330R
R9	1M5
R11	470R
R12	100k
RV1	2k min. trimpot

Capacitors

C1	4u7/16 V tantalum or RBLL electro. (See text)
C2	100n greencap
C3	33u/16 V tantalum or RBLL electro. (See text)
C4, C6	10u/16 V electro.
C5	6u8/16 V tantalum or RBLL electro. (See text)

Semiconductors

D1	1N914 or 1N4148
LED1, 2	TIL220R or similar (see text).
Q3, Q4	BC548, BC108 or similar
IC1	LM394 (see text)
IC2	LM311N
IC3	4093B
IC4	LM340T/5 or 7805
IC5	555

Miscellaneous

ETI-330 pc board; 12 V single changeover contact (10 A rating) pc mounting relay (such as the Fujitsu FRL611DO12 or similar); diecast aluminium box 120 mm long by 95 mm wide by 40 mm deep or similar; 10-way terminal strip; DPST or TPST toggle switch (for concealed switch); length of automotive electrical cable; sundry nuts and bolts.

Price estimate

We estimate that the cost of purchasing all the components for this project will be in the range:

$25 - $32

Note that this is an **estimate** only and **not** a recommended price. A variety of factors may affect the price of a project such as — quality of components purchased, type of pc board (fibreglass or phenolic base), type of front panel (if used) supplied etc — whether bought as separate components or made up as a kit.

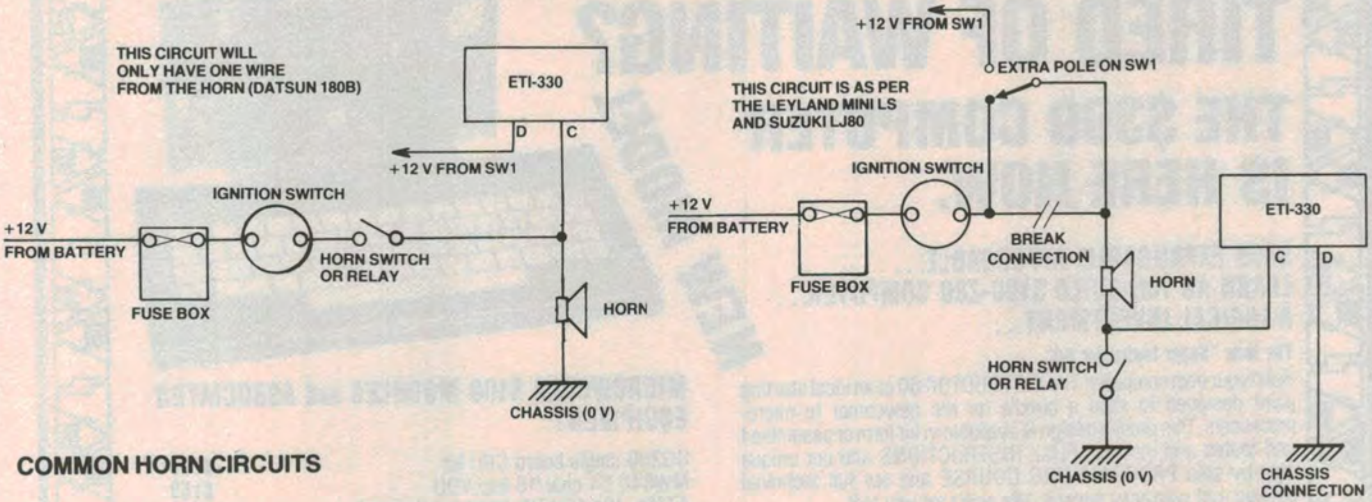
Installation

Firstly, mount the 'Alarm On' LED (the one that flashes) and the 'Alarm Tripped' LED on the dash in convenient positions where they can be seen from outside the vehicle. You can obtain LEDs mounted in metal and plastic mounting which is secured by a nut or clip, and these are ideal for this application.

The alarm is switched on by a concealed switch which may be located under the dash or under the driver's seat. Alternatively, an externally mounted keyswitch may be used. If you install the latter, entry and exit delay may be reduced to about half a second by changing the value of C1 to 1u.

We used a two-pole switch, one pole to switch the supply to the alarm, the other to short out the points when the alarm is switched on. Thus, if somebody does gain entry to the car and ignores the alarm or disconnects the horn, they will not be able to start the car even if they jumper the ignition!

Connection to the earth strap is quite straightforward. Take a wire from terminal A and solder it to the end of the earth strap. Terminal B is taken and



COMMON HORN CIRCUITS

soldered to the battery terminal connection. It's a good idea to keep these leads fairly short to reduce noise pick-up. Ours were about one metre long.

The positive supply, via the alarm switch, should be taken through an in-line fuse holder, directly from the battery positive terminal. The normal fuse holder in a car is usually under the dash and could easily be pulled out by a thief when the alarm goes off.

The output from the alarm is a pair of switched contacts, which operate the horn by bypassing the horn switch or, on some cars, the horn relay. We have shown two common horn circuits. The the first circuit the horn switch is bypassed by the relay contacts. The second circuit is a little more complex and requires an extra pole on the alarm switch. If you want to short out the points as well you will need a three-pole double-throw switch. Make sure you break the connection from the ignition switch to the horn as shown, or when you switch the alarm on you will also switch on the ignition!

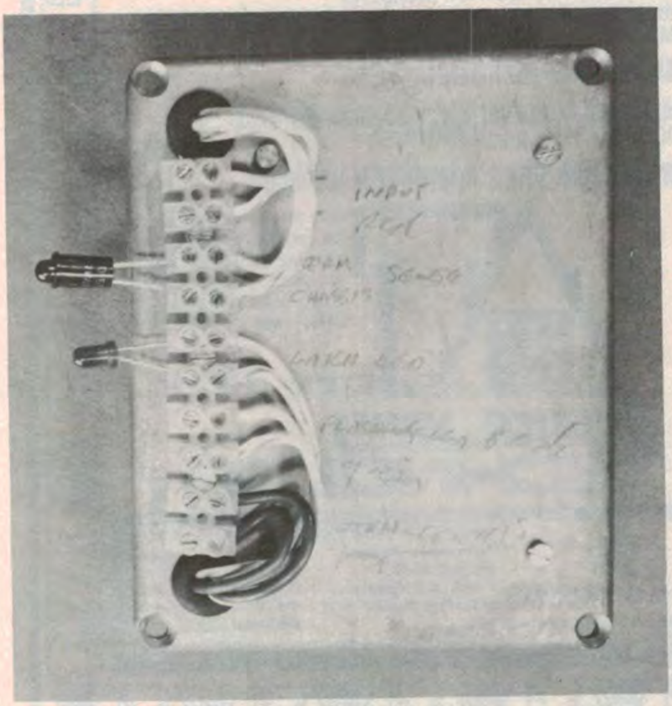
Try to make all wiring as neat as possible and try to blend it in with the car's wiring so it is not obvious to a thief what wire he has to pull out to stop the alarm.

Setting up

When all the wiring is complete, all that remains is to set the sensitivity trimpot. Disable the entry and exit delay by removing C1, or alternatively connect a high impedance voltmeter across C1. With no current being drawn from the battery, adjust RV1 until the alarm just fails to trip or C1 fails to start to charge. Note the position on the trimpot. Turn on the interior light and the alarm should trip. If it does not, check your first adjustment; if it is correct, you probably have the leads to the earth strap and the battery negative terminal swapped.

Turn the trimpot until the alarm just won't trip or C1 doesn't charge when the interior light is turned on. Note this position. The correct position for RV1 is midway between these limits, for reliable operation.

Next check that the alarm doesn't trip on the car radio or the electric clock. Some mechanical clocks are rewound by a motor every few hours, or even days, and these are often a cause of false triggering. If false triggering occurs from the radio or the clock, reduce the sensitivity. In some extreme cases it may be necessary to use a higher wattage interior light, though I found operation to be extremely reliable with a five watt light, and there was sensitivity to spare! ●



Everything is mounted on the lid of the diecast box and terminations made via a 10-way terminal block mounted on the outside of the lid. Mark each lead, especially polarity where necessary.